WHAT CAN WE LEARN FROM THE LEARNERS?

SOME RESULTS AND IMPLICATIONS FROM "SCIENCE AND SCIENTISTS" A COMPARATIVE STUDY IN 22 COUNTRIES

Svein Sjøberg, (University of Oslo, Norway, *svein.sjoberg@ils.uio.no)*

Abstract

By comparing your national or local situation with the state of affairs in other countries, you come to see your own choices and priorities with new eyes. There are, however, many different approaches to international and comparative studies. Some studies rank countries by level of achievement, and may indirectly define norms and universal standards. Other studies may open up for cultural variation and provide options for different choices. This paper presents a study of the latter category.

The study is called Science And Scientists (SAS). The SAS-study explores cultural and gender differences on topics that are of relevance for science teaching. More than 40 researchers from 22 countries have collected information from some 10000 13-year old pupils from all continents. This paper presents selected results from three different items in this study. The three (out of seven) items that are considered here are related to the pupils' prior *experiences*, their profile of *interests* and their expressed *plans and motivations* for their own future. The results shows that are some rather universal trends in the gender profile of children's' experiences as well as their interests in science topics. Gender differences are particularly (and surprisingly) high in some of the North- European countries and in Japan. These findings are discussed in some detail.

The SAS-study provides empirical evidence for an informed deliberation about priorities in the school curriculum. The purpose of the study is to stimulate the debate on how science curricula can be made more relevant and suited to fit the experiences and the needs and interests of different learners in different countries. The SAS-study was meant to be only a modest and exploratory study, but has become a rather large undertaking. Plans for a more detailed and carefully planned study of a similar nature are also presented.

Large-scale comparative studies. Limitations and side-effects

Science curricula and textbooks in different countries have striking similarities. Some consider this fact to be a reflection of the cultural neutrality and universality of science, while others see it as an unwarranted consequence of the cultural domination of some countries over others. Large-scale comparative studies like the IEA TIMSS (Third International Mathematics and Science Study) (se e.g. TIMSS 1998) may have as a (possibly unintended) side effect a pressure to harmonize or universalise science curricula across nations. Test format as well as curricular contents may provide standards, 'benchmarks' or norms for participating countries as well as for other countries. Furthermore, the international and cross-cultural nature of TIMSS-like studies has necessarily implied the development of items that can be used independent of educational or social context to avoid cultural bias. Hence, test items tends to become decontextualized and rather abstract. This development runs contrary to recent thinking in teaching, learning and curriculum development. The publication and availability of TIMSS items in many countries provides an 'incentive' to use tests that both in its closed multiple choice format and its lack of social context run contrary to national or local traditions.

Comparative research in education is important, but there is an obvious need to complement the valuable data from TIMSS-like studies with more open and culturally sensitive information and perspectives (Atkin and Black 1997). The recent OECD PISA study (Programme for International Student Assessment) is an ongoing attempt to widen the scope of such large-scale studies, and the underlying framework for PISA is, in contrast to TIMSS, not bound to the school curricula. The publication of the first results from PISA (OECD 2001) indicates that the PISA studies will meet some of the criticism raised against the IEA-based studies like TIMSS.

But TIMSS and PISA still have some common characteristics. They are both high-level initiatives 'from the top' to monitor scholastic achievement, and the main results are various rankings on league-like tables. The studies are also (with some exceptions) confined to rich countries in the OECD. In most countries these studies are initiated and (rather heavily!) funded by governments and ministries of education. Such studies stem from the decision-makers' and politicians' (legitimate!) need to have comparable data on the scholastic achievement of their pupils and to have some measures of efficiency and cost-benefit aspects of their national educational system. In an age of globalisation and economic competition, the national authorities are increasingly concerned about how their own system compares with other systems, measured against common standards or 'benchmarks'. Similarly, national authorities have a legitimate need to get international comparable data on unit costs, about the effects of teacher training, class size, effects of resource usage etc. One may, of course with some exaggeration, characterize projects like TIMSS and PISA as the educational parallel to what is known as Big Science. The scale and costs of these studies are many factors higher that the kind of research that most science educators are involved in. The institutions that perform these studies are often government agencies for research and development, or research institution from which the government may expect a certain degree of loyalty. Such research does not emerge from an independent and critical academic research perspective.

