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Students' interest and experiences in physics and chemistry related themes: Reflections based on a ROSE-survey in Finland

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Abstract

Interest in physics and chemistry topics and out-of-school experiences of Finnish secondary school students (n=3626, median age 15) were surveyed using the international ROSE questionnaire. Based on explorative factor analysis the scores of six out-of-school experience factors (indicating how often students had done something outside of school) and eight topic factors (indicating how interested students were in learning about something) were studied. The students had a lot of out-of-school experiences in simple measuring and observing and in ICT use, but they had few science and technology related hobbies and activities or experiences of camping. Several gender differences were found. *Observing natural phenomena and collecting objects* was the most important factor correlating with the topic factors. Factors measuring experiences of ICT use and the use of mechanical tools had the lowest correlations with the topic factors. Based on the results, the implications for science education will be discussed.

Keywords

Physics and chemistry education, students' interest, out-of-school experiences

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Introduction

Several concepts, such as interest, motivation or attitudes are used to describe motivational aspects of science education. We use the concept "interest" and interpret it as a content-specific motivational variable that can be both empirically investigated and theoretically reconstructed (Krapp, 2007). Interest research has shown that students will engage in science learning activities and, moreover, choose science courses in upper secondary school if they are interested in the topics to be learned (for a review, see Osborne, Simon & Collins, 2003; Hidi, Renninger & Krapp, 2004).

In this research we will use the data collected in Finland with the ROSE (The Relevance of Science Education; http://www.ils.uio.no/english/rose/) questionnaire. The ROSE-project aims to shed light on factors of importance to the learning of science and technology for the upper grades of comprehensive school (Schreiner & Sjøberg, 2004). Data collected by the ROSE questionnaire has already been used for different purposes in different countries, such as for international comparisons of the data; for giving information to science teachers, teacher educators, student teachers, and textbook authors; for taking part in local education policy discussions; and for understanding youth culture and sociological and sociocultural points of view of science education. In this article we will use items in the ROSE questionnaire which measured how interested students were in learning certain physics and chemistry related topics or themes and what kind of physics and chemistry related out-of-school experiences students had. We use the term "related" before "topics" and "out-of-school" to describe the nature of ROSE questionnaire items (explained in the Methodology chapter). Students' responses to the items are interpreted to indicate task- or knowledge-based situational interest as will be shown in the next chapter. ROSE-data has thus far not been analysed in the framework of interest or motivation research and, therefore, we aim to shed light on it within this context.

For our analysis we chose only ROSE items which relate to student interest in physics or chemistry. We had three reasons for doing this: firstly, we have already analysed the Finnish ROSE data from the point of view of biology and geology education (Lavonen et al., 2005; Uitto, Juuti, Lavonen, & Meisalo, 2006); secondly, there are 169 items concerned with science related interest issues, thus making it difficult to analyse and discuss the subject in a proper way; thirdly, it is known that science in general and school biology in particular is quite interesting for students, but most students, especially girls, do not find school physics and chemistry and careers and occupations in those fields interesting (Osborne, Simon & Collins, 2003; EU, 2004; EU, 2005).

Consequently, as students' interest is so important to the learning of physics and chemistry and any future involvement in the subjects, it is useful to know what students find interesting about them and what kind of experiences they have had in physics and chemistry related activities. Research has already identified several factors that interrelate with interest in physics and chemistry learning: nationality, gender, the perceived relevance of physics and chemistry from the point of view of further studies or occupation, interest in the contents of physics and chemistry, interest in contexts where physics or chemistry content or topics are met, interest and enjoyment in an activity type or the teaching methods used, perceived achievement, level of difficulty, and appreciation of the topic (Simon, 2000; Stokking, 2000). Also, OECD (2006) has included an affective domain to the PISA framework, giving the reason that "Students' interest in and attitudes toward science play an important role in students' decisions to develop their science knowledge further, pursue careers in science, and use scientific concepts and methods productively throughout their lives" (OECD, 2007, p. 39).

Student interest in physics and chemistry

Since Herbart (1965a, 1965b), modern pedagogy has emphasized the value of interest not only as a mean, but as an educational end in itself. Modern interest research (for a review, see Hidi, Renninger & Krapp, 2004) has confirmed Herbart's conception. Namely, interest-based motivation to learn has positive effects both on the studying processes and on the quantity and quality of learning outcomes. To clarify the concept of interest, we review the literature of interest, especially in the context of school physics and chemistry. Interest is typically approached from two major points of view. One is interest as a characteristic of a person and the other is interest as a psychological state aroused by specific characteristics of the learning environment. Traditionally, the former approach has been termed topic interest or personal interest and the latter has been called situational interest (Krapp, 2003).

Personal interest is topic specific, persists over time, develops slowly and tends to have long-lasting and stable effects on a person's knowledge and values (Hidi, 1990). It refers to the dispositional motivational structure of an individual (Krapp, 2007) or to information that is of enduring personal value, activated internally, and topic-specific (Hidi, Renninger & Krapp, 1992; Krapp, Hidi & Renninger, 1992). Pre-existing knowledge, personal experiences and emotions form the basis of personal interest (Schiefele, 1991). Moreover, Krapp (2003) has assumed that the fulfilment of so-called basic psychological needs for *competence*, *autonomy*, and *social relatedness* are important for the development of personal interest. And personal interest can be subdivided into latent and actualised interest (Schiefele, 1991; 1999).

Actualised personal interest (interestingness) is a topic-specific motivational state that determines one's engagement style in an activity. According to Schiefele (1991) individuals with a high actualised interest display a mastery orientation characterised by challenge-seeking and continued effort in the face of failure or setbacks. But those with a low actualised interest adopt a performance orientation characterised by avoidance of challenge and of task-related anxiety given failure.

Individuals follow their *latent personal interest* when they engage in intrinsically motivated activities (cognitive engagement) naturally and spontaneously. Schiefele (1999) has suggested that latent personal interest is a content-specific concept and a facilitator of learning, and that it consists of two kinds of valences: feeling-related and value-related. Feeling-related valences are feelings that are associated with a topic or an object, for instance, feelings of enjoyment and involvement. Value-related valences refer to the attribution of personal significance to an object. For example, nature values can have an effect on students' interest in science (Uitto, et al., 2004). Thus, some objects of interest are preferred as involvement with them creates, for instance, strong feelings of excitement, whereas other objects of interest are preferred as they may have high personal relevance. Thus, personal interest engages students in activities which they appreciate or which give them a good feeling. This type of interest can also be understood as a consequence of intrinsic motivation. According to Schiefele (1999, p. 259), "*intrinsic motivation* to learn is defined as the intention to engage in a specific learning activity because the activity itself is interesting, enjoyable, or otherwise satisfying." This kind of behaviour is based on the need to feel competent and self-determined (Deci & Ryan, 2000). However, sometimes it is difficult to identify if students choose activities out of interest for the topic or simply to attain social relatedness among their friends or to please their parents. For example, using a science kit or utensils as an out-of-school activity can happen simply for constructing a social relatedness with parents. Therefore, Deci (1992, p. 55; see also Krapp, 2002) has related interest also to this type of integrated external regulation but noticed that importance may be more significant than interest in describing this self-determined extrinsic motivation.

