Student experience and interest in science: Connections and implication for further education

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Student experience and interest in science: Connections and relations with further education

Abstract

Students' problems with learning science in school are well documented. Earlier studies report on differences in students' interest in and attitudes towards science due to gender and age. However, fewer studies have focused on relations with experience and recruitment on a detailed content level. Present paper presents a statistical analysis of student interest in specific content areas and combines this with student experience of science and science-related activities outside school. The result shows that patterns of interest and experience can be identified. These patterns showed differences in gender and also relate to student preferences of upper secondary education. The results are presented on both a detailed content and an experience level. The results are discussed in relation to the purpose of compulsory science education. The study contributes to the discussion about a more relevant science education by presenting concrete content and experience dimensions from a student perspective.

Keywords: Students' interest, experience, science, gender, PCA, cluster analysis

Introduction

Students' interest in science has long been a topic for discussion. Gardner (1975) summarized the research done in the earlier decades of the 20th century and called for more attention to be paid to gender differences. A number of studies have been conducted since. Today there is a broader discussion around the world concerning the purpose and aim of science education. It has been shown that when science is taught many students experience difficulties relating to the topics presented (Lindahl, 2003; Lyons, 2006; Jenkins and Nelson, 2005). Millar (2006) argue that science education needs to fulfil two missions: educating students to take part in cultural movements while at the same time preparing some for future studies. Societies need experts within the fields of science in combination with an informed population. One of the obstacles in developing a science education from this standpoint is the lack of consistency in describing the content of science (Duschl, 2000; Fensham, 1988, 2000; Millar, 2006). Dawson (2000) argues that the science content taught in school has not changed significantly over time, while the interest of the students has. The study in this paper relate to this discussion by presenting detailed components of student's interest in science shown in relation with student's experiences.

In a review of students' attitudes towards science, Osborne, Simon & Collins (2003) state that the interest and experience are important dimensions to elaborate in order to make school science more engaging for young people and to make more students to study science. In this connection Vetleseter Bøe (2011) point out that there are important differences between girls and boys to consider, but within science education there are few studies concerned with the student perspective (den Brok, Fischer and Scott, 2005; Francis & Greer, 1999; Jenkins, 2006). In addition, studies are full of subtle shades of difference and uses various methodologies, making comparisons difficult (Mattern and Schau, 2002). One critical aspect to consider is the fact that students are different and for this reason more detailed studies are pertinent (Donnelly, 2004; Jenkins, 2006). Thus, Jenkins (2006) as well as Jidesjö *et al.* (2009) argue that students are more specific in their relation to certain content than is indicated by broad categories like 'science' or school subjects. In other words, there are sub-fields within the subject level that should be taken into consideration. Such patterns of interest and experience are analysed and presented in this paper.

Schreiner (2006) used sociological theories of identity construction to investigate why an individual shows interest in a particular area of science. She identified five different types and showed how students in each of these types relate to science content depending on who they are and who they want to be. Schreiner (2006), Dawson (2000) and Jenkins (2006) all point to societal development as affecting people's experiences of science, which in turn affects their expressed interest in certain content. It has also been shown that when female students are given a chance to put school science in relation with working life and societal relevance it improves their understanding and desire to learn (Jidesjö, Danielsson & Björn, 2014).

Relating science to stories from people's lives and their ways of experiencing content outside school are important for learning, especially for females (Chinn, 2009). Pugh and Girod (2007) describe a model in which the student's experience of science is understood as deeply rooted in their daily lives. This has been shown to be important for learning science already at an early age (Jakobson & Wickman, 2008; Milne, 2010). Already in nursery school activities influence a child's willingness for further engagement with science (Mantzicopoulos, Samarapungavan & Patrick, 2009; Saçkes, Cabe Trundle, Bell & O'Connell, 2011). Unfortunately, for many students their interest in science decline as they move through the educational system (Tolstrup Holmegaard, Møller Madsen & Ulriksen, 2014; Sokolowska, De Meyere, Folmer, Rovsek & Peeters, 2014). In secondary education Chang, Yeung & Hung Cheng (2009) showed connections between science in school and science in society to be important for student's learning, especially for female learners. Van Eijck & Roth (2009) showed in addition that encountering school science from an individual experience perspective later influences career choices. In this connection, Chinn (2009) argue that experiences are important to elaborate further. Smith (2005) as well as Bulnuz & Jarrett (2010) argue that student's experiences should be involved in lesson planning and teacher's selection of science content.

This study analyse students' reported experiences of science and science-related activities in relation to their reported interest in specific science content. The results are related with student's preferences for upper secondary education. The analysis is performed by statistical analyses of experiences together with an analysis of student interest. Relationships between experience and interest, gender differences and connections with students' considerations of choices in upper secondary education are presented.