The SAS-study: a small-scale comparative study

The comparative study reported here is very different from the large TIMSS and PISA studies. It is low-cost, it is emerging from the 'bottom' instead of from governments and ministries, it includes not only the wealthy nations but also developing countries, and its prime purpose is to open up for critical discussions about priorities and local variation in the science curricula. The concern is *not* about any ranking from good to bad, or comparisons with given standards or benchmarks. The purpose is to open up for critical discussions abut priorities, based on empirical evidence gathered in diverse cultures.

In many countries, mainly the industrial, there is currently a kind of disenchantment with science. There is a fall in the recruitment to (some) science-related studies and careers. The SAS-study emerges partly as an attempt to understand these trends, but also from the perspectives of critical pedagogy and with a critical perspective on the role and function of science curricula. There is today a widespread concern to try to make science curricula meaningful, relevant and adapted to different groups and different cultures (Cobern and Aikenhead 1998, Ogawa 1995). *The lack of relevance* of the S&T curriculum is probably one of the greatest barriers for good learning as well as for interest in the subject. In any discussion about *relevance*, it becomes important to know more about the views, experiences and perspectives of the learners.

The present study is a modest attempt to shed light on differences as well as similarities in what pupils bring to school, what perspectives and plans they have and what kind of interests they have. The study is called *Science And Scientists, the SAS-study*. The prime concern is about diversity due to different cultures and gender. The intention is to provide data and perspectives that may give an empirical foundation for an informed discussion about the relationship that the learner has to the science curriculum and science teaching. The development of the SAS-project is a joint undertaking, involving science educators from very different cultures.

Methods and Samples

The SAS project used a questionnaire that was developed, piloted and finalized in a cooperation between this author (from Norway), Jane Mulemwa from Uganda and Jayshree Mehta from India. We met for on several occasions through our joint engagement in organizations like GASAT and IOSTE, and we were also jointly involved FEMSA (Female Education in Mathematics and science in Africa) a large African project to address gender equity in science education in Africa. The SAS questionnaire consisted of 7 groups of items. The aspects that were studied were the following: The pupils' science-related out-of-school *experiences*, their *interests* in learning about different topics in science, their *perceptions* of science as an activity and *images* of scientists as persons – and their *priorities* for future life or work. The questionnaire also consisted of some open-ended questions, like "What would you like to do if you were a scientist?" The "draw-a-scientist- task" was also included, and the pupils were asked to comment on their drawing in writing.

The final instrument was made available to researchers from other countries through various science education networks like IOSTE and NARST. The participating researchers collected national data, following agreed procedures for sampling, administration, data collection and coding. Empty data files in SPSS and Excel were provided by the project, which also refunded some costs, in particular for researchers in developing countries. Data files were returned to this author, merged into a larger file and recoded for analysis. Details of procedures, sampling etc are given in Sjøberg 2000a.

Some 40 researchers from 22 countries provided data from about 10 000 pupils at the age of 13. The countries are, in alphabetical order**:** *Australia, Chile, England, Ghana, Hungary, Iceland, India, Japan, Korea, Lesotho, Mozambique, Nigeria, Norway, Papua New Guinea, Philippines, Russia, Spain, Sudan, Sweden, Trinidad, Uganda and USA.*

Several national reports have been published; the participating researchers and the list of publications are given in the SAS-report (Sjøberg 2000a). A brief report is also available as chapter in a recent book (Sjøberg 2000b). The data files for the SAS-project are now available from the author for further analysis by the participants. This paper mainly presents data that are not published before.

Results: General observations

The data document that children in different parts of the world come to school with a variety of different science-related experiences. Their interests in science topics show great variations, and their plans and priorities differ. If one wants to build on children's experiences and meet their interests and perceived needs, such information is of crucial importance. In spite of the variations within each country, the participating countries seem to come out in clusters on many aspects, often reflecting the country's level of development. Children from African countries seem to share many background experiences, and they also seem to have the same interests, similar priorities for future job and they have the same (very positive) image of science and scientists etc. There also seem to be gender-related differences that follow similar cultural patterns. This means, among other things, that the definition of feminine and masculine behaviours and attitudes seems to follow cultural patterns. Also developed countries have some likenesses with each other, and the Nordic countries come out as a group with strong similarities. In the following, some more detailed results are given, although the available space does not permit complete tables or graphs.

