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Science for all or science for some: What Swedish students want to learn about in secondary science and technology and their opinions on science lessons

Abstract

This article presents Swedish results from 'the Relevance of Science Education' (ROSE) study, which is a large world wide comparative research project based at the University of Oslo. The Swedish sample consisted of 751 students, most of whom were 15 years old, from 29 schools and data were collected in spring 2003. Student opinions about science lessons are presented in relation to enrolment intentions for upper secondary school together with what they want to learn about in science and technology. The findings indicate that secondary science instruction seems to address only a minority of the students, those that have chosen science or technology in their further education. At the same time, all students have interest in science and technology and many seem most interested in some important issues in societal development. The results are discussed from the perspective of learners and contribute to the debate about establishing a scientific literacy approach in compulsory education.

Introduction

During the 1990s, research into the attitudes of students to science was not pursued to the same extent as in earlier decades, especially the 1970s and 1980s. Nevertheless, teachers remain interested in such investigations because the affective response of students to what is presented has a great influence on the success of instruction. In research concerned with these questions, key terms are student attitudes and interests. These are not easy to define because the terms overlap, they are difficult to measure and there is in addition a temporal aspect to consider. Perhaps these are the main reasons why researchers increasingly have avoided grappling with this area (Ramsden, 1998). In recent years, however, research in the field has once again appeared, not least because of discussions on the purpose of school science.

Science content in schools has been debated for a long time and there are many different opinions about how to choose and treat it (Duschl, 2000; Fensham, 1988, 2000). In recent decades, there has been much discussion about scientific literacy concerning the aims, definition and practice of school science (Bybee, 1997). DeBoer (2000) emphasizes that teachers must always adapt to prevailing conditions and therefore science education requires a broad conceptualization of goals. Society needs experts in science and technology as well as a population with a good general level of education which means that some students will go on to work in the world of science and technology while others will deal with science based social issues. At present, in many countries fewer young people choose science as a career and many express negative attitudes to school science. The most important factors influencing these attitudes include gender and the quality of teaching (Osborne, Simon & Collins, 2003). Millar (2006) gives an account of the tension between 'pre-professional training for some' and 'scientific literacy for all' and relates how school science can provide scientific literacy in practice. He analyzes what this tension means for the selection of content and teaching skills keeping in mind that people are consumers of scientific knowledge rather than producers. He suggests that we take advantage of young people's interest in science and technology and deal with it in the compulsory school system in a fashion more attuned to everyday experience of the subjects, for example through media, thereby creating the prerequisites for good citizenship.

Gardner (1975) reviewed and elucidated what is meant by student attitudes towards science. He emphasized the need for taking into deeper consideration children's experience of joy, wonder, satisfaction and delights in school science and distinguished between attitude towards science and scientific attitude. The former refers to interest in content, the attitude toward scientists and social responsibility and the latter refers to open-mindedness, honesty and critical thinking. Gardner demonstrated several different methods of collecting and analyzing data about students' attitudes towards science and the need to consider several variables, such as urban vs. rural children, socio-economic status, childhood experiences, parental interest, school variables, curriculum, instructional variables and gender. The review brought to light gender differences as the most important variable, noting that boys are more informed about physical sciences and girls are more familiar with biology and health.

Since the1970s, a lot of research has taken place using these variables. Studies have confirmed strong gender differences with girls being more negative towards school science (Greenfield, 1997; Kelly, 1986; Mattern & Schau, 2002; Murphy & Beggs, 2003; Reid & Skryabina, 2003). Jones, Howe and Rua (2000) showed that gender variation depends however on the school science content. Several studies have found that interest varies over time and that interest decreases with increasing age (George, 2000; Greenfield, 1997; Murphy & Beggs, 2003; Spall, Stanisstreet, Dickson & Boyes, 2004). When young people are asked what they are interested in, physical science often comes at the bottom of the list (Angell, Guttersrud, Henriksen & Isnes, 2004; Spall et al., 2004) and topics concerning different aspects of biology come out on top and vary with age (Baram-Tsabari & Yarden, 2005). Lindahl (2003) showed that in Sweden student interest in physics and chemistry is low and decreases during the last years of compulsory school. She concluded that this has little to do with age, as interest in other subjects is higher and increases. She also found that it has little to do with gender, since both girls and boys put these subjects at the bottom of their ranking lists. Schreiner (2006) described five student types as signs of late modern identities with distinct orientations towards science. She used ROSE data from around the world and detected a cross-national pattern in relation to modernization. The more modernized a country is, the stronger the gender differences become and this has consequences for the subject matter young people want to learn about.

Francis and Greer (1999) showed the affective domain to be a complicated multi-dimensional field of research and put forward variables that are operationally feasible. Attitudes towards science have been measured in so many ways that results are sometimes difficult to compare (Mattern & Schau, 2002). Dawson (2000) indicated that school science has not changed much with regard to content yet student interest has changed. Student experiences of school science (Osborne & Collins, 2001), reviewed by Lyons (2006), disclose transmissive pedagogy, decontextualized content and unnecessary difficulty as core issues in several countries, with consequences for enrolment in advanced science programmes and for a science-for-all perspective.