Data, material and methods

The analyses were carried out using the Swedish national empirical data set from the global Relevance of Science Education (ROSE) study. The data base contains student's answers to a questionnaire and is the latest national Swedish study on student's interest in and experience towards science. For a full methodological description of ROSE see Schreiner & Sjøberg (2004). Present study uses two large data sets about students' experience and interest.

The main instrument in ROSE is a questionnaire. This questionnaire is based on short positive statements (avoiding negations) to which the students responded using a four-point Likert scale ranging from 'Not interested or Never' (value 1) to 'Very interested or Often' (value 4). The Likert scale was chosen as it is easy to construct and easy to respond to. The even number of points on the scale was chosen to avoid a middle response alternative that allows students to be neutral. With an odd number of alternatives, an ordinal bias in the middle box is probable (Oppenheim, 2000).

The questionnaire is divided into seven different categories. Present paper is based on the categories 'My out-of-school experiences' and 'What I want to learn about'. The 'My out-of-school experiences' part of the questionnaire asks about 61 different activities with relevance for science in which children might have been involved. The 'What I want to learn about' category includes108 questions about specific science content. For details on questions see Appendices A and B.

In the Swedish part of ROSE, additional questions were asked about the students' choices for upper secondary level. This enables an analysis of the data in relation to different groups of students. Students' choices made in upper secondary school were grouped into five different categories. The first consists of vocational programmes related to health, childcare, commerce and restaurants (here called 'Vocational (health…)'). The second of vocational programmes related to industry, construction and engineering, denoted 'Vocational (industry…)'. The third is related to social science, media and art programmes, here expressed as 'Social science…'. The fourth category contains the natural science and technology programmes, here called 'Science and technology'. The fifth contains all other programmes and is called 'Other'.

The sample was generated in Spring 2003 by targeting the student cohort in the ninth and final year in the Swedish compulsory school system (average age 15). A national sample of 29 schools and 751 respondents were selected from a total population of 1577 schools and 110 000 respondents. The national Swedish statistics agency selected the schools to ensure a representative national sample, using the same variables as in the OECD/PISA (2006) study. The schools were contacted and each school selected one class to participate in the study. A test officer visited each school to present the project, stating that participation was voluntary, and describing how the data would be ethically treated. The test officers distributed and collected the questionnaires.

Statistical multivariate analysis

The aim of the study was to statistically analyse the relationship between experience and interest in science. Given the large number of variables (61 and108 questions in the two sections of the questionnaire studied) it was not possible to analyse the relationships directly. Therefore, principal component analysis (PCA) with varimax rotation was used as a first step. It is a common multivariate technique for data reduction. It uses a change in coordinates to reduce a large number of variables to a few orthogonal principal components (PCs) that best describe the majority of the variation within the data set. As a rule of the thumb, only PCs with eigenvalues > 1 are of interest. Each of these components is a weighted linear combination of all input variables. The weights (called loadings) show the influence of the variables on the respective components. The variables with a high loading (> 0.5) are used to interpret the component. A score for each respondent is calculated for each component using the weighted linear combinations of variables (questions). These components are then the new variables and scores for the observations that will be further analysed (Jolliffe, 2002). PCA was conducted for the experience and interest variables separately to search for underlying patterns. It will give a first indication on how the different questions relate to each other.

An ordinary t-test was performed for each of the principal components to determine whether there were gender differences. For each component, the mean score of females was compared to the mean score of males to find significant differences how females/males have answered.

Correlation analysis was performed between the two component groups to see whether there were any significant relationships between the experience and interest components. It will show if there are interest areas related to specific experiences. The commonly used Pearson's correlation coefficient was used for this.

Finally, cluster analysis was used to group all components into clusters based on their similarity in terms of the experience and interest variables. The hierarchical Ward's minimum variance clustering algorithm (Ward 1963) was used. At each iterative step, the clustering routine joins the two most similar clusters to minimize the variance within a cluster and simultaneously maximise the variance between clusters. The results were evaluated using a dendrogram, which is a graphical presentation showing the optimal number of clusters.

Clustering was also used on the student responses to test for significant differences between the students' various choices for upper secondary education using a Chi^2 test. The test was used to see if the distribution of the clustered students followed the expected choice of schools or not.

All tests were performed at a significance level of 1%.

Results

Principal component analysis and gender differences

The principal component analysis of the 'My out-of-school experience' data set of 61 questions resulted in 12 experience principal components with eigenvalues > 1. The total variance explained by the components is 59%. The components are presented in Appendix A showing the loadings (> 0.5) of each component to aid their interpretation. Based on this, the components were named to summarise the main theme of the dominating loadings for respective component (Table 1).

To investigate whether there is a gender difference in experience, the means of males and females for each component scores are compared using t-tests (Table 1).