Situational interest is assumed to be spontaneous, fleeting, and shared among individuals. It is an emotional state that is evoked suddenly by something in the immediate environment and it may have only a short-term effect on an individual's knowledge and values. Schraw and Lehman (2001) describe that situational interest is aroused as a function of the interestingness of the topic and is also changeable and partially under the control of teachers. They have categorised situational interest into three main categories based on research about learning from texts. We follow this categorisation while we present next an appropriate categorisation of situational interest from the point of view of physics and chemistry learning. These categories are content-based, task-based, and knowledge-based situational interest.

Content-based interest refers to properties of the content to-be-learned, for example the content of a text; information acquired from a web page; or an observation or data acquired during practical work. Carefully selected, well-organised, coherent, relevant, seductive (increase curiosity) and vivid texts, information or other contents are interesting to students (Schraw, 1997; Schraw, Flowerday & Lehman, 2001). Furthermore, for example information or an event that is unusual (e.g., a web page or an exiting observation acquired in a demonstration) can arouse content-based situational interest.

Task-based interest refers to properties of the task. It could be generated at school by choosing an appropriate teaching method, grouping of students, an interesting activity or through offering students meaningful choices (offering the feeling of autonomy in task and goal setting). There is an overlap between the concepts "task-based situational interest" and "motivation". As already mentioned, Krapp (2003) assumes that the fulfilment of basic psychological needs are important for the development of personal interest. Respectively, central to *Self-Determination Theory* are also: the *need for competence*, the *need for autonomy*, and the *need for social relatedness (the need to belong to a group)* (Deci & Ryan, 2004). Consequently, task-based interest could be generated through giving support to students' feeling of autonomy, competence and social relatedness. Moreover, task-based situational interest depends on the way a task is perceived. According to Ryan, Sheldon, Kasser and Deci (1996, pp. 20-21), cultural and interpersonal contexts influence what tasks people emphasise: for example, in which contexts the task appears (Hoffman, 2002, Lewalter & Krapp, 2004). Role of context is especially emphasised in context-based approaches, like *Science – Techonology – Society – Environment (STSE or STES)*, where contexts are used as the starting point for the development of scientific ideas and interest (Bennett, Hogarth & Lubben, 2003; Hodson, 2003). For example Sjøberg (2000) explored the effect while presenting the same content in different contexts. He found that the context in which science ideas are taught, rather than the ideas themselves, is an important influence on interest (Lavonen et al., 2005). Finally, we include also perceived future relevance of a subject in task-based situational interest.

Knowledge-based interest refers to interest that is generated due to relevant prior knowledge. Therefore, it is useful to know what experiences and prior knowledge students have in the domain of knowledge to be learned. These are learned through different out-of- and in-school activities. Out-of-school activities may occur for example at home in everyday situations like interaction with friends, watching TV, reading books or magazines, in various hobbies, junior organisations and in institutions like museums and zoos. Students can participate in these activities according to their own free will. From the point of view of situational interest, it is important to help students to access appropriate background knowledge when dealing with a new content or task.

One important focus of physics and chemistry related interest research has been the differences in male and female students' interest in science in general, in science subjects, and topics and contexts. For example, it is known that in general girls are less interested than boys in physics and that there is a small decrease in interest in physics with increasing age. Boys and girls as groups are interested in different aspects of science, with girls being equally or a little less interested than boys in light, sound and heat, and much less interested in mechanics, electricity and radioactivity (Häussler, 1987; Sjøberg, 2000; Biklen & Pollard, 2001). Jones, Howe and Rua (2000) have showed that the out-of-school experiences of boys are relevant to physics (electronic games, rockets, microscopes), whereas those of girls are more closely associated with biology (bird watching, sewing seeds, planting). The interests of boys and girls in the science subjects taught at school are rather different with boys preferring technical subjects (aeroplanes, computers, new sources of energy) and girls preferring subjects that have a bearing upon perception and everyday life (colour, diet, fitness and health). The gender difference in interest is explained typically through the influence of culture. Culture has an affect on male and female interest in science, on science education as well as on their careers. (Hasse, 2002) Therefore, it is important to know what characteristics in the culture or what kind of artefacts and activities or styles of doing science are interesting for male and female students (Rosser, 1995; Rolin, 2007). However, the interpretation of the data is not easy or obvious and, moreover, different conclusions are made based on the same data, although clear gender differences can be observed (Spelke, 2005).

At school a curriculum guides students' behaviour – not their free will (see Byman & Kansanen, in press) and therefore, it is valuable to know how interest develops. Several researchers (e.g., Krapp, 2002) have made a distinction between *catching* and *holding* situational interest. Hidi and Renninger (2006) have recently suggested a four-phase model of interest development. This model integrates two conceptualisations of interest which both have two phases. First, there is *situational interest*. This consists of the phase in which the interest is first caught (triggered) and the subsequent phase in which interest is held (maintained). Catching or triggering refers to variables that initially stimulate students to become interested in a specific topic.

Holding interest refers to variables that empower students with a clear goal or purpose. Essential to the shift from catching to holding a student's situational interest can be supported by an appropriate learning situation (e.g., context, teaching method, use of computers or the Internet or a textbook) that make a topic meaningful and personally relevant to students according to his or her personal goals (Mitchell, 1993; Schraw et al. 2001). Second, there is *personal interest*, consisting of the two phases of emerging personal interest and well-developed personal interest (see e.g., Renninger, 2000). Emerging personal interest is characterised by positive feelings, stored knowledge and value. It is typically but not exclusively self-generated and instructional conditions or the learning environment can enable the development of it. Consequently students can self-regulate interest and, moreover, in certain conditions situational interest can transform into personal interest and, therefore, it is partially under the control of teachers. Student's affective response to the topic forms the link between interest and learning (Ainley, Hidi & Berndorff, 2002; Sansone, Wiebe & Morgan, 1999).