> *"With so many education authorities around the world now recognizing that short term "band-aid" approaches have done little to address the growing disenchantment of students with traditional school science, these authorities may now be more willing than in the past to embrace approaches and curricula that engage and nurture the interests of today's young people.'"*
>
> (Lyons, 2006, p. 608)

Similar findings are presented by George (2006) who found that science self-concept is the most important predictor of attitudes towards science and that attitudes towards the utility of science are of critical importance, since they are associated with attitudes towards science, especially over the middle and high school years.

Student alienation from school science leads to a concern about recruitment and about establishing a general education in which science and technology constitute essential parts. Research into student opinions about science lessons, enrolment intentions and what they want to learn about in science and technology delivers messages for different stakeholders (Jenkins & Nelson, 2005; Ramsden, 1998). In a research project called 'Science and Scientists' (SAS) Sjøberg (2000) pointed out that children in different parts of the world have dissimilar experiences when they meet school science. The data presented in this paper deals with what Swedish students say they want to learn in science and technology and their opinions regarding these fields of knowledge. The data are part of a large worldwide research project, 'the Relevance of Science Education' (ROSE) study, which is a development of the SAS-study under the direction of Professor Svein Sjøberg at the University of Oslo. Full details about ROSE, including background, rationale, underlying ideas, data collection and methodological issues can be found in Schreiner and Sjøberg (2004). Both the SAS- and ROSE-projects focus on student opinion regarding what is relevant to learn and what is experienced in different societies. Cultural and historical factors have marginalized student opinion in educational research and curriculum development. Students have for the most part been regarded as objects of study incapable of determining what they should learn. During their period of training, students are not considered to be qualified participants in fundamental decisions (Jenkins & Nelson, 2005). The purpose of this paper is to argue the value of recognising the views of students in the curriculum decision-making process and to suggest that choices being made by students with regard to further study can be identified in their interests and attitudes.

The research questions to be addressed in this paper are:

- What are Swedish secondary students' opinions of school science?
- How are the students' opinions about compulsory school science reflected in their choices for upper secondary education?
- What are the students interested to learn about in secondary science and technology?

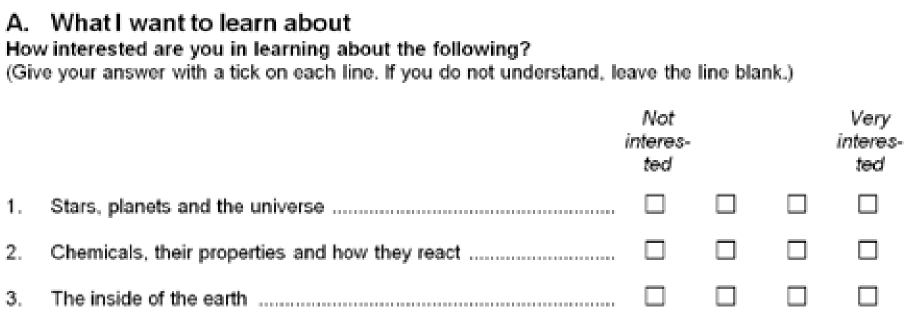
Methodology

The ROSE project's main instrument is a questionnaire, which is divided into seven different categories. In this paper results from the categories 'What I want to learn about' and 'My opinions about science and technology' are presented. In the 'What I want to learn about' category there are questions concerning astrophysics, earth science, human biology with sex and reproduction, genetics, zoology, botany, chemistry, optics, acoustics, electricity, energy, technology, 'Science, technology and society' (STS) and 'Nature of science' (NOS). The questions were put into different contexts such as spectacular phenomena, fear, technological ideas and inventions, aesthetical aspects, beauty, care, health, personal use and everyday relevance. In Sweden two more categories were added to the original ROSE questionnaire. One open response question about what occupation a student would like to have as an adult and eight items about science events in and outside school that a student might find interesting. In conclusion students were asked what study programme they had chosen for upper secondary school. This question makes it possible to analyze the data as seen from the choice of further education after compulsory schooling. In addition, it makes it possible to compare opinions towards compulsory science lessons of future science students with future non science students and of students who have chosen a more academic upper secondary programme with those who have chosen a vocational programme, making this a unique contribution to the literature from the ROSE project.

The first part of the questionnaire asked students how interested they were in learning about 108 different topics. The intention of these questions was to get evidence regarding student interest in contents and contexts. Some of the topics may seem controversial and unusual in a science context, e.g. topics regarding ghosts, horoscopes, mind reading and religion. The inclusion of these topics does *not* mean that these topics must be legitimate parts of a science curriculum. They are simply included to investigate the variety of student interests, also in unusual contexts.

The students answered on a four-grade Likert scale ranging from Not interested (value 1) to Very interested (value 4). Figure 1 is an example from the questionnaire.

The Likert-scale was chosen because it is easy to construct and easy to respond to. A student was presented with short positive statements and negations were avoided making translation easier. The questionnaire used an even number of alternatives to avoid a middle response alternative that allows students to be neutral. Respondents may choose the middle alternative for other reasons as well: they may be neutral, do not understand or do not care. With an odd number of alternatives, an ordinal bias in the middle box is probable (Oppenheim, 2000). With four alternatives, students are forced to take a stand. However, the introduction to the questionnaire reminded students that they could refrain from answering if they did not know or did not understand a question. Only the endpoints were labelled since respondents are more likely to interpret a scale as continuous if inner alternatives simply divide the scale into three intervals with equal size. When labelling middle alternatives, more adjectives are needed to separate the categories and these adjectives are not


A. What I want to learn about

How interested are you in learning about the following?