There are statistically significant gender differences in seven of the twelve components (Table 1). Males have significantly higher mean values for technology when it comes to 'build and construct' together with using media. This means that the males have reported a higher experience in these activities than the females. Females have significantly higher mean values for experience of technology when it is about investigating and documenting together with 'Beauty dreams and romance', farming, cooking and environmental concern. The largest significant differences are for the 'Technology (build and construct)' component and for the 'Beauty, dreams and romance' component.

Table 1. Gender differences of experience principal components. Mean difference between females and males for each principal component. A positive difference shows that the mean value of the component score was higher for females than males. Components with statistically significant differences (p < 0.01) are shown in italics. Also the p-value for respective test is presented.

Experience Principal Components	**Mean difference**	**p-value**
Technology (build and construct)	*–1.107*	<.001
Technology (investigate and document)	*.453*	.000
Use the computer	–.032	.686
Beauty, dreams and romance	*.848*	<.001
Life on a farm	*.385*	<.001
Outdoor life	–.108	.173
Media consumer	*–.245*	.002
Cooking	*.504*	<.001
Sickliness	.150	.057
Orientate	–.113	.152
Environmental concern	*.241*	.002
Science	–.165	.036

The principal component analysis of the 'What I want to learn about' data set of 108 questions resulted in 17 interest principal components with eigenvalues > 1 (Table 2). The components are presented in Appendix B together with the loadings (> 0.5). The total variance explained by these components is 65%. Once again they were interpreted and named after the dominating loadings per component (see Table 2).

Also the interest components were tested for gender differences, using a t-test to compare the mean score for female's respective males' for each of the interest components.

There are statistical significant gender differences in half of the interest components (8 out of the 17; see Table 2). A significantly higher female score is found for 'body and health', 'New Age', 'Earth science' and 'body and beauty' which indicate those to be more important for females compared to males. A significantly higher male interest was found related with the components of 'violence, war and weapon', 'everyday technology' and 'build and repair', indicating a higher interest among the males to learn such matters.

Table 2. Gender differences of interest principal components. Mean difference between females and males for each principal component reflecting students' interest in science and technology. A positive mean difference means that the mean value of the component score was significantly higher for females. Components with statistical significant (p < 0.01) differences are shown in italics. Also p-values are presented.

Interest Principal Component	Mean difference	p-value
Body and health	*.933*	<.001
Astronomy and wonder	−.171	.035
Violence, war and weapon	*−.745*	<.001
Farming and ecology	.029	.724
Everyday technology	*−.587*	<.001
New Age	*.594*	<.001
History and philosophy of science	−.004	.964
Earth science	*.234*	.004
Animals	−.056	.489
Beauty	*.236*	.004
Environmental concern	−.005	.953
Exercise	.111	.172
Music	.028	.727
Weather phenomena	−.058	.474
Use causing illness	.050	.541
Build and repair	*−.267*	.001
Body and beauty	*.341*	<.001

Correlation and cluster analysis of components

Correlation analysis was performed between the experience and interest components to see if and how they are related.

The experience components correlate significantly with interest components in 35 (out of 204) cases (see Appendix C). There are no patterns among the correlations. Most of the significant bivariate correlation coefficients are positive, indicating that a high interest is reflected also in a high experience score. Only five correlations are negative meaning that a high interest has a corresponding low experience or a high experience goes together with a low interest. The correlation coefficients are all relatively small, without any overwhelming evidence of a correlation between interest and experience.

Ward's linkage cluster analysis was used to search for underlying patterns and groups of similarities of principal components. All experience and interest components were included simultaneously. The result is plotted as a dendrogram (Figure 1). It shows how groups of components cluster step-by-step to end up in three homogenous clusters.