Figure 1 summarises previous literature review and presents a taxonomy of the concepts dealing with interest and development of interest. This is a modified version of

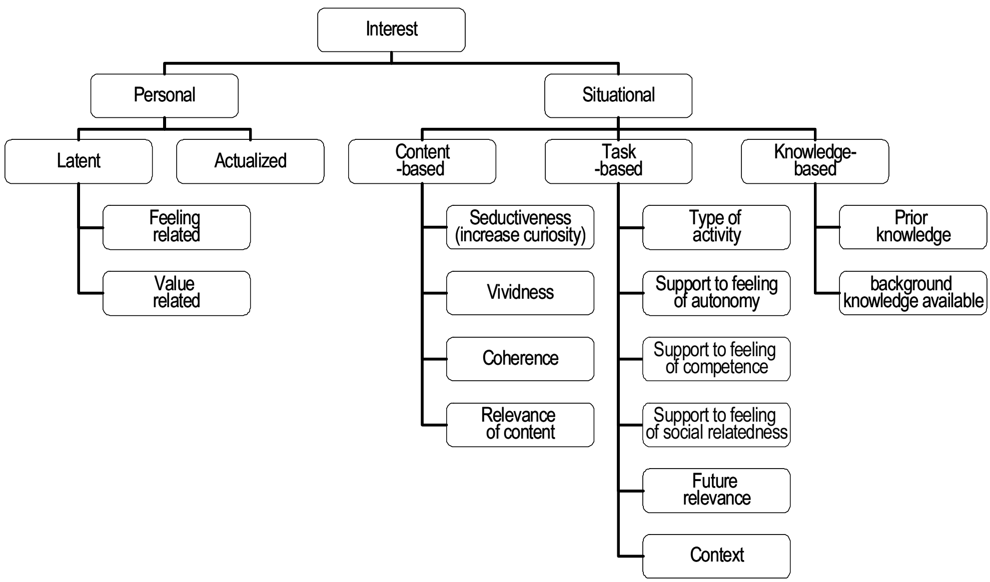

Figure 1. A taxonomy of personal and situational interest.

the taxonomy presented by Schraw and Lehman (2001) which was based on interest related empirical research.

Method

Research questions

In the present study, we focus on Finnish lower secondary school students' (median age 15) content-, task- and knowledge-based situational interest. According to our theoretical framework, introduced in the previous chapter, refers to content-based situational interest or disposition type personal interest (interestingness). Based on the knowledge regarding students' "out-of-school activities" we are able to discuss possibilities to help students to catch task- or knowledge-based situational interest. Further discussion can be based on the correlations between students' physics and chemistry related out-of-school activities and the interest to learn physics and chemistry topics. The research questions are:

- What physics and chemistry related out-of-school experiences do students have?
- What physics and chemistry related topics students are interested in learning?
- What gender differences are there among students in the physics and chemistry related out-of-school experiences and in the interestingness of physics and chemistry related topics?

When students are given the choice of what to do, they tend to choose familiar things that interest them or novel and complex things they are curious about. Intrinsically motivated activities are activities which students do naturally and spontaneously when they follow their inner interests. Thus, the fourth research question of the present study is the following:

- What kind of correlations are there between students' physics and chemistry related out-of-school experiences and interestingness of physics and chemistry topics?

The instrument

We will use the data gathered by some ROSE questionnaire items in Finland. The ROSE questionnaire has been prepared through international co-operation so that the findings could help teachers and researchers to make science education and learning more interesting (Schreiner & Sjøberg, 2004). Firstly, we will use items which measured how interested students were in learning certain physics and chemistry related themes. We interpret that the answers to those items indicate students' content based situational interest. Secondly, we will use ROSE items which clarified what kind of physics and chemistry related out-of-school experiences students had. Students' responses to these items are interpreted to indicate task- or knowledge-based situational interest as was argued in the previous chapter.

In the ROSE questionnaire, there were altogether 61 items measuring students' out-of-school experiences. However, in this research only 36 physics and chemistry related items are used. The students were asked: "*How often have you done this (e.g., used binoculars) outside school*?" Students answered by ticking the appropriate box on a four-point Likert scale, the extreme categories being *Never* and *Often.* The responses were scored 1, 2, 3 and 4. These items give us information about students' activities outside school and physics and chemistry related task-based situational interest.

Respectively, there were altogether 108 items measuring how interesting different topics are for students. But here 46 physics and chemistry related items are used. The students were asked: "*How interested are you in learning about the following (e.g., stars, planets and the universe)*?" Students answered by ticking the appropriate box on a four-point Likert scale, the extreme categories being *Not interested* and *Very interested.* When questionnaires are used in research the researchers do not actually know what kind of interest the responses are reflecting. Therefore, Krapp (2007, p. 9) has introduced the concept of an actually "operating" interest. It can either be caused by an already existing dispositional interest (individual or personal interest) or by the topic or conditions of teaching and learning situation (interestingness). Consequently, the above mentioned 46 items could give us information about students' physics and chemistry related content-based situational interest or disposition type personal interest.

We use the term "related" to describe the nature of the ROSE questionnaire items we have selected. Actually we selected those items which had clear connections to biology or geology out of all 169 items. As such, some of the selected items do not have a clear connection to physics and chemistry. In our exploratory research we are aiming to find new physics and chemistry contents and contexts or activities that might make physics and chemistry education more interesting. Therefore, we have also chosen items like "*collect different stones or seashells*" and "*sort garbage for recycling or for appropriate disposal*" to our analysis.

Data collection

Altogether, 75 lower-secondary schools were randomly selected from the list of Finnish-language comprehensive schools in Finland. In each of these schools, about 65 pupils were asked to answer the survey, which meant about three classes from each school. In total, we had 4954 pupils participating in the survey. The questionnaire was sent to the schools in spring 2003, and the school principals were asked to organise the survey and return the completed questionnaires. The national and international purposes of the survey were carefully explained on a cover sheet. Altogether, 26 reminders (37% of the selected schools) were sent to those principals who had not returned the survey in time. The survey was answered by 3626 pupils (1772 girls) in 61 schools representing 81% of the selected schools. The number of pupils answering the survey was 7% of the whole age cohort. Thus, the external validity of the present research could be evaluated to be quite high and the sample represents the population quite well.

The pupils' answers were read by optic scanners and data was saved to SPSS. The data was cleaned in SPSS by looking carefully at all lines and for example running frequency tables for all variables to search for values outside the 'legal' range.