Results: Prior experiences

One group of items is called *Out of school experiences: What I have done.* This is an inventory of 80 activities that may have bearing on the teaching and learning of science. This item has also been used in previous research in a slightly different form. (Sjøberg and Imsen 1987, Whyte, Kelly and Smail 1987). Attempts were made to sample activities that might be of relevance for the learning of science, and to try to make the list balanced with regards to gender and cultural differences. The calculated overall score (Sjøberg 2000a) showed that we had been successful in this respect; most countries had similar averages and most countries had only small differences in the overall activity score for girls and boys.

On this item, we often observed what we might call a traditional gendering pattern. Boys in nearly all countries have considerably more experience with activities such as these: Using guns, bows and arrows, using new technologies, car-related activities, (using car jack, charging batteries etc.), mechanical activities (using pulleys and levers) electrical activities (fixing leads, using batteries, motors, bulbs) using tools (saw, hammer etc.), mending bikes.

Girls had in general more experience with nature-oriented (and more peaceful) activities like collecting gems, flowers, mushrooms, observing the sky, the moon and the stars. Girls also had more experience in household-related activities like *preparing* food. On the other hand (and maybe surprisingly?) boys had, in most countries more experience than girls in *preserving* and *storing* food (salting, smoking, drying etc)

Some sorts of experience had different gendering patterns in industrialized and developing countries. Caring for animals and other farming activities are boys' activities in developing countries, while the same activities are typical girls' activities in industrial countries. The underlying reason may be that agricultural activities are basic economical, life-sustaining activities in developing countries, while they are more related to leisure and hobby in industrialized countries.

Some typical experiences among the Nordic (here: Norway, Sweden and Iceland) children seem to be strongly related to outdoor life. Nordic children (girls and boys) have more experience than others in activities like setting up tents, making fire, using binoculars, making flute of straw or wood, collecting mushrooms and edible berries. We also note that Norwegian children (in particular boys) have the highest score of all on "using air-gun and rifle" – possibly a reminiscent of an old hunting (and fishing) tradition, still surviving as a leisure activity?

Results: Interesting science topics

This group of items is called *Things to learn about* and is a similar list to the one about experiences. It is an inventory of possible topics for inclusion in the science curriculum. 60 topics are listed. Some results from the analysis of interests in science topics have been published elsewhere (Sjøberg 2000a and 2000b). Here follows some general observations.

Children in developing countries are interested in learning about nearly everything! This is possibly a reflection of the fact that for them, education is a luxury and a privilege, and not seen as a painful duty, as is often the case in more wealthy nations! Japanese children are less interested in S&T than children in other countries -- in particular about the car, new technologies and communication! We return briefly to this at the end of the paper. The Nordic countries (and Japan) are more gendered in children's interests than other countries! We also comment on this observation at the end of the paper.

This item provides a wealth of data that may be of value for a discussion on how to construct a science curriculum that meets the interests of different learners in different cultures. To illustrate this point, we give one example, see table 1, where some of the data for two selected countries are contrasted – based on the gender difference.