(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Not interested			Very interested
1.	Stars, planets and the universe	☐	☐	☐	☐
2.	Chemicals, their properties and how they react	☐	☐	☐	☐
3.	The inside of the earth	☐	☐	☐	☐

Figure 1. The ROSE questionnaire, see Schreiner and Sjøberg (2004) for a full version.

always easy to translate properly (Schreiner & Sjøberg, 2004). In the analysis we interpreted the scale as an interval scale and numbered the alternatives from one to four, even though it is an ordinal scale.

The translation was made from the English original as verbatim as possible without losing shades of meaning. This first Swedish version of the questionnaire was compared with the Norwegian one. Fellow researchers read the translation and compared it with the original English questionnaire after which a revised and final Swedish version was constructed.

In spring 2003 the student cohort aged 15 in Sweden (ninth and last year in the Swedish compulsory school system) comprised about 110 000 individuals distributed over 1 577 schools, information supplied from the national Swedish statistics agency 'Statistics Sweden' (http://www.scb.se). From these, 30 schools were randomly selected out of a sample with nine stratum variables, the same as in the OECD/PISA study to ensure a national sample with correct weight for each type of school. The schools themselves selected one class. The size of the classes varied from 20 to 35 students with the exception of one class with 15 students. A test officer visited each school to present information about the project, distribute the questionnaires and later collect them. Nothing problematical was reported regarding data collection from 751 students from 29 schools with 358 girls and 392 boys (1 missing) (Oscarsson & Jidesjö, 2005).

Results

Secondary students' opinions of school science

Table 1 (next page) presents sixteen different items about 'My science classes' with mean values for boys and girls with standard deviation (SD), mean differences between girls and boys and standard error differences (SED). Mean differences that are statistically significant are presented with their p-values and shown in bold.

Students find school science quite interesting (mean 2.71 in Table 1) but not when compared with other subjects (mean 1.95 in Table 1). Students believe that everyone should study school science and it is sometimes helpful in everyday life but they do not want to have as much school science as possible, as other things are more interesting. At the same time, school science does not open their eyes to new and exciting jobs. Few want to become scientists and most students do not want to seek employment in technology. Accordingly, young people are uncertain as to whether or not there are occupations associated with school science.

There are small differences between boys and girls, with some exceptions. Very few girls want employment in technology, while boys show a slightly positive attitude to such a career. Girls also see school science as more difficult, they disagree more strongly about wanting to become a scientist and they are less likely to want to have as much school science as possible.

The Swedish ROSE study added a question about choices of upper secondary school programmes. As there is an important tension between the two purposes of school science, i.e. 'pre-professional training for some' versus 'scientific literacy for all', the next step in this analysis is to look if this tension can be recognized among the learners' opinions. The students were grouped according to their choice according to the list below. About 10 % of the students chose programmes for upper secondary level that did not fall within these categories. The first two categories consist of vocational programmes and the next two represent programmes which are more preparatory for tertiary education.

1. 14% chose vocational programmes related to health, childcare, commerce or restaurants.
2. 13 % chose vocational programmes related to industry, construction or engineering.
3. 35 % chose the social science, media or art programmes.
4. 27 % chose the natural science or technology programmes.

Table 1. To what extent do students agree with the following statements about the science classes they have had at school? Means, standard deviations (SD), mean differences (girls-boys), standard error differences (SED) and p-values. Mean differences in bold face are for statements with statistically significant gender differences with p-values. 1=disagree 4=agree

	Statement	Girls mean (SD)	Boys mean (SD)	All mean (SD)	Mean difference Girl-Boy	SED	p
1.	School science is a difficult subject	2.68 (1.01)	2.34 (1.05)	2.50 (1.04)	**0.34**	0.076	<0.001
2.	School science is interesting	2.73 (1.04)	2.69 (1.10)	2.71 (1.07)	0.04	0.079	
3.	School science is rather easy for me to learn	2.53 (1.07)	2.66 (0.96)	2.60 (1.02)	-0.13	0.075	
4.	School science has opened my eyes to new and exciting jobs	2.06 (1.05)	2.08 (1.04)	2.07 (1.04)	-0.02	0.077	
5.	I like school science better than most other subjects	1.87 (1.02)	2.02 (1.09)	1.95 (1.06)	-0.15	0.078	
6.	I think everybody should learn science at school	2.90 (1.09)	2.73 (1.14)	2.81 (1.12)	0.18	0.082	
7.	The things that I learn in science at school will be helpful in my everyday life	2.75 (1.00)	2.63 (1.04)	2.69 (1.02)	0.12	0.075	
8.	I think that the science I learn at school will improve my career chances	2.51 (1.11)	2.52 (1.11)	2.52 (1.11)	-0.01	0.081	
9.	School science has made me more critical and sceptical	1.96 (0.89)	2.11 (0.98)	2.04 (0.94)	-0.15	0.069	
10.	School science has increased my curiosity about things we cannot yet explain	2.53 (1.10)	2.42 (1.10)	2.47 (1.10)	0.11	0.081	
11.	School science has increased my appreciation of nature	2.24 (0.96)	2.15 (0.98)	2.20 (0.97)	0.09	0.072	
12.	School science has shown me the importance of science for our way of living	2.16 (0.95)	2.19 (0.93)	2.18 (0.94)	-0.03	0.069	
13.	School science has taught me how to take better care of my health	2.35 (0.99)	2.26 (1.00)	2.30 (1.00)	0.09	0.073	
14.	I would like to become a scientist	1.56 (0.93)	1.79 (1.06)	1.68 (1.00)	**-0.23**	0.073	0.002
15.	I would like to have as much science as possible at school	1.64 (0.90)	1.86 (1.01)	1.75 (0.96)	**-0.22**	0.071	0.002
16.	I would like to get a job in technology	1.55 (0.88)	2.63 (1.18)	2.12 (1.18)	**-1.08**	0.077	<0.001