The statistical analysis

Although the scales are strictly interpreted as ordinal, we assume that while answering the students perceived the scales to be more or less interval scales. Hence, it is also easier to discern the findings when they are presented as a means to each item. If the mean for an item "*How often have you done this outside school*?" was over the middle of the scale (2.5) the activity was interpreted as happening often. If the mean for an item "*How interested are you in learning about the following (e.g. stars, planets and the universe)*?" was over the middle of the scale (2.5) the interest was interpreted as positive.

Due to large skewness and kurtosis of the score distributions of some physics and chemistry related items, such as items measuring students' experience of mobile phone use (skewness -2.1 and kurtosis 3.9), they were not included in the analysis. In the out-of-school experiences data used in the analysis the skewness varies between -1.07 and1.22 and kurtosis between -1.36 and1.32 and in the interestingness data, used in the analysis, the skewness varies between -0.59 and 0.77 and kurtosis between -1.32 and -0.49. The skewness and kurtosis values used in the analysis were in a reasonable range and, thus, acceptable for the use of multivariate methods.

An Exploratory Factor Analysis (EFA) was used to reduce the number of original variables, measuring students' out-of-school experiences and interestingness of physics and chemistry topics, to a smaller number of factors. In the EFA analysis, maximum likelihood (ML) was used as the extraction method rotation being Promax (kappa = 4) with Kaiser Normalization. The ML method was chosen for the analysis because it yields the most clearly differentiated factors (Gorsuch, 1983, p. 117). Missing values were replaced with means. The comprehensibility criteria was used in both analyses and the number of factors was limited in the first analysis to six and in the second analysis to eight, since the meaning of the factors were then readily comprehensible (Dunteman, 1989, pp. 22–23). Several other solutions were also examined but then the solutions were not as easily comprehensible. All factors whose eigenvalues exceeded 1 before the rotation were included in the solution. The calculated Kaiser-Meyer-Olkin Measure of sampling adequacy and the Bartlett's test of sphericity for the factor analysis showed that the data were adequate for EFA analysis. For the out-of-school experiences factor analyses the KMO of Sampling Adequacy was 0.931 and in the Bartlett's Test the approximate Chi-Square was 43780 (df =630, $p<.001$). For topic factor analyses the corresponding values were for KMO 0.953 and for the Bartlett's Test 79863 (df =1035, $p<.001$).

To compare girls' and boys' out-of-school experiences and interestingness of physics and chemistry topics, factor related sum-variables were calculated of the items having the main loading for each factor. The means of the boys' and girls' sum-variable distributions were compared using the Independent-Samples *t*-test (two-tailed). As an additional check we tested the power of the difference using Cohen's *d*

$$d = M_g - M_b \,/\, S.D._{pooled}, \text{ where } S.D._{pooled} = \sqrt{\left[\left(S.D_g^2 + S.D_b^2\right) \,/\, 2\right]} \text{ (Cohen, 1988)}$$

The Independent-Samples *t*-test procedure compares means for two groups of cases. Cohen's *d* measures the effect size for the difference between boys and girls: no effect at $d < 0.2$, small effect at $0.2 \le d < 0.5$, moderate effect at $0.5 \le d < 0.8$, and large effect at $d \ge 0.8$.

The two-way Pearson's correlation analysis was used to find out if there were any relations between students' out-of-school experience factors and topic factors. Cohen (1988) gives also the rules for effect size of the Pearson's *r*: no effect at $r < 0.1$, small effect at $r = 0.1$, medium effect at $r = 0.3$, and large effect at $r = 0.5$. Correlations and their significances are presented in Table 5.

Quantitative measurements have been criticised in general. Based on surveys, it is difficult to understand in detail the structure of students' interests (Osborne, Simon & Collins, 2003). Kelly, Chen & Crawford (1998) reviewed a number of journal articles focusing on methodological weaknesses of surveys and research interviews. Based on this they analysed two problems in the use of surveys or interviews in science education research: the nature of the elicitation and the missing of classroom context. They argued that when surveying students' opinions, the researcher is not merely tapping into the students' memories, but is also inviting the students to engage and think in a certain way. Secondly, without observational data the survey data lack features which are present is social situations in a classroom. On the other hand, surveys like this research yield information about the interestingness of the studied topics. We know that the interpretation of data must be meticulously undertaken when it has been acquired using this kind of research methodology which has certain limitations.

Results

Several ML solutions with Promax rotation (Kappa=4) were conducted with the items describing students' physics and chemistry related out-of-school experiences. The number of factors chosen was six (FE1-FE6), since the meaning of the factors was then readily comprehensible (Dunteman, 1989, pp. 22–23) and their initial eigenvalues before rotating were higher than 1.

The statistical fit of the six-factor solution was not acceptable, $\chi^2 = 3307^{***}$. However, the examination of the residuals indicated no hidden variation, thus supporting the six-factor solution. Gorsuch (1983, p. 153) has also stated that the ML significance test in EFA can overestimate the factor number. Thus, each factor was named according to the loaded items, emphasising the highest loadings (λ) and contents common for factor items. Factors were named as presented in Table 3. The six-factor solution of students' out-of-school activities explained 47% of the extraction sums of squared loadings (Table 1).

Based on the means of students responses presented in Table 1, the students had a lot of physics and chemistry related out-of-school experiences in using a camera, basic electronic devices and using Information and communication technologies, like searching the internet for information or using a word processor or computer games. Moreover, they had several experiences in measuring with simple measuring equipment, such as a thermometer, ruler, tape and stopwatch. They had little experience in using mechanical devices, such as a wind- or watermill, pulley and water pump, or making small devices like an instrument or model such as a toy plane, boat or working with compost, leaves and garbage. The standard deviations were relatively high compared to the mean. This indicates large diversity among the experiences of the students.

Table 1. Loadings of factors measuring students' physics and chemistry related out-of-school experiences (FE1-FE6) reduced by the EFA on students' out-of-school activities items, (The λ <0.3 are not included).