"What I want to learn about" Data from Norway and Japan. The list is sorted by the *difference* between boys and girls.				
"Girls' science" Norway	**M-F**		**"Girls' science" Japan**	**M-F**
AIDS: What it is and how it spreads	**-24**		How to heat and cook food the best way	**-26**
The rainbow, what it is and why we can see it	**-22**		The rainbow, what it is and why we can see it	**-26**
Why people in different parts of the world look different and have different colours of the skin	**-19**		Why the sky is blue and why the stars twinkle	**-18**
What we should eat to be healthy	**-18**		What are colours and how do we see different colours?	**-17**
Why the sky is blue and why the stars twinkle	**-17**		Music, instruments and sounds	**-16**
Birth control and contraceptives	**-16**		Sounds and music from birds and other animals	**-15**
What are colours and how do we see different colours?	**-15**		Plants and animals in my neighbourhood	**-13**
Sounds and music from birds and other animals	**-12**		How birds and animals communicate	**-12**
How birds and animals communicate	**-12**		How science and technology may help disabled persons (blind, deaph, physically handicapped etc.)	**-11**
How we can protect air, water and the environment	**-11**		What we should eat to be healthy	**-9**
"Boys' science" Norway			**"Boys' science" Japan**	
How radioactivity affects life and my own body	**11**		How science and technology may help us to get a better life	**13**
The possible dangers of science and technology	**12**		Satellites and modern communication	**13**
New sources of energy: from the sun, from the wind.	**15**		The possibility of life outside earth	**13**
Important inventions and discoveries	**17**		The origin and evolution of the human being	**15**
How science and technology may help us to get a better life	**18**		New sources of energy: from the sun, from the wind etc.	**16**
Light and optics	**20**		Rockets and space travel	**17**
How things like telephone, radio and television work	**20**		The possible dangers of science and technology	**17**
Acoustics and sound	**21**		How things like telephone, radio and television work	**17**
Atoms and molecules	**22**		Important inventions and discoveries	**18**
Computers, PCs and what we can do with them	**23**		Computers, PCs and what we can do with them	**19**
What an atomic bomb consists of and how they are made	**24**		What an atomic bomb consists of and how they are made	**19**
Chemicals and their properties	**25**		Atoms and molecules	**20**
Rockets and space travel	**26**		How a nuclear power plant functions	**21**
Electricity, how it is produced and used in the home	**27**		Lightning and thunder	**24**
How a nuclear power plant functions	**27**		X-rays and ultrasound in medicine	**24**
Satellites and modern communication	**29**		Electricity, how it is produced and used	**24**
Latest development in technology	**37**		Latest development in technology	**27**
The car and how it works	**43**		The car and how it works	**30**

Table 1 "What I want to learn about" – (part of the list) sorted based on the *difference* between girls and boys. The list shows data from Norway and Japan. For each country, the topics with the most female gender difference are shown (on top) and (at the bottom) the topics with the strongest boys' profile are shown. The number is the difference in percent between boys and girls who have indicated that are interested in the topic.

The list of possible science topics in this item consists of 60 items, and only the top and bottom parts of the list are shown in table 1. In this table, only the *difference* between girls' and boys' score is shown. We note that the actual gendered differences at the ends of 'the spectrum' are extreme. This means that in both countries there are topics in science that stand out as exceptionally gendered in the favour of girls (the top of the list), and even more topics with a very strong boys' profile (the bottom of the list). We also note that there are strong similarities between the lists for the two countries, in spite of the large cultural difference between these countries. For both countries, *girls* show a greater interest than boys in aspects of biology, health and nutrition. They are also more interested in aspects with a possible aesthetic dimension (colours, sound, music, blue sky, twinkling stars etc.) Boys in both countries, however, express much greater interest than girls do in cars, technology, PCs, rockets, nuclear power plant, electricity etc.

Some of these results are hardly surprising; they actually fit well with what one stereotypically calls girls' and boys' interests. The surprise is, however, that the actual difference is so *extreme*. Take learning about "The car and how it works" as an example. In Norway, 76 % of the boys and 33 % of the girls are interested. Japan is even more extreme, although the actual numbers are much smaller: 36 % of the boys, and only 6 % of the girls are interested! Similar details can be noted at the other extreme of the spectrum.

What we can learn from this is that the 'ideal' science curriculum for girls and boys are indeed very different – although they may both be considered good and valid science! Data like these should be kept in mind when curricula are written and textbooks produced. If one puts early emphasis on the technological aspects of science, one will definitely turn off the potential interests that girls might have in the subject!

The data also contains some surprises. *Boys* are in most countries more interested than girls on topics like

- The possible dangers of science and technology
- How science and technology may help us to get a better life
- How science and technology may help handicapped
- New sources of energy, from the sun, from wind etc.
- How radioactivity affects life and my own body
- Famous scientists and their lives

These results run contrary to what is often assumed, e.g. that girls are more interested in the possible misuses of science, that they are interested in the human and historical aspects of science and that they are interested in how science and technology may improve life and help people. The SAS data do *not* give support to these claims, at least not as general claims.

In spite of the great gender disparities, some topics seem to be high on the list for girls as well as boys in most countries. (Then we focus on actual percentages, and not on *differences* in score!)