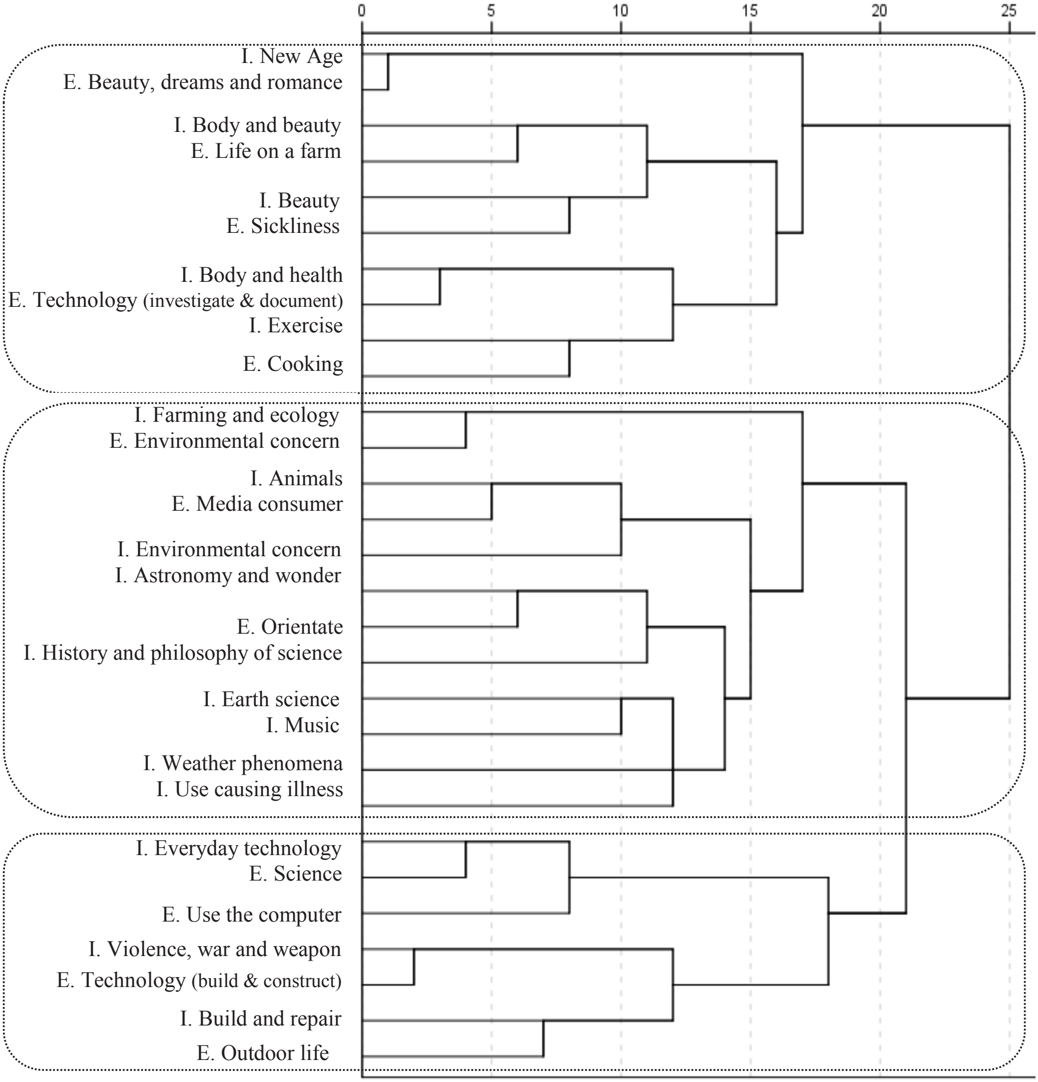

Figure 1.Dendrogram showing a cluster representation of students' experience (E) and interest (I) components of science and technology. The three major clusters are circled.

When combining the experience and interest components, three major cluster themes emerge, each including components from the two sets (Figure 1). To a large extent the first cluster is concerned with items related to the body, health and beauty. For eight of the ten components included in this cluster, the mean value of the component score was significantly higher for females, the exceptions are 'Sickliness' and 'Exercise'. The middle cluster contains items related to the environment, astronomy and media, where only a minority of the component score showed gender differences. The third cluster consists of 'Everyday technology', 'Science', 'Use the computer', 'Violence, war and weapon' and 'Outdoor life'. In four of the seven components in this cluster, the mean value of the component score was significantly higher for males (except 'Science', 'Use the computer' and 'Outdoor life').

Further upper secondary science studies

To determine whether there are significant differences in programme choice due to experience and interest components, all five programme categories were tested against each other (Table 4). Only significant ($p < 0.01$) differences are presented.

Table 3. Differences in interest and experience components of science and technology between five categories of programme choices made for upper secondary education. Results from t-test are presented with mean differences and p-values (t-test).

Experience component	Programme	Programme	Mean difference	p-value
Technology (build and construct)	Vocational (industry…)	Vocational (health…)	1.094	<0.001
		Social science…	1.078	<0.001
		Science and technology	0.799	<0.001
	Other	Vocational (health…)	0.629	<0.001
		Social science…	0.613	<0.001
Beauty, dreams and romance	Social science…	Vocational (industry…)	0.612	<0.001
		Science and technology	0.539	<0.001
Media consumer	Science and technology	Vocational (health…)	0.609	<0.001
		Vocational (industry…)	0.582	<0.001
		Social science…	0.451	<0.001
		Other	0.681	<0.001
Orientate	Science and technology	Vocational (health…)	0.751	<0.001
		Vocational (industry…)	0.579	<0.001
		Social science…	0.374	0.002
Interest component				
Body and health	Vocational (industry…)	Vocational (health…)	−0.771	<0.001
		Social science…	−0.677	<0.001
Astronomy and wonder	Science and technology	Vocational (health…)	0.529	<0.001
Violence, war and weapon	Science and technology	Vocational (health…)	0.815	<0.001
		Social science…	0.726	<0.001
		Other	0.571	0.001
Everyday technology	Vocational (industry…)	Social science…	0.437	0.010
New Age	Social science…	Vocational (industry…)	0.642	<0.001
		Science and technology	0.421	<0.001
		Other	0.530	0.002
History and philosophy of science	Science and technology	Vocational (health…)	0.451	0.007
		Vocational (industry…)	0.516	0.002
Earth science	Science and technology	Vocational (health…)	0.596	<0.001
		Vocational (industry…)	0.647	<0.001
Environmental concern	Science and technology	Vocational (health…)	0.459	0.006
Build and repair	Vocational (industry…)	Vocational (health…)	0.567	0.003
		Social science…	0.612	<0.001