	Factor							
I have ...	M	S.D.	FE1	FE2	FE3	FE4	FE5	FE6
Used a windmill, watermill, waterwheel, etc.	1.6	.83	.76					
Made a model such as a toy plane or boat etc.	2.0	.98	.75					
Used a water pump or siphon	2.1	.98	.66					
Mended a bicycle tube	2.1	1.1	.63					
Made a bow and arrow, slingshot, catapult or boomerang	2.3	.98	.62					
Used a rope and pulley for lifting heavy things	2.1	1.0	.59					.41
Opened a device to find out how it works	2.7	1.1	.44					
Made an instrument (like a flute) from natural materials	1.7	.84	.41		.35			
Changed or fixed electric bulbs or fuses	2.8	1.0	.38	.36				
Measured the temperature with a thermometer	3.3	.83		.89				
Used a measuring ruler, tape or stick	3.3	.83		.84				
Used a stopwatch	3.3	.82		.79				
Used a camera	3.4	.79		.60				
Connected an electric lead to a plug etc.	3.5	.82		.59				
Recorded on video, DVD or tape recorder	3.3	.89		.46				
Used binoculars	2.9	.82		.42				
Read about nature or science in books or magazines	2.5	.96			.60			
Collected different stones or seashells	2.1	.90			.57			
Collected edible berries, fruits or plants	3.0	.90	-.30		.55			
Watched nature programmes on TV or in a cinema	2.9	.88			.55			

Table 1. Continued...

			Factor					
I have ...	M	S.D.	FE1	FE2	FE3	FE4	FE5	FE6
Tried to find the star constellations in the sky	2.8	.97			.44			
Sorted garbage for recycling or for appropriate disposal	2.5	1.0			.44			
Made compost of grass, leaves or garbage	1.7	.88	.37		.44			
Visited a science centre or science museum	2.3	.82			.33			
Downloaded music from the internet	2.8	1.2				.69		
Sent or received e-mail	3.3	.92				.65		
Played computer games	3.3	.86				.58		
Used a word processor on the computer	3.4	.82				.56		
Searched the internet for information	3.6	.71				.54		
Used a dictionary, encyclopaedia, etc. on a computer	2.5	.99	.34			.43		
Made a fire from charcoal or wood	2.5	1.1					.72	
Prepared food over a campfire, open fire or stove burner	2.4	.99					.70	
Put up a tent or shelter	2.5	.88			.30		.46	
Used a wheelbarrow	2.9	.88						.73
Used a crowbar	2.5	1.0	.40					.66
Used tools like a saw, screwdriver or hammer	3.1	.89						.31
Eigenvalue			8.3	4.0	2.3	.9	.7	.6
% of total variance			23.1	11.1	6.5	2.6	1.9	1.7

When analysing the factor structure of the items measuring interestingness of physics and chemistry topics the Goodness-of-fit Test again gave a high value: χ^2 = 5794*** thus supporting the rejection of the eight-factor model. However, the examination of the residuals indicated no hidden variation, thus supporting this solution. Each factor was named according to the loaded items, emphasising the highest loadings and contents common for factor items. The eight factors describing interestingness of physics and chemistry topics (FI1-FI8) explained 57% of the extraction sums of squared loadings (Table 2). Factors are named as presented in Table 4.

Table 2. Loadings of factors measuring interestingness of physics and chemistry topics or interestingness factors (FI1-FI8) reduced by the EFA on students' opinions on how interested they are in learning about physics and chemistry topics (The loadings $\lambda<0.3$ are not included).

	Factor									
	M	S.D.	FI1	FI2	FI3	FI4	FI5	FI6	FI7	FI8
How things like radios and televisions work	2.4	.96	.96							
How cassette tapes, CDs and DVDs store and play sound and music	2.4	.99	.91							
How mobile phones can send and receive messages	2.5	.95	.82							
The use of lasers for technical purposes (CD-players, etc.)	2.3	1.0	.74							
How computers work	2.5	1.0	.70							
Optical instruments and how they work (telescope, camera, etc.)	2.0	.91	.40							
Explosive chemicals	2.4	1.1		.94						
Biological and chemical weapons and what they do to the human body	2.5	1.0		.92						
How the atom bomb functions	2.6	1.1		.89						
The effect of strong electric shocks and lightning on the human body	2.7	.95		.66						
Deadly poisons and what they do to the human body	2.7	.97		.63						
How a nuclear power plant functions	2.1	1.0		.43						
Chemicals, their properties and how they react	2.0	.88		.34						
Black holes, supernovas and other spectacular objects in outer space	2.7	1.1			.88					
How meteors, comets or asteroids may cause disasters on earth	2.7	1.0			.81					
Stars, planets and the universe	2.6	.99			.80					
Rockets, satellites and space travel	2.4	1.0			.76					
The first landing on the moon and the history of space exploration	2.3	1.0			.63			.40		

Table 2. Continued ...

	Factor									
	M	S.D.	FI1	FI2	FI3	FI4	FI5	FI6	FI7	FI8
How it feels to be weightless in space (how humans feel)	3.0	1.0			.57					
The use of satellites for communication and other purposes	2.1	.95			.48					
How to find my way and navigate by the stars	2.3	.98			.39		.36			
The greenhouse effect and how it may be changed by humans	2.2	.94				.97				
The ozone layer and how it may be affected by humans	2.2	.93				.89				
What can be done to ensure clean air and safe drinking water	2.6	.94				.81				
How technology helps us to handle waste, garbage and sewage	2.2	.92				.66				
How energy can be saved or used in a more effective way	2.4	.97				.53				
New sources of energy from the sun, wind, tides, waves, etc.	2.3	.96				.47				
How the ear can hear different sounds	2.1	.87					.88			
How the eye can see light and colours	2.2	.90					.78			
How radiation from solariums and the sun might affect the skin	2.2	.96					.60			
How X-rays, ultrasound, etc. are used in medicine	2.2	.93					.60			
How different musical instruments produce different sounds	2.1	.97					.49			
Light around us that we cannot see (infrared, ultraviolet)	2.1	.91					.41			
How radioactivity affects the human body	1.9	.91					.41			
Electricity, how it is produced and used in the home	2.1	.90						.90		

Table 2. Continued ...

			Factor							
	M	S.D.	FI1	FI 2	FI 3	FI 4	FI 5	FI 6	FI 7	FI 8
How to use and repair everyday electrical and mechanical equipment	2.1	.95						.88		
How electricity has affected the development of our society	2.2	.90						.66		
Detergents, soaps and how they work	1.9	.84						.45		
How petrol and diesel engines work	2.1	1.1						.40		
How different narcotics might affect the <u>body</u>	<u>2.7</u>	.97							.88	
How alcohol and tobacco might affect the <u>body</u>	<u>2.6</u>	.94							.86	
The possible radiation dangers of mobile phones and computers	2.3	.95							.36	
How loud sound and noise may damage my <u>hearing</u>	<u>2.4</u>	.91							.33	
Why the <u>stars</u> twinkle and the sky is blue	<u>2.3</u>	.99								.85
Why we can see the rainbow	2.2	.93								.83
How the sunset colours the sky	2.3	.97				.33				.41
Eigenvalue			14.4	3.6	2.4	1.7	1.4	1.0	.8	.9
% of total variance			31.3	7.9	5.2	3.7	3.1	2.2	1.8	1.9

Based on the means of students' responses presented in Table 2, the most interesting physics and chemistry topics for students are related to astronomy: space, stars, planets, meteors, black holes, supernovas and the universe. Less interesting topics relate to technical devices, like optical and musical instruments; electrical and mechanical equipment; petrol and diesel engines; nuclear power plants and communication satellites. However, technical devices dealing with information and communication technologies (mobile phones and computers) are interesting for students. Again the standard deviations were relatively high compared to the mean. This indicates large diversity among the interest of the students.