Most popular among girls *and* boys in most countries are the following topics:

- The possibility of life outside earth
- Computers, PC, and what we can do with them
- Dinosaurs and why they died out
- Earthquakes and volcanoes
- Music, instruments and sounds
- The moon, the sun and the planets

Similarly, one can identify a list of the **least popular** (for girls and boys) in most (mainly the rich) countries:

- How to improve the harvest in gardens and farms
- How plants grow and what they need
- Plants and animals in my neighbourhood,
- Detergents, soap and how they work
- Food processing, conservation and storage
- Famous scientists and their lives

From this list we see that the concern to make science more relevant by concentrating on what is "concrete, near and familiar" is not necessarily meeting the interests of the children. They may, in fact, be *more* interested in learning about the possibility of life in the universe, extinct dinosaurs, planets, earthquakes and volcanoes!

Results: Important for future job

This item is called *Important for a future job* and consists of a list of 15 factors that might be important for the choice of a future job (if such a choice exists!). The pupils are invited to judge the personal relevance of each of these factors. An example of the data is provided by Table 2

Of importance for choice of job	Girls	Boys	Boys-Girls	Total
Have an exciting job	0,94	0,94	0,00	0,94
Have more time for my family	0,94	0,92	-0,01	0,93
Get a secure job	0,92	0,91	-0,01	0,92
Have more time for my friends	0,91	0,88	-0,03	0,89
Have more time for my own interests and hobbies	0,82	0,84	0,02	0,83
Use my talents or abilities	0,78	0,81	0,04	0,79
Make my own decisison	0,77	0,80	0,03	0,78
Help other people	0,82	0,73	-0,10	0,77
Earn lots of money	0,71	0,82	0,11	0,76
Developing new knowledge and skills	0,64	0,71	0,08	0,67
Work with people instead of things	0,66	0,55	-0,11	0,61
Make and invent new things	0,41	0,63	0,22	0,52
Have an easy and simple job	0,44	0,52	0,08	0,48
Become famous	0,31	0,51	0,20	0,41
Control other people	0,14	0,29	0,15	0,21

Table 2. Factors of importance for future job. Norwegian SAS-data. The columns show results for girls and boys and total. A separate column gives the difference between the boys' and girls' score. The factors are sorted by decreasing importance, based on the total score. (The maximum possible score is 1,0, details of scoring are given in Sjøberg 2000a))

We see from this list that although there is general agreement between girls and boys on the importance on some of the factors, there are also remarkable differences on other aspect between the priorities of girls and boys. We see that the difference is 'in favour' of boys on factors like "Make and invent new things", "Become famous", Control other people", "Earn lots of money", while the girls put considerably more emphasis on "Working with people instead of things" and "Helping other people".

In order to simplify these matters, a factor analysis was performed. We identified the following four components. (The suggested name is 'invented' as a label that seems to fit with the contents.)

1. **Ego-orientation** (famous, rich, controlling others, easy job)
2. **Time and security** (time for friends, family, myself – and a secure job)
3. **Self-development** (using talents and abilities, developing knowledge and skills, taking decisions, exciting job)
4. **Others-orientation** (Helping others, working with people)

When applying this to the participating countries, we find that factors 2 and 3 ("Time and security" and "Self-development") are rather gender neutral in practically all countries. The other two factors are strongly gendered.

In all but 2 countries, boys seem to be "Ego-oriented", with Iceland, Sweden, England and Norway as the most extreme! On the other hand, in all but two countries girls seem to be much more "Others-oriented" than boys. Also on this aspect, Norway and Sweden are the most strongly gendered. Details are given in table 3.