The result shows that in four out of the twelve experience components and in nine out of the seventeen interest components there is a significant difference between the choices made for upper secondary education. The students who choose vocational programmes in industry, construction and engineering are not significant different from the experience component of 'Build and construct' together with the interest components of 'Everyday technology' and 'Build and repair'. Students who choose 'Science or technology' for upper secondary education have significantly higher PC scores in the experience components of 'Media consumer' and 'Orientate'. They also have significantly higher PC scores in the interest components of 'Astronomy and wonder', 'Violence, war and weapon', 'History and philosophy of science', 'Earth science' and 'Environmental concern'.

It is interesting to note that, if the significance were tested on a 5% level and comparing the science and technology students with all other students, it would have included the experience component of 'Science' (p-value 0.050 with mean difference 0.176) and 'Weather phenomena' (p-value 0.052 with mean difference –0.358). In total there were nine components where the students who choose science and technology programmes showed statistically significant differences from the other students. A majority of those components (seven out of nine) belong to the middle cluster in Figure 1.

The social science students were shown to be more connected with the experience components of 'Beauty, dreams and romance'; their interest components were associated with 'New Age' and 'Body and health'. The category 'Other programmes' was found to differ in the experience components of 'Technology (build and construct)'. The students who choose vocational education related to health, childcare, commerce or restaurant were found to differ significantly from the other education groups in several cases. All of them, except one case ('Body and health'), differ from the other programmes.

Cluster analysis

For the final analysis another cluster analysis was carried out, clustering students with similar experience and interest component scores. This resulted in three clusters of students (153, 122 and 257 students per cluster) with similar preferences (Experience and Interest). Cross tabulation of these three clusters and the five categories of students' choices for upper secondary education are presented in Table 4.

Table 4.Cross-tabulation of number of students in a cluster distribution of student choices for upper secondary education in five different categories

	Cluster		
Programme	1	2	3
Vocational (health…)	16	33	23
Vocational (industry…)	15	2	53
Social science…	56	65	67
Science and technology	49	13	79
Other	15	9	29

The number of students falling into each category (cluster and programme) differ from what would be expected (Chi-squared test, $p < 0.001$), meaning that there is a significant relationship between the three clusters of student distributions and choices made for upper secondary education. The result shows that how the choices are made for upper secondary education is not independent on the clusters based on experience and interest.

Discussion

It has been shown that experience is important for learning science at early ages (Milne, 2010; Mantzicopoulos, Samarapungavan & Patrick, 2009; Saçkes, Cabe Trundle, Bell & O'Connell, 2011) as well as in secondary education (Chang, Yeung & Hung Cheng, 2009). Previous research have shown that science education needs to be humanised and adapted to fulfil the need of a public understanding of science (Duschl, 2000; Fensham, 2000; Jenkins & Nelson, 2005; Donnelly, 2004). One obstacle in doing this are the limited connections with specific science content (Jenkins, 2006). Present paper present detailed analyses by splitting up the science subjects to focus on their content. Furthermore, by analysing the content level in relation with student experience and gender, the study contributes to the knowledge of how young peoples' interest in science is related to their previous experiences and with desirable choices for upper secondary education.

The students' experiences of science and science-related activities grouped into twelve components, where technology activities, use of a computer, and aspects of beauty and dreams were the most prominent. The smaller groups were characterised by experience of farming and cooking, outdoor life, media, sickness and the concern for the environment. The only item with a clear relation to carrying out a science activity was 'Used a science kit', which was the only item in its component. Another component that is clearly related to interest and experience in science outside school was the media category.

There is evidence in the literature that daily life activities are important aspects of learning science in school (Pugh & Girod, 2007). The detailed character of the twelve experience components in this study underscores this point and were used in the further analysis. The point in presenting the character of students' experiences is not that science in school should be only about daily life activities, but that it is important to be aware of and take into account as different individual requirements for learning (Donnelly, 2004) and to understand differences among students, which is pointed out as important by Jenkins (2006). In discussing these results, it should be noted that Schreiner (2006), using data from children all around the world, found that larger cultural movements were involved. Young people across the developed world gave similar answers to those of Swedish children. Such results indicate that even though the data are limited to a Swedish context they can be relevant in an international discussion.