Although factor analysis helps us in grouping the items, it is also useful to search for possible contexts in items. A closer look at items indicates that different contents are interesting when they are presented in the context of the human body: the feeling of weightlessness and the effects of narcotics, alcohol, tobacco, strong electric shocks and poisons on the human body. However, there are also contents (radiation, hearing, seeing) in human body contexts which are not interesting to students. Some contents in an environmental context are interesting (clean air and safe drinking water and saving of energy) and some are not interesting (greenhouse effect and ozone layer and how they may be affected by humans). It appears that contents which are concrete and near the human body are more interesting than abstract ones.

Comparison of boys' and girls' out-of-school experiences and interest in physics and chemistry topics or interestingness factors are presented in Table 3 and Table 4. In both tables also means (*M*) and Standard deviations (*S.D.*) for factor related sum variables of item scores for boys and girls are presented.

Table 3. Factors measuring students' physics and chemistry related out-of-school experiences and comparison of boys and girls.

	Girls		Boys		*t* 1)	*d* 2)
	M_g	$S.D_g$	M_b	$S.D_b$		
FE1 Science and technology related hobbies or activities	1.8	.54	2.5	.61	971***	0.69^C
FE2 Measuring and observing with simple tools	3.4	.48	3.2	.67	142***	0.34^B
FE3 Observing natural phenomena and collecting objects	2.6	.51	2.3	.57	177***	0.55^C
FE4 ICT use	3.1	.57	3.2	.69	2.7^{ns}	0.16^A
FE5 Camping	2.4	.79	2.5	.79	13***	0.13^A
FE6 Use of mechanical tools	2.7	.74	2.8	.76	213***	0.13^A

1) ^{ns} $p > 0.05$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
2) ^{A} no effect ($d < 0.2$), ^{B} small effect ($0.2 \le d < 0.5$), ^{C} moderate effect ($0.5 \le d < 0.8$), ^{D} large effect ($d \ge 0.8$)

Boys had more science and technology related hobbies or activities than girls and girls more experiences in observing natural phenomena and collecting objects than boys. The effect size measure did not indicate gender difference for the experiences of ICT use, camping and use of mechanical tools. The power of gender difference was 'small' in the factor *Measuring and observing with simple tools*. Boys had more *Science* *and technology related hobbies or activities* than girls, and girls more experiences in *Observing natural phenomena and collecting objects* than boys (moderate effect).

Table 4. Factors measuring students' interest in physics and chemistry topics and comparison of boys and girls

	Girls		Boys		t 1)	d 2)
	M_g	$S.D_g$	M_b	$S.D_b$		
FI1: How technological devices work	2.1	.70	2.6	.78	489***	0.67^C
FI2: Effects of explosive and poisonous objects on the human body	2.1	.67	2.7	.74	476***	0.85^D
FI3: Astronomy and cosmology	2.5	.72	2.6	.75	12***	0.14^A
FI4: Environmental issues	2.3	.74	2.3	.75	$.7^{ns}$	0.00^A
FI5: Physics and chemistry phenomena in human beings	2.2	.61	2.1	.64	9.4**	0.16^A
FI6: Technology in society and in everyday life	1.8	.60	2.4	.68	575***	0.94^D
FI7: Dangerous chemicals and radiation for human beings	2.6	.70	2.4	.77	85***	0.27^B
FI8: Physics and chemistry phenomena in the environment	2.4	.83	2.1	.78	190***	0.37^B

1) ^{ns} $p > 0.05$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
2) ^{A} no effect ($d < 0.2$), ^{B} small effect ($0.2 \le d < 0.5$), ^{C} moderate effect ($0.5 \le d < 0.8$), ^{D} large effect ($d \ge 0.8$)

The most interesting physics and chemistry topics were astronomy and cosmology as well as chemicals and radiation that are dangerous for human beings. Less interesting for the students were topics dealing with technical devices. Boys were much more interested than girls in explosive and poisonous objects and their effect on the human body as well as in technological themes (large effect). Astronomy and cosmology, environmental issues and physical and chemical phenomena in relation to human beings were equally interesting for boys and girls. The effect size measure did not indicate a gender difference for student interest in astronomy and cosmology, environmental issues and physics and chemistry phenomena regarding human beings. The power of gender difference was 'small' regarding dangerous chemicals and radiation for human beings and physics and chemistry phenomena in the environment.

Correlations between factors measuring students' physics and chemistry related out-of-school experiences and interest in physics and chemistry topics (content-based situational interest or disposition type personal interest) are presented in Table 5. In the table, also the power of the Pearson's r is presented

Table 5. Pearson correlation coefficients between factors measuring students' physics and chemistry related out-of-school experiences and interest in physics and chemistry topics

	FI1: How technological devices work	FI2: Explosive and poisonous objects	FI3: Astronomy and cosmology	FI4: Environmental issues	FI5: Phenomena in human being	FI6: S&T in everyday life	FI7: Dangerous for human being	FI8: Phys & chem phen in environment
FE1 experiences of S&T hobby activities	.35***	.37***	.16***	.11***	.13***	.44***	-.17***	-.11***
FE2 experiences of meas. and observing	.11***	.16***	.26***	.23***	.24***	.10***	.21***	.23***
FE3 experiences of nature and collecting	.08***	.14***	.36***	.45***	.38***	.16***	.28***	.41***
FE4 experiences of ICT use	.19***	.22***	.20***	.08***	.11***	.14***	.03	.00
FE5 experiences of camping	.21***	.26***	.20***	.19***	.19***	.26***	.07***	.06**
FE6 experiences of use of big tools	.15***	.22***	.11***	.08***	.10***	.18***	.01	.01

Power of Pearson's r:
no effect at $r < 0.1$; small effect at $0.1 < r < 0.3$;
medium effect at $0.3\ r < 0.5$; large effect at $r > 0.5$

Discussion and conclusions

According to our literature review, a teacher can partly regulate the catch component of situational interest or actualised personal interest (interestingness) and also students can be themselves encouraged to self-regulate interest. Moreover, a teacher can promote the change of situational interest to personal interest by systematically choosing seductive, vivid, coherent and relevant content in an appropriate context and, moreover, guide his or her students to autonomy supporting activities. Once a teacher succeeds in catching the situational interest of his or her students the critical phase is then how to hold it long enough so that it leads to personal interest to engage in learning physics and chemistry. Our aim in this paper was to analyse what out-of-school experiences students frequently had and what they wanted to learn according to their free will. Students' physics and chemistry related out-of-school experiences could reflect physics and chemistry related tasks- or knowledge-based situational interest or tell what they are eager to do. Task-based situational interest of students is reflected in what they want to learn spontaneously. Teachers can use this information (what topics are interesting for students) when they are planning physics and chemistry lessons.