Other-orientation (helping others, working with people)				
***Sorted* by gender difference**				
COUNTRY	**Girls**	**Boys**	**Boys-Girls**	**Total**
Sweden	0,78	0,59	-0,19	0,69
Norway	0,75	0,64	-0,11	0,69
Hungary	0,82	0,73	-0,09	0,78
Chile	0,84	0,75	-0,09	0,80
Uganda	0,85	0,77	-0,07	0,81
Japan	0,73	0,66	-0,07	0,70
Iceland	0,74	0,67	-0,07	0,70
USA	0,76	0,70	-0,06	0,73
Australia	0,80	0,75	-0,05	0,77
Philipines	0,84	0,80	-0,05	0,82
England	0,73	0,69	-0,04	0,71
Spain	0,77	0,74	-0,03	0,76
India	0,78	0,75	-0,03	0,77
Papua New Guinea	0,74	0,72	-0,03	0,73
Sudan	0,79	0,77	-0,02	0,78
Nigeria	0,82	0,80	-0,02	0,81
Mozambique	0,87	0,86	-0,01	0,86
Lesotho	0,86	0,86	-0,01	0,86
Trinidad	0,75	0,76	0,01	0,75
Korea	0,68	0,70	0,02	0,69

Table 3 "Other-orientation" (Helping other people, working with people) among children in different countries SAS-data. Data are given for girls, boys and total as well as the gender difference. The list is *sorted* by gender difference. Maximum score is 1,0

Discussion: Some paradoxes and surprises

Many findings in the SAS-study are hardly surprising. The overall gender profile follows a pattern that is well documented. But some results are rather unexpected (at least for this author). Two such examples will be briefly discussed here: (1) The low interests in science and technology among Japanese children and (2) the seemingly paradoxical situation regarding gender equity in the Nordic countries.

Japan: Top in score – lowest in attitudes and interests!

Many results from Japan call for attention, in particular when they are seen in connection with other kinds of information. Let us look at some of the paradoxes: Japan tends to be on top on most international tests on pupils' achievement in science and mathematics (SISS, TIMSS etc.). Even on the recent PISA (2001) study, Japan comes out on the international top on achievement in mathematics and as number 2 in mathematics (right behind Korea). In spite of the high scores on achievement testing, the TIMSS data (TIMSS 1996 p 121 ff.) also indicate that Japanese children have more negative *attitudes* to both mathematics and science than pupils have in any other (of the nearly 50) TIMSS countries.

The data presented in this paper and in the other SAS-reports (Sjøberg 2000a and b) support and give more detail to this observation. Item by item, we find similar results: Japanese children are much less likely than others to be interested in most science items – in particular those related to modern advances in technology – an area where Japan is among the world leaders, and an area of prime economical importance for Japan.

Gender differences are in many aspects large in Japan. According to our study, Japanese girls are at the lowest place when it comes to interest in science, both when the question is a global one like "Is science interesting?" and on the very specific topics briefly mentioned in this paper. Japanese girls also state that they find science more difficult to understand than any other group in this study. (Sjøberg 2000a) (In spite of this, they actually score higher than girls in most other countries!)

Science educators in Japan have recently become very interested in these matters, since the low interest in science and technology and the lack of interests to pursue studies and careers in these fields may create serious problems for Japanese economy. The low birth rate in Japan and the highest life expectancy in the world further exacerbate the problem. Possible explanations as well as possible policies and remedies are debated. It falls beyond the scope of this paper to explore this issue, but it is expected to be an area of interesting debate and an area where one can learn from cross-cultural research. Professor Masakata Ogawa has recently initiated an international comparative research to shed light on science education and the importance of gender, language and culture. He was also the Japanese partner in the SAS-project. Perspectives and results from the SAS study and the planned ROSE-project (see the last paragraph) will be an important input in the ongoing Japanese project.

Norway and the Nordic countries: What about the gender equity?

The SAS-study has shown that the Nordic countries (here represented by Norway, Sweden and Iceland) on many aspects come out with greater differences between girls and boys than most other countries. In particular, we have documented large differences in the interest to learn science (Sjøberg 2000a). The data presented in this paper about priorities for a future job also indicate a very strongly gendered value profile among Nordic children: Girls as "others- oriented"; they want to help other people and work with people instead of things. Boys, on the other hand, are "ego-oriented"; they are more oriented towards making money and getting personal benefits. The analysis of children's drawings and their free writing on "Me as a scientist" (both reported in Sjøberg 2000a) also documents large gender differences in values and perspectives among the Nordic children. Data from TIMSS and PISA provides similar evidence on large gender differences in achievements as well as attitudes to science.