In seven out of twelve experience components, there were statistically significant differences between males and females. In a study from the 70's Gardner (1975) showed that males were associated more with physical science and females with biology and health. Since then, not many studies have been carried out on a content level but mostly on a subject level (Jenkins, 2006). From a content level of analysis, the empirical findings of the present study partly confirmed previous results, but also offered opposing evidence. In regard to the experience components, females were shown to be more associated with technology when it relates to investigations and documentation. If these results are confirmed in other studies, Jenkins (2006) and Donnelly (2004) are right in their argument that future research needs to be more specific because there are variations underlying broad categories like 'physical science', 'gender' and 'experience'. Some of this variation have been presented in this paper.

Seventeen interest components were identified when asking secondary students what they were interested in learning about. Here, too, there are statistically significant gender differences (eight out of seventeen components) due to previous experiences. 'Body and health' stands out as of particular interest, together with 'Astronomy and wonder'. 'Violence, war and weapons', 'Farming and ecology' and 'Everyday technology' are also primary interests. 'History and philosophy of science' were also identified together with 'New Age', zoology, 'Environmental concern' and the use of different products causing disease. Determining whether all these are legitimate aspects of learning science in school is beyond the scope of this paper. The point is to pay attention to what young people want to learn about and try to develop a reasonable understanding of the findings. Dawson (2000) argues for the importance of societal development: the content of science education in school has not changed much over decades, but what students are interested in learning about has. The seventeen interest components with their item loadings described in present paper make a contribution to this discussion by their concrete character and by their relation with experience and further education. A limitation of the study is that the data base used in this paper are from 2003 and items like "use of computer" could have changed in many ways; yet it is still the latest national Swedish large-scale study within the affective domain containing both interest and experience dimensions. New large scale studies on student interest in and experience of science are desirable to check for changes and similarities.

The cluster analysis indicated that there are important connections between experience of science outside school and the desire to learn about certain content areas. Cluster analysis revealed three major clusters of experience and interest components. One is characterised by aspects of beauty and wonder together with body and health items to which females responded more positively. The second cluster contains components related mainly to environmental matters, natural science and media. This was the cluster in which most of the components of students who choose science and technology for upper secondary education were found. The last cluster consists of the practical matters of everyday technology, as well as wars and weapons, which were identified as a more male cluster.

The results presented here indicate that there is much science learning going on outside school, and that this probably starts at an early age. Different experiences relate to the learning of science in school, and group together with interest. An educational implication of this result is that policy discussions related to making more students study science and technology, or to making science education more interesting, should probably carefully consider the interplay between science in school and science in society (see also Jenkins, 2006).

All students show interest in some areas of science and technology. It would be wrong to argue that young people are uninterested in learning science. There are other cultural aspects to consider (Schreiner, 2006). Lyons (2006) sums up studies from three countries and presents common themes in the difficulties young people experience in learning science in school: the content is mostly taught in a transmissive manner, which is perceived as decontextualized and the students often learn the content without seeing any personal relevance in it. The findings presented in present paper indicate that students are interested in learning about science and technology in relation to experience.

Present paper contributes to science education research on students' experiences outside school and their interest in learning science. The results present a concrete description of experiences and interests and relate them to each other. It shows that technology, the use of communication media, beauty, dreams and romance, caring for animals, cooking, body and health issues and environmental concern are important experiences connected with interest themes like body and health, astronomy, wars and weapons, farming, technology, history and philosophy of science, animals and aspects of beauty. Students are different, but there are patterns of interest and experience. Scientific activities such as using a science kit were clustered together with activities such as putting up a tent, making a wood fire, preparing food over a campfire, as well as building and repairing things. Several of these are typically assumed male activities. Many researchers in science education have claimed for years that females are somewhat excluded in science and technology (Kelly, 1986; Dawson, 2000). This paper shows that there are as many science components connected with female experiences and interests as there are male ones, which becomes more obvious when broad categories are broken up and topics are analysed on a content level. The results also indicate that experience outside school is connected to interests in specific science content and related with desires for studying science and technology for upper secondary level.

When students were asked about what they want to learn about, they report several areas and aspects of science. The results should not be understood as to what should be taught. It should be understood as a shift in perspective in an ongoing discussion about students' interest in science. If schools are understood as societal institutions dealing with student learning, the structure of teaching could be implemented as a function of learners' experiences and interest (see also Lyons, 2006; Jenkins, 2006). Instead of debating about students being uninterested in learning science, it would be more constructive to start from the need of the learners and conditions caused by societal development, that is, by experiences outside school.

Conclusions

The purpose of this paper was to analyse students' experience and interest in science and to relate those to each other. The results indicate that there are important connections between experience and interest, which also relates to preferences of future studies. The nature and content of the experience and interest in science and technology was described in concrete terms and discussed both from the purpose of giving all students a scientific literate education as well as preparing some for future studies. Future national and international studies on interest and experience are important for continued and deepened knowledge capacity on those matters. Science at a compulsory level should focus not only on preparing students for future studies, but also on preparing them for citizenship. In both cases experiences and interest themes will be important aspects to consider when working to establish a public understanding of science for democratic purposes.