Table 2 shows results with mean values for the different choices of upper secondary programmes.

Table 2 displays significant differences between the categories of upper secondary choices. Only future science and technology students agree with a majority of the statements about their science classes in compulsory school. There are large statistically significant differences ($p<0,001$) between future science students and future non-science students in all statements in Table 2 except statement 13 'School science has taught me how to take better care of my health'. Future vocational students and social science students have means below 2 for many statements, which is low on a four-point Likert scale. As an example, only about 5 % of future vocational students clearly agree (score 4) to statements like 'School science has opened my eyes to new and exciting jobs' and 'I like school science better than most other subjects'. It seems as enrolment intentions for upper secondary school are correlated with student opinions about science lessons in the compulsory school system. The next step in this analysis is to find out what content are of interest to *all* students.

Table 2. To what extent do students agree with the following statements about the science classes they have had at school? Mean values for categories created from students' choices of upper secondary programs. 1=disagree 4=agree

	Statement	Vocational programs (health, childcare…)	Vocational programs (industry, construction or engineering)	Social science, media or art.	Science or technology
1.	School science is a difficult subject	2.89	2.45	2.69	1.99
2.	School science is interesting	2.60	2.47	2.49	3.32
3.	School science is rather easy for me to learn	2.18	2.36	2.44	3.27
4.	School science has opened my eyes to new and exciting jobs	1.70	1.70	1.80	2.90
5.	I like school science better than most other subjects	1.55	1.72	1.64	2.76
6.	I think everybody should learn science at school	2.51	2.39	2.81	3.33
7.	The things that I learn in science at school will be helpful in my everyday life	2.42	2.34	2.66	3.12
8.	I think that the science I learn at school will improve my career chances	2.05	2.01	2.32	3.38
9.	School science has made me more critical and sceptical	1.74	1.85	2.07	2.33
10.	School science has increased my curiosity about things we cannot yet explain	2.25	2.18	2.52	2.89
11.	School science has increased my appreciation of nature	1.97	2.06	2.27	2.34
12.	School science has shown me the importance of science for our way of living	1.95	1.99	2.24	2.47
13.	School science has taught me how to take better care of my health	2.37	2.05	2.33	2.41
14.	I would like to become a scientist	1.29	1.34	1.46	2.43
15.	I would like to have as much science as possible at school	1.46	1.44	1.55	2.45
16.	I would like to get a job in technology	1.46	2.54	1.63	2.83

What students want to learn

The 20 most popular of 108 different topics regarding what students want to learn are presented in Table 3 with mean values for girls and boys, mean differences, standard error differences and p-values.

Table 3. What students want to learn about. The 20 most popular topics out of 108 ranked according to mean in a falling order. Means with standard deviations (SD), girls' means, boys' means, mean differences (girls-boys), standard error differences (SED) and p-values. Mean differences in bold face are statements with statistically significant gender differences with p-values. 1=Not Interested 4=Very Interested

	Statement	Mean (SD)	Girls mean	Boys mean	Girls mean - Boys mean	SED	p
1.	How to exercise to keep the body fit and strong	3.03 (0.96)	3.21	2.87	**0.34**	0.069	< 0.001
2.	How it feels to be weightless in space	3.00 (1.02)	2.90	3.10	**-0.20**	0.075	0.008
3.	The possibility of life outside earth	2.93 (1.05)	2.96	2.91	0.06	0.072	
4.	Why we dream while we are sleeping, and what the dreams may mean	2.93 (1.06)	3.35	2.55	**0.81**	0.077	< 0.001
5.	How different narcotics might affect the body	2.84 (1.00)	3.14	2.56	**0.58**	0.070	< 0.001
6.	How alcohol and tobacco might affect the body	2.83 (0.98)	3.12	2.57	**0.55**	0.069	< 0.001
7.	What to eat to keep healthy and fit	2.81 (1.02)	3.13	2.52	**0.60**	0.072	< 0.001
8.	What we know about HIV/AIDS and how to control it	2.80 (1.01)	3.20	2.44	**0.76**	0.069	< 0.001
9.	How to perform first-aid and use basic medical equipment	2.79 (1.00)	3.12	2.50	**0.62**	0.070	< 0.001
10.	Phenomena that scientists still cannot explain	2.77 (1.12)	2.71	2.84	-0.13	0.082	
11.	Thought transference, mind-reading, sixth sense, intuition, etc...	2.77 (1.11)	3.10	2.47	**0.63**	0.079	< 0.001
12.	Sexually transmitted diseases and how to be protected against them.	2.77 (0.97)	3.11	2.45	**0.66**	0.067	< 0.001
13.	Cancer, what we know and how we can treat it	2.74 (1.03)	3.11	2.39	**0.72**	0.071	< 0.001
14.	How meteors, comets or asteroids may cause disasters on earth	2.71 (1.04)	2.61	2.81	**-0.20**	0.076	0.009
15.	How my body grows and matures	2.69 (1.00)	2.95	2.46	**0.49**	0.072	< 0.001
16.	How computers work	2.69 (1.03)	2.38	2.98	**-0.61**	0.071	< 0.001
17.	Sex and reproduction	2.68 (0.94)	2.85	2.53	**0.32**	0.068	< 0.001
18.	Black holes, supernovas and other spectacular objects in outer space	2.67 (1.11)	2.57	2.76	**-0.20**	0.081	0.016
19.	How to protect endangered species of animals	2.65 (1.02)	2.91	2.42	**0.49**	0.073	< 0.001
20.	Unsolved mysteries in outer space	2.65 (1.12)	2.66	2.63	0.03	0.083	