The Nordic countries are often considered "world champions" in gender equity. Gender equity has been a major political concern since the mid 70-s. Much has been accomplished, and the overall picture is undoubtedly rather positive. Legal barriers have been removed a long time ago; laws against discrimination and unequal pay are in operation. Female participation in politics and the labour market is among the highest in the world. In the education system, girls and women dominate the overall picture, with some 56% of tertiary students being female.

Official statistics and international reports confirm the leading position of the Nordic countries regarding gender equity. UNDP (United Nations' Development Program) publishes an annual Human Development Report. The analysis and conceptual development behind these reports is well respected. The main indicator that is developed by UNDP is the *Human Development Index* that is used to describe and monitor progress in this complicated area. All the 5 Nordic countries are among the 15 on the top of this list, which includes nearly 200 countries. In 2001 Norway was no 1 on the list.

The UNDP report has also developed indices that describe the situation of particular social sectors. In 1995 the focus was on gender, and from that year, UNDP has also reported on a so-called *Gender Empowerment Measure.* This index measures the degree of achieved equity regarding aspects like health, education, salaries, participation in politics and on the labour market etc. In the 2001 report, the Nordic countries have the following ranks on this list: 1 Norway, 2 Iceland, 3 Sweden, 4 Finland and 12 Denmark (UNDP 2001). As one can see, the overall picture seems to be positive, and the three Nordic countries taking part in SAS are actually the first three on this list of gender empowerment. *But equity does not exist in the field of science*. The percentage of women in science and engineering is very low – lower than in most other parts of the world. The enrolment of women into these fields has actually gone down the last years. And the gender difference in achievement and attitudes are large, also in the TIMSS and PISA studies.

The issue is of great political concern in these countries, where the gender equity is considered a pride. The reason for the observed differences in career choice does not seem to be the girls' lack of ability or lack of self-confidence! Even very able girls turn their backs to science and engineering. The girls' choices seem to be rather deliberate, based on value-orientations and emotional, personal factors. Some of the underlying values for girls are indicated above: The girls' high person-orientation and relatively low orientation towards money, career and things.

If this is correct, it shows that we should pay more attention to the underlying values, ideals and ideologies in science education. Textbooks as well as classroom teaching carry implicit (sometimes also explicit) messages about the nature of the subject and the underlying values. If we believe that these values are not strictly determined and logically deduced from the nature of science per se, we should analyse, discuss and possibly reconsider these aspects.

We have through the SAS-study documented large differences between the experiences, values and interests of girls and boys. It is very likely that girls encounter a science curriculum that neither builds on their prior experiences or fits well with their profile of interests. We hope to use the SAS data to argue for a reorientation of the Norwegian science curriculum.

Some conclusions and implications

It is evident from this study that children come to school with a rich variety of relevant *experiences* that could and should be utilized in the teaching and learning science at school. This study does not indicate whether this resource is actually used in a systematic way or not, but it may indicate how this might be done.

The *interest* in learning seems to be much higher in developing countries than in the rich and technologically developed countries. An explanation for this may be that education in developing countries is largely seen as a privilege that everybody strive for, while many pupils in the rich countries see school as a tedious duty that is imposed on them. The same perspective may explain the strong interest in science expressed by girls in developing countries: Girls in these countries often have less access to all sorts of education than boys have, therefore learning science may be seen as a very positive option.

The profile of the experiences and interests does, however, vary strongly between *countries*. This fact should call for caution when it comes to "importing" foreign curricula and it should indicate a need for some scepticism against the pressure to "harmonise" science curricula against universal common standards or benchmarks. Although science *per se* may be universal (a debate that is not pursued here!), *science curricula* for children should reflect the needs and priorities for children in each country. Data from projects like SAS may provide a basis for deliberations about curricular priorities.

It is also evident that the profile of experiences as well as interests is rather different for *girls and boys* in most countries. In general, the gender differences in interests are greater in rich countries than in developing countries, both when summed over all topics and when these are studies separately. Gender differences are very high in some North-European countries and in Japan, an aspect that is discussed a little above. If gender equity in science education is a national concern, one should go in some detail in analysing possible biases in the curricula, textbooks and classroom teaching. A study like SAS may be one approach to such issues, because it can shift the debate from a general theoretical level to a more concrete level, based on empirical evidence.

