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**Abstract.** *The attitudes of lower and upper secondary school students (the 9-11<sup>th</sup> forms, aged 15-17, boys and girls separately) toward natural sciences were investigated by using an inquiry method in Sweden, Finland and Latvia during 1998-2005. Results of this study show, that positive attitudes have decreased from 1998 to 2005 at the 9<sup>th</sup> form both in Latvia and in Sweden. In Finland, an increase among boys, who recognize subjects of the natural circle (except for General Science) as necessary, was observed. The number of positive answers of the Finnish girls was, however, in 2005 much smaller than in 1998. In a special investigation in Latvia was shown, that generally the least interest in the Natural subjects is observed among the 11<sup>th</sup> formers. The findings of this study indicate increased quantity of the respondents denying the importance of natural sciences as a whole, as well as overt difference between boys and girls in estimations of the importance of natural sciences.*

**Key words:** *attitude to science, natural subjects, gender, differences, survey.*

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## SCIENCE SUBJECTS CHOICE AS A CRITERION OF STUDENTS' ATTITUDES TO SCIENCE

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### Introduction

In the last few decades, the number of students in natural sciences and technical programmes has been decreasing in many countries, including ones with high levels of industrial development. This phenomenon leads to not only a reduction in the number of specialists in the above-mentioned fields, but also to a decrease in scientific and economical competitiveness of the country. Due to globalization, this is a very important trend.

Several assumptions and hypotheses have been made in order to explain this phenomenon. Such as, that the level of preparation in comprehensive schools has fallen, or that society has been increasingly dominated by humanitarian ideas already since the 60s and 70s, and in some cases these ideas have acquired extreme forms denying the role of natural sciences in the development of mankind in general. On the other hand, various investigations have been done in the field of natural sciences didactics to find out the factors which determine the students' attitudes toward natural sciences. The content of the natural sciences syllabus is also changing: besides of the classical themes of biology, chemistry and physics, interdisciplinary questions and problems have been added. The investigation of the school's handling of these interdisciplinary problems cannot and should not be confined only to natural science subjects separately, e.g. to chemistry, biology or physics; these problems must be treated from the viewpoint of general nature science didactics.

Various integrated courses appear occasionally, but these are usually short-lived, because there is no long-term commitment from the teachers for making them an integral



part of the curriculum. The reason for the quite low popularity of these integrated courses and in some cases for insufficient effectiveness might be found in the fact that any of the smallest portions of the knowledge may be a non-integrated part of one subject, which is not sufficiently understood and discussed in teacher education.

Gradually, the conceptual approach of applying natural sciences in the context of social and cultural problems is getting stronger. The international competitive project ROSE (The Relevance of Science Education) can be mentioned as a good example. Its main idea is based on the assumption that natural sciences and technologies are important aspects in the processes of all countries, regardless of the level of cultural and material development (Schreiner & Sjöberg, 2004).

However, the attitudes of students toward natural sciences still remain one of the most important problems in this respect. The attitudes, or more precisely motivation, correlate with the above-mentioned trend of reduction in the number of students attending a university (Rekruterung, 1998). Also the choice of the programmes at upper secondary school depends on student's attitudes toward science at lower secondary school (Lindahl, 2003), although there are some other factors, what also affect programme and/or subject selection.

This is why a lot of research has been done on the subject: the specialists are attempting to identify the factors leading to these attitudes, as well as how the factors act and interact.

The aim of the research is to find ways to coordinate these factors in order to change young people's attitude toward natural sciences. For example, it is important to find the factors what cause the respondents to answer: "I have always loved natural sciences" (Gedrovics, 1998). This kind of research requires continued monitoring for a long period of time, so that the mechanisms in how the factors work can be found.

The results of the study were obtained during a period of several years, from 1998 to 2005, by presenting a number of questionnaires to a group of respondents in Latvia, Sweden and Finland. The respondents were students at forms 8-12 in Latvia, and the respondents from Sweden and Finland were at forms 9 and Gy2. The results have been summarized in this paper. The questionnaire consisted of a set of questions charting the students' attitudes toward natural sciences, as well as a question asking what school subjects, in their opinion, should be compulsory for all students in secondary school. We assumed that the answers to this question in the context of other similar questions could, to some extent, at the schools chosen, work as an indicator characterizing the students' attitude toward natural sciences.