Table 4. What students do not want to learn. The 20 least popular topics out of 108 ranked according to mean in a falling order. Means with standard deviations (SD), girls' means, boys' means, mean differences (girls-boys), standard error differences (SED) and p-values. Mean differences in bold face are statements with statistically significant gender differences with p-values.
1=Not Interested 4=Very Interested

Statement		Mean (SD)	Girls mean	Boys mean	Girls mean-Boys mean	SED	p
89.	How the sunset colours the sky	2.08 (0.97)	2.31	1.87	**0.44**	0.069	<0.001
90.	How different musical instruments produce different sounds	2.08 (0.98)	2.06	2.09	-0.03	0.072	
91.	The ability of lotions and creams to keep the skin young	2.05 (1.03)	2.54	1.60	**0.94**	0.068	<0.001
92.	Why religion and science sometimes are in conflict	2.05 (1.02)	2.22	1.88	**0.34**	0.074	<0.001
93.	How different sorts of food are produced, conserved and stored	2.02 (0.88)	2.02	2.03	-0.01	0.065	
94.	How to improve the harvest in gardens and farms	2.02 (0.93)	1.99	2.04	-0.06	0.068	
95.	Optical instruments and how they work (telescopes, cameras, microscopes, etc.)	2.01 (0.90)	1.88	2.11	**-0.23**	0.066	<0.001
96.	Atoms and molecules	1.99 (1.02)	1.84	2.13	**-0.29**	0.074	<0.001
97.	Organic and ecological farming without use of pesticides and artificial fertilizers	1.99 (1.00)	2.07	1.91	**0.16**	0.074	0.026
98.	How scientific ideas sometimes challenge religion, authority and tradition	1.94 (0.98)	1.96	1.91	0.05	0.072	
99.	How mountains, rivers and oceans develop and change	1.93 (0.84)	1.96	1.90	0.06	0.061	
100.	How technology helps us to handle waste, garbage and sewage	1.90 (0.87)	1.81	1.98	**-0.17**	0.064	0.008
101.	Why scientists sometimes disagree	1.87 (0.90)	1.88	1.86	0.02	0.066	
102.	Benefits and possible hazards of modern methods of farming	1.87 (0.89)	1.83	1.90	-0.07	0.066	
103.	Plants in my area	1.84 (0.85)	1.92	1.75	**0.17**	0.062	0.006
104.	Detergents, soaps and how they work	1.81 (0.82)	1.94	1.69	**0.25**	0.059	<0.001
105.	How plants grow and reproduce	1.79 (0.83)	1.84	1.75	0.08	0.061	0.171
106.	Famous scientists and their lives	1.66 (0.84)	1.59	1.72	**-0.13**	0.062	0.032
107.	How crude oil is converted to other materials like plastics and textiles	1.58 (0.77)	1.47	1.68	**-0.20**	0.056	<0.001
108.	Symmetries and patterns in leaves and flowers	1.40 (0.68)	1.53	1.28	**0.25**	0.049	<0.001

Table 5. What girls and boys want to learn about ranked according to means in a falling order. Mean values and mean differences. Common items in italic.
1=Not Interested   4=Very Interested