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Appendix A

Principal component analysis of student experiences in science and technology described in twelve different components. The components are labelled, named and shown with their item loadings ≥ 0.5.

1. Technology (build and construct)	
used a crowbar (jemmy)	.792
used a rope and pulley for lifting heavy things	.751
mended a bicycle tube	.737
charged a car battery	.686
used a water pump or siphon	.598
used tools like a saw, screwdriver or hammer	.595
connected an electric lead to a plug, etc.	.594
used an air gun or rifle	.589
opened a device (radio, watch, computer, telephone, etc.) to find out how it works	.557
made a model such as toy plane or boat, etc.	.546
made a bow and arrow, slingshot, catapult or boomerang	.538
used a windmill, watermill, waterwheel, etc.	.503

2. Technology (investigate and document)	
used a measuring ruler, tape or stick	.700
measured the temperature with a thermometer	.690
used a camera	.623
changed or fixed electric bulbs or fuses	.589
used a stopwatch	.558
recorded on video, DVD or tape recorder	.549
used binoculars	.545

3. Use the computer	
sent or received e-mail	.762
searched the Internet for information	.730
downloaded music from the Internet	.680
played computer games	.641
used a word processor on the computer	.612
used a dictionary, encyclopaedia, etc. on a computer	.568
used a mobile phone	.564
sent or received an SMS (text message on mobile phone)	.544

4. Beauty, dreams and romance	
tried to find the star constellations in the sky	.648
collected different stones or shells	.609
read my horoscope (telling future from the stars)	.607
knitted, weaved, etc.	.553
walked while balancing an object on my head	.540
5. Life on a farm	
cared for animals on a farm	.754
milked animals like cows, sheep or goats	.740
watched (not on TV) an animal being born	.723
6. Outdoor life	
made a fire from charcoal or wood	.702
put up a tent or shelter	.701
prepared food over a campfire, open fire or stove burner	.657
7. Media consumer	
read about nature or science in books or magazines	.638
watched nature programmes on TV or in a cinema	.618
8. Cooking	
baked bread, pastry, cake, etc.	.663
cooked a meal	.631
9. Sickliness	
been to a hospital as a patient	.755
seen an X-ray of a part of my body	.671
taken medicines to prevent or cure illness or infection	.611
taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.)	.525
10. Orientate	
used a compass to find direction	.707
read a map to find my way	.664
11. Environmental concern	
sorted garbage for recycling or for appropriate disposal	.571
made compost of grass, leaves or garbage	.500
12. Science	
used a science kit (like for chemistry, optics or electricity)	.528

Appendix B

Principal component analysis of student interest in science and technology described in seventeen different components. The components are labelled, named and shown with their item loadings ≥ 0.5.

1. Body and health	
What we know about HIV/AIDS and how to control it	.789
Cancer, what we know and how we can treat it	.774
Sexually transmitted diseases and how to be protected against them	.757
Biological and human aspects of abortion	.711
How to control epidemics and diseases	.688
Birth control and contraception	.672
How to perform first-aid and use basic medical equipment	.654
How babies grow and mature	.653
How my body grows and matures	.652
How different narcotics might affect the body	.632
How the human body is built and functions	.631
Epidemics and diseases causing large losses of life	.629
How gene technology can prevent diseases	.624
Sex and reproduction	.585
How alcohol and tobacco might affect the body	.582
Eating disorders like anorexia or bulimia	.581
Heredity and how genes influence how we develop	.568
How radiation from solariums and the sun might affect the skin	.524

2. Astronomy and wonder	
Black holes, supernovas and other spectacular objects in outer space	.733
Stars, planets and the universe	.729
How meteors, comets or asteroids may cause disasters on earth	.692
Unsolved mysteries in outer space	.675
Rockets, satellites and space travel	.636
The first landing on the moon and the history of space exploration	.631
The possibility of life outside earth	.628
The inside of the earth	.555
How to find my way and navigate by the stars	.527
Earthquakes and volcanoes	.504
The use of satellites for communication and other purposes	.503
Dinosaurs, how they lived and why they died out	.503
Phenomena that scientists still cannot explain	.477