### Methodology of Research

The international part of the research was performed during the stay of one of the authors (J.G.) at the University of Linköping, as a scholarship holder of the Visby programme. Questionnaires were used as a basic research method. This way, it was possible to gather a large amount of data with minimal effort. In the questionnaire, the students were presented with a set of school subjects, including all basic, traditional subjects. The task for the students was to choose which subjects, according to their opinion, should be compulsory for all students. Only their choices of natural science subjects as compulsory are presented in this article.

The research took place mainly during autumn term in 2004, apart from Finland (January 2005) and Sweden (half of the data was collected in March 2005). Additionally, the same questions had been asked in Latvia, in connection with earlier research on didactics in natural sciences (2003). This can be regarded as a national part of this research. All questionnaires were processed using the SPSS software, version 12.0.1.

The target group of the research consisted of students with an average age of 15-16 years. Most of them were at the beginning of their studies in secondary school at the time of the research. Students at the 11<sup>th</sup> form in Latvia, two years older, were chosen as a control group. The control groups in Sweden and in Finland comprised of students at the second form of gymnasium (Gy2).



**Table 1. Number of respondents.**

Country, form	Year of research									Total
	1998 <sup>a</sup>			2003/2004 <sup>b</sup>			2004/2005 <sup>a</sup>			
	total	boys	girls	total	boys	girls	total	boys	girls	
LV, 8	-	-	-	112	61	51	-	-	-	112
LV, 9	152	57	90	82	36	46	198	80	109	432
Fi, 9	42	20	21	-	-	-	248	124	124	290
SE, 9	133	51	78	-	-	-	57	33	23	190
LV, 10	-	-	-	98	39	59	-	-	-	98
LV, 11	98	45	52	76	27	49	188	77	105	362
Fi, 11	47	20	27	-	-	-	118	63	54	165
SE, 11	107	30	74	-	-	-	69	39	29	176
LV, 12	-	-	-	96	41	55	-	-	-	96
SE, 12	-	-	-	-	-	-	17	11	6	17
Total	579	223	342	464	204	260	895	427	450	1938

<sup>a</sup> international part of investigation; <sup>b</sup> national part of investigation  
LV – Latvia, Fi – Finland, SE – Sweden

The national part of the research involved students at the 8<sup>th</sup>-12<sup>th</sup> form in Latvia. A brief summary of the respondents in both parts of the research is given in Table 1.

### Results of Research

Research results of science subjects as compulsory subjects in upper secondary school, grouped by the respondents' country, form and gender, are summarized in Table 2. From the data it is evident that the students' preferences between different subjects within natural sciences vary greatly.

For example, in Latvia the number of students at the 9<sup>th</sup> form considering biology, chemistry or physics to be compulsory has decreased significantly during the last six years. In the boys' group, the differences for all three subjects are statistically significant.

In Finland, it can be observed that interest in traditional natural science subjects has increased in the boys' group but in the girls' group a lack of interest has been observed. In chemistry, the difference in the girls' group is statistically significant.

The greatest difference during this period of 6 years can be seen in opinions of the students at the 9<sup>th</sup> form in Sweden. In fact, the difference could be caused to some extent by insufficient care, while filling in the questionnaires. The fact that Swedish students, both boys and girls, have marked only some subjects, often only 3-7 out of the 17 proposed, could serve as evidence indicating this.

However, it should be observed that in Swedish schools, the teaching and learning process have been organized around programmes for several years. This means that while a wide range of subjects are available only in total; the subjects available for each student depend on the programme they have chosen at the beginning of studies and they are not allowed to choose separate subjects.

In Latvia, the conception of a compulsory subject of the 11<sup>th</sup> form (Gy2) students is different in comparison with the conception of the students in lower secondary school. Thus, for example, in the boys' group, the number of students admitting the necessity of studying natural sciences has increased. Meanwhile, a decline in interest can be observed in the girls' group.