	What girls want to learn	Girls mean	Girls-Boys mean	What boys want to learn	Boys mean	Girls-Boys mean
1.	Why we dream while we are sleeping, and what the dreams may mean	3.35	0.81	*How it feels to be weightless in space*	3.10	-0.20
2.	*How to exercise to keep the body fit and strong*	3.21	0.34	How the atom bomb functions	3.03	-0.91
3.	What we know about HIV/AIDS and how to control it	3.20	0.76	Explosive chemicals	3.01	-0.98
4.	How different narcotics might affect the body	3.14	0.58	How computers work	2.98	-0.61
5.	What to eat to keep healthy and fit	3.13	0.60	*The possibility of life outside earth*	2.91	0.06
6.	How alcohol and tobacco might affect the body	3.12	0.55	Biological and chemical weapons and what they do to the human body	2.88	-0.64
7.	How to perform first-aid and use basic medical equipment	3.12	0.62	*How to exercise to keep the body fit and strong*	2.87	0.34
8.	Sexually transmitted diseases and how to be protected against them	3.11	0.66	Phenomena that scientists still cannot explain	2.84	-0.13
9.	Cancer, what we know and how we can treat it	3.11	0.72	How meteors, comets or asteroids may cause disasters on earth	2.81	-0.20
10.	Thought transference, mind-reading, sixth sense, intuition, etc...	3.10	0.63	Black holes, supernovas and other spectacular objects in outer space	2.76	-0.20
11.	Eating disorders like anorexia or bulimia	3.09	1.38	How cassette tapes, CDs and DVDs store and play sound and music	2.76	-0.52
12.	Biological and human aspects of abortion	3.02	1.13	The effect of strong electric shocks and lightning on the human body	2.74	-0.48
13.	*The possibility of life outside earth*	2.96	0.06	Rockets, satellites and space travel	2.74	-0.61
14.	How my body grows and matures	2.95	0.49	Brutal, dangerous and threatening animals	2.70	-0.20
15.	Life and death and the human soul	2.94	0.67	How things like radios and televisions work	2.67	-0.42
16.	How to protect endangered species of animals	2.91	0.49	The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	2.67	-0.74
17.	Birth control and contraception	2.91	0.69	Very recent inventions and discoveries in science and technology	2.67	-0.52
18.	*How it feels to be weightless in space*	2.90	-0.20	How mobile phones can send and receive messages	2.66	-0.20
19.	Epidemics and diseases causing large losses of life	2.88	0.62	Unsolved mysteries in outer space	2.63	0.03
20.	How to control epidemics and diseases	2.88	0.56	How petrol and diesel engines work	2.61	-0.96

The most popular topics are a student's own body, health and diseases. Space and phenomena we cannot explain are also popular, and these topics show the smallest gender differences. Students want to learn more about what to eat and how to exercise to keep the body healthy and fit. There is also a relatively large interest in alcohol, narcotics and tobacco and how they affect the body as well as with why we dream when we sleep and what dreams mean. The items concerning health are important questions both in research and for society in general. HIV/AIDS, cancer, how to perform first aid and use basic medical equipment, sex and reproduction and how to protect oneself from sexually transmitted diseases are also contexts of health with a strong connection to societal matters. Space is another interesting context for young people today and several items about this are among the 20 most popular things students want to learn about. One topic is how to protect endangered animal species. This context deals with biological diversity and is the stage for important discussions in science today. How computers work is also put forward; computers of course have a great impact on our way of living.

The 20 least popular topics are presented in Table 4 with mean values for girls and boys, mean differences, standard error differences and p-values.

The least interesting topics include how different musical instruments produce sounds; the ability of lotions and creams to keep skin young; how different foods are produced, conserved and stored; how to improve garden and farm harvests; optical instruments and how they work; organic and ecological farming; plants in my area and how they grow and reproduce; detergents, soaps and how they work; and how crude oil is converted to other materials. These are ten topics one could call everyday life contexts and young people dislike them the most. One may have expected that for example lotions and creams would come out on top because it is connected to the body and many people use it every day. This is not the case. The most popular topics include modern diseases, what to eat and how to exercise to keep the body fit, not how food is produced, conserved and stored. In addition, atoms and molecules are at the bottom list. The idea of particles causing phenomena in the world is a fundamental aspect of science but the students seem to dislike it the most.

Gender differences

Table 5 shows gender differences in science topics with the 20 most popular items for boys and girls, presented with mean values and mean differences.

A closer look at girls' and boys' most popular topics reveals that there are both common interests and divergences (Table 5). The overall mean for girls is 2.41 and for boys 2.31. Some unusual contexts in science education are found among the girls e.g. 'life and death and the human soul' together with 'thought transference and mind reading'. How to exercise to keep the body fit and strong as well as space are popular topics for both sexes. Girls are oriented towards health issues and the body, why we dream, diseases, drugs, abortion, eating disorders, and occultism. Boys are oriented towards space, bombs, explosive chemicals, weapons and new technology.

Science students versus non-science students

As there are significant differences between future science students and future non-science students concerning their opinions about their science lessons, it is interesting to see if those differences persist when it comes to where their interest lie. When looking at all the 108 items in this part of the ROSE questionnaire, students who have chosen science or technology programmes for upper secondary school have an overall mean of 2.53 compared with all the other students' overall mean of 2.36 which is a significant difference ($t=5.67$, $p<0.001$). Nevertheless, future science students have the same favourite topics as other students.

Discussion

Secondary students' opinions of school science

Students finishing compulsory school have an interest in science and technology and want to learn more about them, but there is considerable variation. When students were asked about school science lessons, the opinions of boys and girls were largely the same. School science is not interesting when compared with other school subjects (Table 1). A study by Lyons (2006) indicated transmissive pedagogy, perceived difficulty and decontextualized science content as principal problems facing school science. In other words, if young people are to be shown what labour markets connected to science and technology can offer, then out-of-school experiences could be an important aspect to consider when contextualizing science content in late compulsory school. These results are similar to those found in England by Jenkins and Nelson (2005). They summarized their results as 'important but not for me'. If the connection to employment is not clear, it might be possible to help students see what can be in it for them by discussing for example the use of knowledge for social progress. It does not mean that everyone should study science and technology. Discussing what science means for welfare and life style is an important part of scientific literacy (Millar, 2006) and also part of the Swedish science curriculum (the National Swedish Agency for Education, 2000). A limitation in our study is that the ROSE findings are based on the perceptions of students, which are only one consideration of the curriculum. We do not know about their teachers' opinions or other stakeholders' views on these matters. Lindahl (2003) made direct observations, interviewed Swedish students and analyzed how they perceived their science lessons and what influenced their choice for upper secondary school and her work is part of the review carried out by Lyons (2006). Our study thus corroborates studies in different countries, using different methodologies but pointing to similar problems with school science.