3. Violence, war and weapon	
Explosive chemicals	.780

Biological and chemical weapons and what they do to the human body	.716
How the atom bomb functions	.693
Chemicals, their properties and how they react	.660
Atoms and molecules	.646
The effect of strong electric shocks and lightning on the human body	.638
How radioactivity affects the human body	.613
How a nuclear power plant functions	.562
Light around us that we cannot see (infrared, ultraviolet)	.535
Deadly poisons and what they do to the human body	.455
4. Farming and ecology	
Organic and ecological farming without use of pesticides and artificial fertilizers	.736
Benefits and possible hazards of modern methods of farming	.707
How to improve the harvest in gardens and farms	.688
Plants in my area	.640
How different sorts of food are produced, conserved and stored	.608
Medicinal use of plants	.598
How energy can be saved or used in a more effective way	.582
Risks and benefits of food additives	.573
New sources of energy from the sun, wind, tides, waves, etc.	.548
5. Everyday technology	
How cassette tapes, CDs and DVDs store and play sound and music	.802
How things like radios and televisions work	.798
How mobile phones can send and receive messages	.758
The use of lasers for technical purposes (CD-players, bar-code readers, etc.)	.743
How computers work	.709
Electricity, how it is produced and used in the home	.557
How to use and repair everyday electrical and mechanical equipment	.528
Optical instruments and how they work (telescope, camera, microscope, etc.)	.504
6. New Age	
Thought transference, mind-reading, sixth sense, intuition, etc.	.800
Ghosts and witches, and whether they may exist	.758
Why we dream while we are sleeping, and what the dreams may mean	.702
Astrology and horoscopes, and whether the planets can influence human beings	.591
Life and death and the human soul	.582
Alternative therapies (acupuncture, homeopathy, yoga, healing, etc.) and how effective they are	.565
7. History and philosophy of science	
How scientific ideas sometimes challenge religion, authority and tradition	.665
Famous scientists and their lives	.607
Big blunders and mistakes in research and inventions	.601

Inventions and discoveries that have changed the world	.578
Why scientists sometimes disagree	.572
Why religion and science sometimes are in conflict	.571
Very recent inventions and discoveries in science and technology	.482
8. Earth science	
How mountains, rivers and oceans develop and change	.532
Clouds, rain and the weather	.530
How people, animals, plants and the environment depend on each other	.520
9. Animals	
Animals in other parts of the world	.704
Brutal, dangerous and threatening animals	.635
How animals use colours to hide, attract or scare	.595
Animals in my area	.588
How to protect endangered species of animals	.523
10. Beauty	
How the sunset colours the sky	.608
Symmetries and patterns in leaves and flowers	.536
Why we can see the rainbow	.451
11. Environmental concern	
The greenhouse effect and how it may be changed by humans	.617
What can be done to ensure clean air and safe drinking water	.587
The ozone layer and how it may be affected by humans	.555
How technology helps us to handle waste, garbage and sewage	.479
12. Exercise	
How to exercise to keep the body fit and strong	.782
What to eat to keep healthy and fit	.680
13. Music	
How different musical instruments produce different sounds	.513
14. Weather phenomena	
Tornados, hurricanes and cyclones	.603
Earthquakes and volcanoes	.515
15. Use causing illness	
The possible radiation dangers of mobile phones and computers	.561
How alcohol and tobacco might affect the body	.552
How different narcotics might affect the body	.532
16. Build and repair	
How to use and repair everyday electrical and mechanical equipment	.470

17. Body and beauty	
The ability of lotions and creams to keep the skin young	.513
Plastic surgery and cosmetic surgery	.504

Appendix C

Correlation coefficients between the 12 experience components and the 17 interest components. Positive correlations are in **bold** type ($p < 0.001$). Non-significant correlations are labelled *n.s.*

Interest	Experience											
	1	2	3	4	5	6	7	8	9	10	11	12
1	-.27	**.27**	*n.s.*	**.23**	*n.s.*	*n.s.*	*n.s.*	**.14**	**.14**	*n.s.*	*n.s.*	*n.s.*
2	*n.s.*	*n.s.*	*n.s.*	*n.s.*	-.22	*n.s.*	**.21**	*n.s.*	*n.s.*	**.20**	*n.s.*	*n.s.*
3	**.32**	*n.s.*	*n.s.*	-.14	*n.s.*	*n.s.*	**.23**	*n.s.*	*n.s.*	**.22**	*n.s.*	*n.s.*
4	*n.s.*	*n.s.*	-.16	*n.s.*	**.19**	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	**.26**	*n.s.*
5	**.27**	*n.s.*	**.17**	*n.s.*	-.15	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	**.21**
6	*n.s.*	*n.s.*	*n.s.*	**.38**	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
7	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	-.13	**.18**	*n.s.*	*n.s.*	**.15**	**.13**	**.14**
8	*n.s.*	*n.s.*	*n.s.*	**.13**	*n.s.*	*n.s.*	**.11**	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
9	*n.s.*	*n.s.*	*n.s.*	*n.s.*	**.18**	*n.s.*	**.22**	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
10	*n.s.*	*n.s.*	*n.s.*	**.19**	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
11	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	**.17**	*n.s.*	*n.s.*	*n.s.*	**.16**	*n.s.*
12	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
13	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
16	**.25**	*n.s.*	*n.s.*	*n.s.*	*n.s.*	**.14**	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
17	*n.s.*	*n.s.*	*n.s.*	*n.s.*	**.15**	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*