The *image* of science and scientists is more positive among children in developing countries than in the rich countries. Children in the developing countries seem to be eager to learn science, and for them, the scientists are the heroes. This is in marked contrast to at least a significant part of the children in the rich countries, who often express sceptical and negative attitudes and perceptions in their responses to several of the SAS items. The notion of the crazy or mad scientist is often found in rich countries. Very few children in the rich countries envisage the scientist as a kind, human and helpful person, whereas this is often the image of scientist in developing countries. (Details are given in Sjøberg 2000a)

This study does not tell which image is closer to "reality". But many of the data indicate that science has a problem with its public image in many developed countries. Most OECD countries are currently worried about the falling recruitment to science and technology studies. Why do children develop these critical attitudes to science and technology, although they live in societies based on such knowledge and its applications? One possibility is that this is a result of low public understanding of science, caused by bad teaching as well as a low or negative profile in the media. Many scientists hold on to explanations like these. But there is another possibility: It may be seen as an indication that many young people have a rather well informed sceptical attitude towards certain aspects of modern society. Maybe their doubts are based on real fears about an unknown future that scientists may lead them into?

Comparative research is important, and it is important for science educators to get involved in cross-cultural research. It often helps you see your own culture from outside, and it may open up for new insights and new alternatives. Data from the large-scale studies like TIMSS and PISA are valuable and important, but should be complemented by less ambitious and more explorative studies like the one presented here. Together, they may provide a foundation for informed debates about priorities and alternatives in science education.

Future plans: The ROSE project

The SAS-study was planned as a modest and exploratory study. The overwhelming international interest in joining the study took us by surprise. As it stands today, the study has several weaknesses stemming from its somewhat ad hoc development. But the results have received great attention, and there is a widespread interest in the further development of a joint study like this, catering for participation from all sorts of cultures.

Plans for a more systematic follow-up study of the SAS-project have been developed under the acronym of ROSE: The Relevance Of Science Education. The target population will be 15-16 year old pupils, i.e. towards the end of the compulsory school in many countries, and before streaming usually takes place. (A description is given at http://folk.uio.no/sveinsj/) Researchers and research institution in more that 30 countries have expressed their interest in participating in this project. The Research Council of Norway will fund this project for a period of three years, and other funding sources are now approached. An international workshop with participants from all continents took place in Oslo in October 2001. Here the research hypotheses were discussed, the research instruments were refined and the logistics was developed. Data collection will start in 2002, and researchers with an interest in the project should contact this author.

References

Atkin J.M. & Black P.(1997) Policy Perils of International Comparisons. *Phi Delta Kappan* (September 1997), 22-28

Cobern, W. W., & Aikenhead, G. (1998) Culture and the learning of science. In B. Fraser, & K. G. Tobin (eds), *The international handbook on science education.* Dordrecht: Kluwer Academic Publishers.

OECD (2001) *Knowledge and skills for Life – First results from PISA 2000*, Paris, OECD (Reports are available at http://www.pisa.oecd.org/)

Ogawa, M. (1995). Science education in a multi-science perspective *Science Education* vol 79, 583-593

Sjøberg, S. (2000a) *Science And Scientists: The SAS-study Cross-cultural evidence and perspectives on pupils' interests, experiences and perceptions-- Background, Development and Selected Results* -- Acta Didactica no 1. University of Oslo. (Available at http://folk.uio.no/sveinsj/)

Sjøberg, S. (2000b) Interesting all children in the 'science for all' curriculum –in Millar, R.; Leach, J.; Osborne, J. (ed.): *Improving Science Education -- the contribution of research,* Buckingham, Open University Press

Sjøberg, S and Imsen, G. (1987): Gender and Science Education in Fensham (ed.): *Development and Dilemmas in Science Education*, London, The Falmer Press

TIMSS (1998) *Mathematics and Science Achievement in the Final year of Secondary School* TIMSS International Study Center, Boston College, MA, USA

Whyte, J. Kelly, A. and Smail, B. (1987) *Girls into Science and technology: Final report in Science for Girls*, Milton Keynes, Open University Press

UNDP (2001) *Human Development Report 2001* New York and London, Oxford University Press (Available at http://www.undp.org/)

Keywords: science curriculum, children's' experiences, interests, priorities, international comparisons