There is a message from many students that they do not think school science has made them more critical and sceptical, it has not increased their curiosity about things we cannot explain, it has not increased their appreciation of nature or the importance of science for our way of life nor has it helped them understand how to better take care of their health. Science instruction could play a very important role in all these areas and Millar (2006) emphasizes several of these aspects as fundamental parts of scientific literacy in practice. He argues it is not only a question of knowing some content, just as important is having ideas about science, e.g. awareness regarding data and their limitations, how knowledge is produced within scientific communities and the ability to make informed decisions while staying awake to possible undesired consequences. Millar argues, like others, that science and technology are important in the education of citizens. The ROSE data reported here indicate that many implications from the part played by science in our way of living are not clear to learners. An appreciation of nature and an understanding of the way resources are used in developing more sustainable methods of exploitation have direct implications for our way of life, our health and are key issues for many researchers today. Contemporary issues facing society are important, yet students do not seem to perceive the relevance of science and technology to these issues. More research is needed into what this means in the shaping of relevant learning environments.

"Pre-professional training for some' or 'scientific literacy for all"

When sorting the data according to choices students made for upper secondary level, a new picture emerges. Only those who chose science or technology programmes show a positive overall attitude towards compulsory school science, while those headed towards vocational programmes, social sciences, art or the humanities seem to be negative. Science instruction in late compulsory level seems to be oriented only to students with an interest in advanced science studies. Science instruction seems to have taken place in a perspective of 'learning for science' instead of 'learning from science' (Fensham, 1988, 2000), which has consequences for establishing a scientifically literate population. This means that there are indications that most students perceive science instruction in late compulsory level as 'pre-professional training for some' instead of 'scientific literacy for all'.

Millar (2006) discusses the need for new curriculum content when establishing a compulsory core science course. This is because the school science curriculum does not include many of the things people have to manage today. He points to health and environmental issues as important examples with epidemiology and clinical sciences as essential knowledge fields in this regard. In the Swedish curriculum the point of including science and technology in compulsory schooling is to prepare all people for citizenship, not to train a few for further studies. The important finding in the present study is that there are significant differences between the opinions of future science students about school science and the opinions of *all other students*.

With this in mind, what then are all students interested in learning about in science and technology? To ask the students what they want to learn about does not mean that they alone are in a position of deciding. The point is to put forward their perspectives as an important voice and regard them as qualified participants in fundamental decisions (Jenkins & Nelson, 2005) and not only as receivers of instruction. Another reason for asking students is that today most people are consumers, rather than producers, of scientific knowledge. Science and technology are part of compulsory education as a prerequisite for citizenship. Societal development is changing the experiences that young people go through and this has consequences for what they find important to learn. Thus in order to develop further, school science should recognize these changing circumstances and consider what it is that *all* students want to learn about.

What students want to learn

Baram-Tsabari and Yarden (2005) analyzed spontaneous questions asked by children after watching a television programme in Israel and found that their interest in science and technology concerned biology with a focus on health issues; the human body; nutrition; technology with a focus on computers; the Internet; modern artefacts; astrophysics with a focus on the Big Bang; spacecraft; and the possibility of extraterrestrial life. In brief, this is perfectly in line with the ROSE data reported here. Lindahl (2003) drew similar conclusions from a qualitative approach, as did Osborne and Collins (2001). In spite of the fact that the studies use different methodologies, are carried out in different countries with different school systems and the samples vary somewhat in age, our results point in a similar direction, i.e. students' interest of societal challenges of present importance. In many of these contemporary challenges, science and technology constitute essential parts. Keeping healthy, life on Earth and the universe are three examples that young people find interesting. In the Swedish curriculum there are learning objectives in this direction (the National Swedish Agency for Education, 2000). These topics can also be found among the 'core science modules' in Millar's (2006) science for citizenship course. In the latest review of students' attitudes towards science carried out by Osborne, Simon and Collins (2003) the importance of a 'science in society' perspective in school science is emphasized. Their detailed analysis indicates that school science offers mostly a backward looking view on well established scientific knowledge while students' interests are concerned with what is of immediate importance and the future. Hence, if school science is estranged from socio-scientific issues, it will have serious consequences for the learners' perceived relevance. With the ROSE data, it is possible to look at some of the socio-scientific issues students put forward but by this, we have not said that these issues are the only important ones. More studies are needed that pay attention to teachers selection and treatment of content, the role of media and other stakeholders' involvement with science content and the consequences of this when young people encounter school science.