However, we cannot say exactly whether students' responses reflect already existing dispositional interest (individual or personal interest) or conditions of teaching and learning situations that could create interestingness in the topic to be learned. Therefore, we cannot discuss our findings exactly in the framework of different kinds of situational interest, like *content- task-* or *knowledge-based* interest. Students' responses reflect "operating" interest, which Krapp (2007, p. 9) has recently introduced. Consequently, Tables 1 – 4 simply tell us what physics and chemistry related out-of-school experiences are popular and what topics are interesting for boys and girls. Especially valuable for discussion are the topics which have a high correlation with an out-of-school experience factor. Single items and factors were already shortly commented on in the previous chapter, and below some general comments based on the tables are made. The standard deviations were relatively high compared to the mean, and therefore there is a large diversity among the experiences and interest areas of the students.

Students' physics and chemistry related out-of-school activities

It seems that both genders have a lot of experiences of ICT use and the use of simple mechanical tools. Therefore, classroom activities could resemble these activities from the point of view of task- or knowledge-based situational interest. Although there are also statistically significant correlations between these factors and several topic-based interest factors, the correlations are not as high as many others. The "*Camping*" factor was also gender neutral and indicated rather high popularity. Moreover, it had relatively high correlations with several topic factors.

Boys and girls had different out-of-school experiences having loadings to the factor "*Observing natural phenomena and collecting objects*". These activities were more popular with girls than with boys. This factor also had a very high correlation with topic factors: "*Astronomy and cosmology*"; "*Environmental issues*"; "*Physics and chemistry phenomena in human beings*"; and "*Physics and chemistry phenomena in the environment*". On the other hand, boys' factor "*Science and technology related hobbies or activities*" had a very high correlation with topic factors: "*How technological devices work*"; "*Effects of explosive and poisonous objects on the human body*"; "*Technology in society and in everyday life*".

Our findings are in part similar to the findings of Jones, Howe and Rua (2000). They showed that the out-of-school experiences of boys are relevant to physics, whereas those of girls are more closely associated with biology. However, we would like to emphasise that there are also several issues which are relevant to physics and chemistry education that are equally experienced by male and female students.

Based on our literature review students' frequently occurring out-of-school activities could reflect their task- or knowledge based situational interest. Presumably activities similar to students' popular out-of-school activities might help students to catch and even hold interest. Some suggestions are presented in the conclusions below.

How interested are students in learning about physics and chemistry topics?

Topics described in items, like "*Why we can see rainbows*" and "*How the sunset colours the sky*", and which had high loadings to the factor "*Physics and chemistry phenomena in the environment*" are impressive and can be witnessed in nature. However, they were not so interesting for students, especially for boys. On the other hand, topics described in items such as "*How it feels to be weightless in space*" and "*Black holes, supernovas and other spectacular objects in outer space*" and which had high loadings to the factor "*Astronomy and cosmology*" were similarly interesting for both genders. Astronomy and cosmology, in general, seem to be very interesting for both boys and girls.

Girls lowest interest was towards topics described in items such as "Detergents, soaps and how they work" and "Electricity, how it is produced and used in the home", and which had high loadings to the factor "Technology in society and in everyday life." However, these topics were very interesting for boys and, therefore, there was one of the highest gender differences between these items. Boys had the highest interest in topics described in items which had high loading to factors "How technological devices work" and "Effect of explosive and poisonous objects on the human body". There was also one of the highest gender differences among these items (e.g., "How mobile phones can send and receive messages" and "The effect of strong electric shocks and lightning on the human body"). These results indicate that the Science – Technology – Society (STS) context was not felt to be so interesting by students, especially by girls. Therefore, it is no wonder that technology is no longer so important in the STS approach (Aikenhead, 1994, pp. 52-53, Hoffmann, 2002).

The most interesting topics for girls were connected in some way to human beings: "*How different narcotics might affect the body*" and *"How radiation from solariums and the sun might affect the skin"*. These items had high loadings on factors: "*Dangerous chemicals and radiation for human beings*" or "*Physics and chemistry phenomena in human beings*". The gender difference of these two factors was small. It seems that the topics which are interesting for girls are also rather interesting for boys. However, this is not so vice versa. The results, in accordance with the findings of Uitto, Juuti, Lavonen, and Meisalo (2006) from the same ROSE data, show that girls were more interested in the context of human biology and health education and even more generally in living nature, such as animals than boys.

The smallest gender differences were in students' interest in topics described in items such as "*How energy can be saved or used in a more effective way*" and "*The ozone layer and how it may be affected by humans*" having loadings to the factor "*Environmental issues*". Therefore, environmental issues are suitable for school science from the point of view of gender neutrality. However, these topics are not very interesting for students. Furthermore, in the same data Uitto, Juuti, Lavonen & Meisalo (2004) found that girls had a more positive attitude towards environmental responsibility than boys, even if in general pupils found global, large-scale environmental problems far removed from their lives. It is possible that if learning about environmental issues could be connected to pupils' every-day life and the state and health of the nearby environment, the learning of chemistry and physics as well as environmental ecology could become more interesting. It is important to know how environmental data are gathered, how the expert knowledge is used in society, and how an individual can contribute to sustainable development on individual and societal levels in science. Science-related environmental issues could be integrated in school physics, chemistry, biology and geography.

Our findings considering interestingness of science themes and type of activities are rather similar to earlier research findings (e.g. Sjøberg, 2000). However, we would again like to emphasise that there are several topics, contexts and types of activities which are relevant to physics and chemistry education and are also equally interesting to both boys and girls.