**Table 2. Science subjects as compulsory subjects in Upper secondary school.**  
Number of agreed answers, in per cent

## a) Form 9

Subjects	Year,		1 9 9 8						2 0 0 4 / 2 0 0 5					
	country		Latvia		Finland		Sweden		Latvia		Finland		Sweden	
	boys	girls	boys	girls	boys	girls	boys	girls	boys	girls	boys	girls		
Biology	78.9*	57.8	50.0	76.2	70.6*	50.0*	51.3*	54.1	67.7	72.6	6.1*	8.7*		
Physics	93.0*	68.9	50.0	57.1	35.3*	37.2	73.8*	63.3	60.5	40.3	6.1*	0		
Chemistry	86.0*	70.0	50.0	66.7*	35.3*	39.7*	57.5*	61.5	60.5	41.1*	6.1*	0*		
Science	45.6	41.1	45.0	42.9	21.6*	33.3*	40.0	36.7	28.2	26.6	3.0*	13.0*		
Geography	77.2	70.0	40.0*	66.7	39.2*	57.7*	78.8	68.8	68.5*	65.3	9.1*	17.4*		
Mathematics	94.7	92.2	50.0*	76.2	60.8*	83.3*	91.3	94.5	91.1*	79.8	24.2*	26.1*		

## b) Form 11 (Gy2)

Subjects	Year,		1 9 9 8						2 0 0 4 / 2 0 0 5					
	country		Latvia		Finland		Sweden		Latvia		Finland		Sweden	
	boys	girls	boys	girls	boys	girls	boys	girls	boys	girls	boys	girls		
Biology	46.7	86.5*	60.0	85.2	29.4	50.0	61.0	59.0*	68.3	74.1	25.6	24.1		
Physics	53.3	73.1*	80.0*	51.9*	40.0	24.3	68.8	56.2*	52.4*	27.8*	30.8	10.3		
Chemistry	46.7	73.1	70.0	51.9*	23.3	23.0	57.1	57.1	49.2	25.9*	15.4	6.9		
Science	35.6	63.5*	65.0*	40.7	83.3*	60.8	42.9	45.7*	25.4*	38.9	46.2*	55.2		
Geography	77.8	92.3*	60.0	77.8	66.7*	39.2	76.6	72.4*	68.3	74.1	30.8*	34.5		
Mathematics	84.4	100.0*	85.0	96.3	96.7	90.5	88.3	90.5*	90.5	92.6	92.3	93.1		

\*statistically significant difference in respective group (form, gender) according year of investigation, computed as Independent-samples T test

In Finland, the boys' group interest in biology and geography might have increased slightly. In other cases in Finland, the number of students at the Gy2 form who acknowledge natural sciences as compulsory in secondary school, has decreased in both the boys' and the girls' groups.

In Sweden, an even larger decrease can be observed among the Gy2 students. This may be evidence of diminishing interest in natural sciences.

The data in Table 2 does not, however, provide a complete picture of attitude changes toward school subjects. In their paper, Lamanauskas and Gedrovics (2005) write that the choice of traditional natural science subjects increased slightly from the 8<sup>th</sup> to 10<sup>th</sup> form (Gy1), at the 11<sup>th</sup> form (Gy2) it decreased but at the 12<sup>th</sup> form (Gy3) it slightly increased again.

In this paper, we have described the changes in the choice of school subjects perceived compulsory by boys and girls at different forms in Latvia. As we can see in Figure 1, the girls have marked less subjects as compulsory in upper secondary school when compared with the boys, except for biology and geography at the 9<sup>th</sup> form (in Latvia). It has to be mentioned, that the difference between the boys' and the girls' positive answers, in general, is not significant statistically.

Thus, evaluating the boys' and the girls' answers separately (Figure 1) it can be concluded that the interest about the subjects of natural sciences is increasing until the 10<sup>th</sup> form. After that the interest is decreasing, with a slight increase again at the 12<sup>th</sup> form. This last increase in interest is neither, however, observed in Geography, nor for girls in Physics and Chemistry.

In order to link the choice of subjects to the motivation to acquire knowledge in natural sciences, several other questions were asked. On the basis of the students' answers, we wanted to



get out the subjects what, in their opinion, should be compulsory.

According to the answers given by the respondents to the question about their *interest in natural sciences outside school* it can be seen that, on the whole, that the number of the students who had at least slight, occasional or regular interest in natural sciences outside school was decreased (Figure 2). The number of the students who were not interested in natural sciences at all was increased. The number of the students, who found it difficult to say whether they had an interest in natural sciences outside school or not, was increased even more significantly. Evidently, the interest in natural sciences of the students seemed to be only slight and occasional.