There is a topic in the questionnaire related to telepathy, mind reading, sixth sense and intuition. One might call this context 'unscientific'. Nevertheless, these matters are discussed in society today and many people claim that they may be used to solve crimes and cure diseases. These beliefs challenge a trust in science and technology as fundamental for welfare and social order. In this connection, it is important to understand what the points are with a scientific world picture. There is no point in making any firm inferences, there is only one statement going in this direction, but when looking at what the girls point at (Table 5) it comes up again as 'life and death and the human soul'. Maybe the interest in those items is in line with the others, i.e. students want to learn more about all the things that are important for our way of life, i.e. socio-scientific issues. Students claim that school science has not increased their curiosity for things we cannot explain. When they are asked what they want to learn about, 'phenomena that scientists cannot explain' comes up among the 20 most popular (see Table 3). Does this mean that there needs to be a context of adventure with authentic challenges if students are to participate? Looking at results from the other studies mentioned in this paper, together with the ROSE results, this is a plausible identification of aspects that is engaging for students in the end of compulsory school. Students in secondary education pay much attention to the human dimensions of science and technology from a global and international standpoint, results also found and discussed by Baram-Tsabari and Yarden (2005).

What students do not want to learn about is also interesting. One way to understand these results is that students have learnt enough about these items and are satisfied with their knowledge about them. On the other hand, if these things were taught in school science, would it not be expected that students would like to learn more about them? We become aware that it is not possible to put these results in a cause - effect relationship. Maybe, it could be that the students' interests are mainly influenced from other variables than those in school. What about parental aspirations, media effects, family socio-economic background, student academic ability or self-efficacy? Another way of interpreting the results is that they are effects from pedagogies used in the schools where ROSE data was collected. In Sweden the school mission is formulated in terms of objectives and capabilities and teachers are free when it comes to the type of teaching and content arrangement (the National Swedish Agency for Education, 2000). Nevertheless, the consistency in the national data set rather implies that there are underlying cultural effects. Furthermore, in the international ROSE data set (Schreiner, 2006) the consistencies among students in the western world also make it probable that there are important cultural elements influencing what students find relevant. Osborne, Simon and Collins (2003) point out that it is not curriculum variables that determine student attitudes towards school science, it is teacher variables and the need for more research investigating those circumstances.

Many students dislike a context like beauty: 'how sunset colours the sky', technology contexts like: 'benefits and possible hazards of modern methods of farming' and 'how technology helps us handle waste, garbage and sewage'. Moreover, students are not really interested in why religion and science sometimes are in conflict, how scientific ideas sometimes challenge religion, authority and tradition, why scientists sometimes disagree and famous scientists and their lives. These constitute topics dealing with scientific practice and its relation to society. The history of science contains fascinating stories that lead to many insights and a better understanding of modern phenomena. 'Things that scientists still cannot explain' is among the most popular topics and 'why scientists sometimes disagree' is among the least popular topics. It is not easy to understand what this is all about. Maybe the message is again that students want to learn about today's content, not about people in the past. Students are more inclined to show interest in tomorrow's science than in yesterday's findings. Today many different actors are involved in presenting science and technology, e.g. science centres, computer games, Internet, television and magazines. These interest groups treat content in a way that encourages people to visit exhibitions, look at programmes or read papers and magazines. These circumstances mean that the ways in which school science presents its topics sometimes are challenged by other stakeholders. The consequences of this for student experiences and for the public function of school science instruction needs to be considered, as discussed by Jenkins and Nelson (2005) and Osborne and Collins (2001). This is one way to further investigate cultural conditions that may have importance for understanding young people's manifestation of will, in this case what they want to learn or not want to learn about.

One final thing to discuss has to do with the gender differences in Tables 3, 4 and 5. Schreiner (2006) tried to interpret ROSE data from other approaches than gender but concluded that student interest in science is gender-specific. In the Swedish data, girls are more positive towards what they want to learn and more negative towards what they do not want to learn. To generalize, girls are oriented towards the human body, health, space and occultism and boys are oriented towards space, technology and weapons. Where girls in secondary education want to learn how to protect endangered animal species, boys want to learn about brutal, dangerous and threatening animals. Of course, there are pitfalls in generalizing; a boy can have a girl's profile and vice versa. Nevertheless, there are significant differences, which are worthy of attention.

Conclusions

One important finding in this paper is that compulsory school science in Sweden caters for the interests of only a minority of students, i.e. those who decide to study science or technology in upper secondary school. This has consequences for education of the general population as scientifically literate citizens. This is not in line with the Swedish curriculum where science and technology is part of preparation for citizenship. There is a need for additional studies to search for cause-effect relations.

Another finding is that secondary student perspectives seem to be in line with modern global challenges facing humanity but there are important differences between boys and girls. The concepts of 'attitudes towards science' or 'towards different school subjects' are too broad. Research needs to be more specific and relate to the specific content being discussed because students show an interest in content, not in subjects. For example, some contents related to biology and physics are among the top 20 that students want to learn about, other contents related to those subjects are not deemed interesting. Maybe we can learn something from the learners and carry out research on what societal development might mean for school science instruction, i.e. to understand student interest as a function of their prior experiences. Adopting this approach involves making the learner's perspectives on content a central rather than marginal issue.

Science and technology are relevant parts of compulsory education since they are important for our way of living. If compulsory schools fail to establish an agenda where thinking and doing science is fun, where science involves participation, the result will be alienation and a feeling of being an outsider. In the absence of knowledge, mysticism grows. Democracies enlighten their citizens in important cultural values and the educational system is part of this. To treat science and technology content in contexts that contribute to important cultural values for different groups is of great importance and needs to be better understood. The voices of learners are a clear and distinct proof of this.

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