Conclusions

Based on our survey results the first challenge is to develop activities or learning tasks for physics and chemistry teaching and learning similar to those out-of-school activities students have and, thereby, taking into account students' task- or knowledge-based situational interest. How can we make physics and chemistry teaching be similar to camping, giving students experiences of nature, collecting, measuring, observing, and ICT use? A simple solution would be to have more site visits, practical work and ICT use in science education. For example Braund and Reiss (2004) argue that access to new materials and to 'real' science and technology or authentic practical work at university or in an industry laboratory can have an effect on both learning and interest. However, the way these activities are organised is more important than the "mechanical" introduction of the activity. Typical to camping activities are the feeling of autonomy and the possibility to solve interesting problems. Success in problem-solving increases a feeling of competence. Moreover, the camping activities are typically organised in a small group. Consequently these activities fulfil psychological needs for *competence*, *autonomy*, and *social relatedness* and are important for the development of personal interest (Krapp, 2003). Therefore, there must be the feeling gained from camping included in physics and chemistry activities. The following suggestions can be implemented based on the "camping metaphor" for physics and chemistry (compare Schraw et al., 2001):

- Offer meaningful choices for students to promote the feeling of autonomy, competence and social relatedness. Offer students experiences of ICT use. When using ICT in science education, it is possible to help students to feel close to peers, offer choices, like possibilities for planning and evaluating ones own activities.
- Select for a topic a context or a framework which enhances imagination or introduces the topic in an interesting framework (see below contexts). Combining storytelling to learning activities could create such a framework.
- Start with topics students already know and continue further onto new topics. Prior knowledge is related positively to interest.
- Encourage students to be active learners so they are productive when camping. Camping should be planned before and during the activity, as there are a lot of possibilities for supporting the feeling of autonomy, social relatedness and competence.
- Help students to understand what is relevant to the learning task. The students should for example be encouraged to set personal goals for the learning task.

The second challenge is to discover how a larger amount of astronomy can be included in school physics and chemistry. This is in parallel with the findings of Osborne and Collins (2001). They indicated also that students would like to learn more about the solar system and the universe.

The third challenge is to increase the role of the human-being context, health education and examples of life sciences in physics and chemistry teaching. For example, ergonomics or anatomy and functioning of the human body might be possible areas. In chemistry, physiological effects of several chemicals can be discussed in the context of the human being. Harms (2002) gives examples in the context of biotechnology, based on surveys, of how science learning could be more interesting for students. He argues that girls are more interested in social and ethical aspects of the topic, boys' interest, however, is directed towards economical and technical aspects. However, these interests are not really knowledge-based, but more are more a kind of curiosity and a general openness towards a new technology.

The fourth challenge lies is in the teaching of technology. Boys like to know more about how technical applications work, but this kind of technical knowledge does not interest girls. However, when considering youngsters' futures, technical applications play a core role in further studies in schools of technology (vocational schools, polytechnics or universities). Thus, it is important to discover more versatile approaches to show the interestingness of technical applications and their importance or relevance to the daily life for all students. Everyone uses technical applications. Therefore, one challenge is to combine usability testing or user-centred design orientation in the teaching and learning of technology. One interesting idea might be to develop this area so that technological applications are looked at more from the point of view of human beings or medical science or biotechnology. Items describing an activity of a human being were interesting for both boys and girls.

In three out of six *physics and chemistry related out-of-school experiences* factors no gender differences were observed (no statistical effect), and in none of the factors there were large differences observed. However, there boys had more science and technology related hobbies or activities than girls, while girls had more experiences in observing natural phenomena and collecting objects than boys. In three out of eight *interest factors in physics and chemistry topics* no gender differences were observed, and in two of the factors large differences were observed. Boys were much more interested in explosive and poisonous objects and their effect on the human body as well as in technological themes. The standard deviations were relatively high compared to the mean. This indicates large diversity among the experiences and interests of the male and female students. Based on the findings of the present study, it is worthwhile being aware that boys and girls as groups have in some out-of-school areas different experiences and in some areas different interests in specific topics and contexts. However, there are areas where both genders have similar experiences or interests. This suggestion is parallel with feminist research in science education which has argued that female students would benefit from a greater diversity in styles and contexts of learning science (Rosser, 1995; Rolin, 2007). Descriptions of interesting contexts could be found in the previous sections.

It is important to understand that the findings of the survey are not absolute; they reflect present-day general trends among young people's perceptions and experiences. Moreover, the results reflect the objects of interest of Finnish boys and girls and the world they experience in relation to science as measured with the questionnaire. However, results of the international ROSE survey (Sjøberg & Schreiner, 2006) indicate that Finnish results may be general in countries having a human development index at the same level as Finland. We suggest to developers of curricula and textbook authors, who have a lot of freedom in choosing different approaches and especially contexts for certain topics, to take the result seriously and implement certain contents and contexts as well as avoiding some of them. In practice classroom situations and learning materials can form the link between interest and learning. We also suggest that teachers' and students' joint-planning can offer a learning environment that promotes students' interest development and the internalisation of the aims and goals of the curriculum in schools (see Byman & Kansanen, in press). In the joint planning process a teacher becomes familiar with interesting topics and students' experiences in the domain to be learned.

Challenges discussed from the point of view of educational material and students' activities should also be discussed in teacher education and professional development projects. In Finnish teacher education, especially, the goal is to reach the "teacher as researcher and autonomous developer of her work" ideal. This means that the outcomes of this study should be combined with a student teacher's reflection and with their pedagogical thesis.

Results of this research do not explain how situational interest develops into a long-standing personal interest (see e.g., Alexander & Jetton, 1996; Krapp, 2002). However, the results offer some viewpoints, about which topics or type of activities can by used to hold situational interest long enough to lead to a motivation to study and about the activities of studying. One interesting approach to physics and chemistry education could be developed by combining technological and human contexts in the activities organised out of school. We will continue with research methodologies that are more complex, qualitative and sensitive than a questionnaire-based study (Osborne, Simon, & Collins, 2003; Kelly, Chen and Crawford, 1998). This explorative study has helped us to recognise relevant research questions in our new Material Science project which is an EU-project that aims to design teaching modules in specific domains related to materials science. The developed modules will emphasise active student engagement, collaborative learning, site visits outside the school and versatile use of ICT in learning. Material science topics also allow us to analyse issues which are interesting for female students, like social and ethical aspects, environmental protection, and advantages and disadvantages of the topic (Harms, 2002). The research questions in our new project deal with the features of the designed modules and how they help students to "catch" and "hold" situational interest during the designed learning activities.

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