While the number of the boys at the 11<sup>th</sup> form (Gy2) who were regularly to some extent interested in natural science subjects decreased, the number of the girls in the same group increased. So a slight increase of interest in natural sciences can be noticed in the upper secondary school girl group. (Figure 2, c and d). It is an evidence of the situation that in some groups the interest was changing and even increasing. However, it does not confirm the desirable conclusion that students' interest in natural sciences would be increased in general during the research period.

Another question asked the students was connected to natural scientific experiments performed by them after school, including at home. As the information shows (Figure 3) the number of negative answers (*never*) was increased. The only exceptions were the 9<sup>th</sup> forms in Finland and Gy2 in Sweden. The previous level of the year 1998 has been practically retained here.

The analysis of the questionnaires according to gender shows that the greatest increase of answers "never" has been observed in the 9<sup>th</sup> form boys' group and in the 11<sup>th</sup> form girls' group in Latvia, as well as among the boys and girls of Gy2 in Finland. The number of students, who have made at least some experiments outside school was decreased.

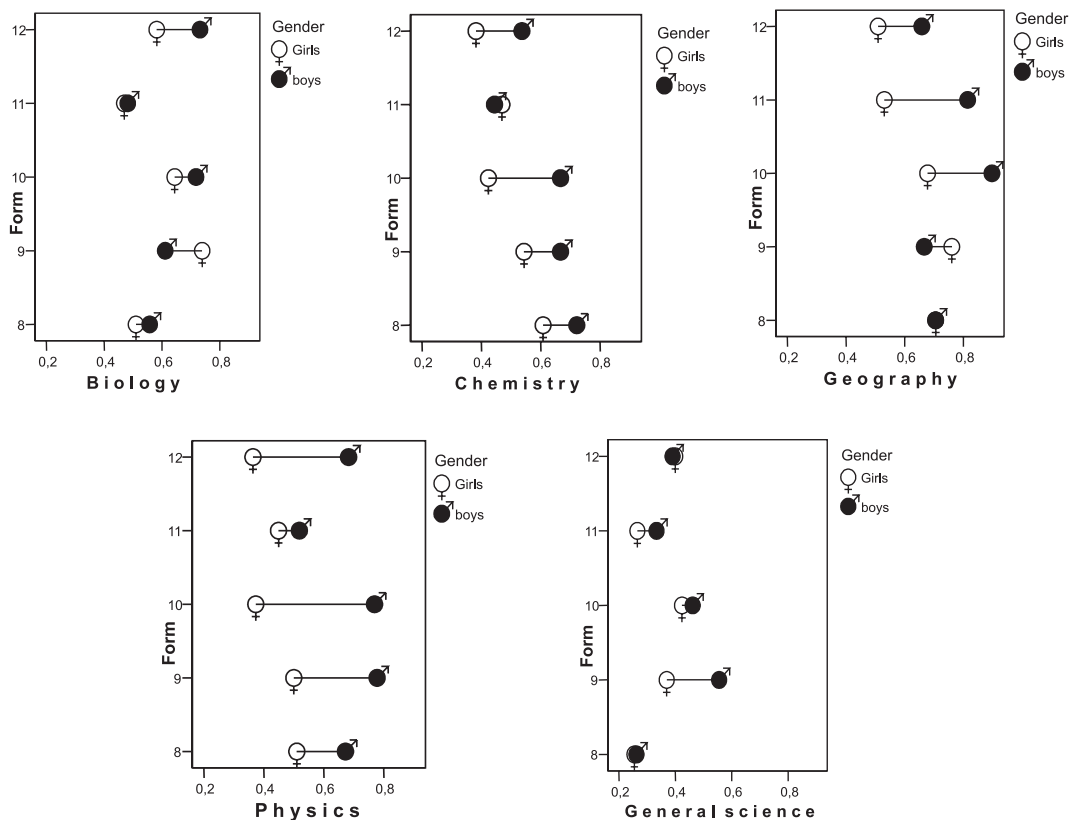


Figure 1. Compulsory school subjects as viewed by Latvian students (the forms 8-12, 2003/2004) On the x-axis are the quotas of respondents (1.0 = 100 %).



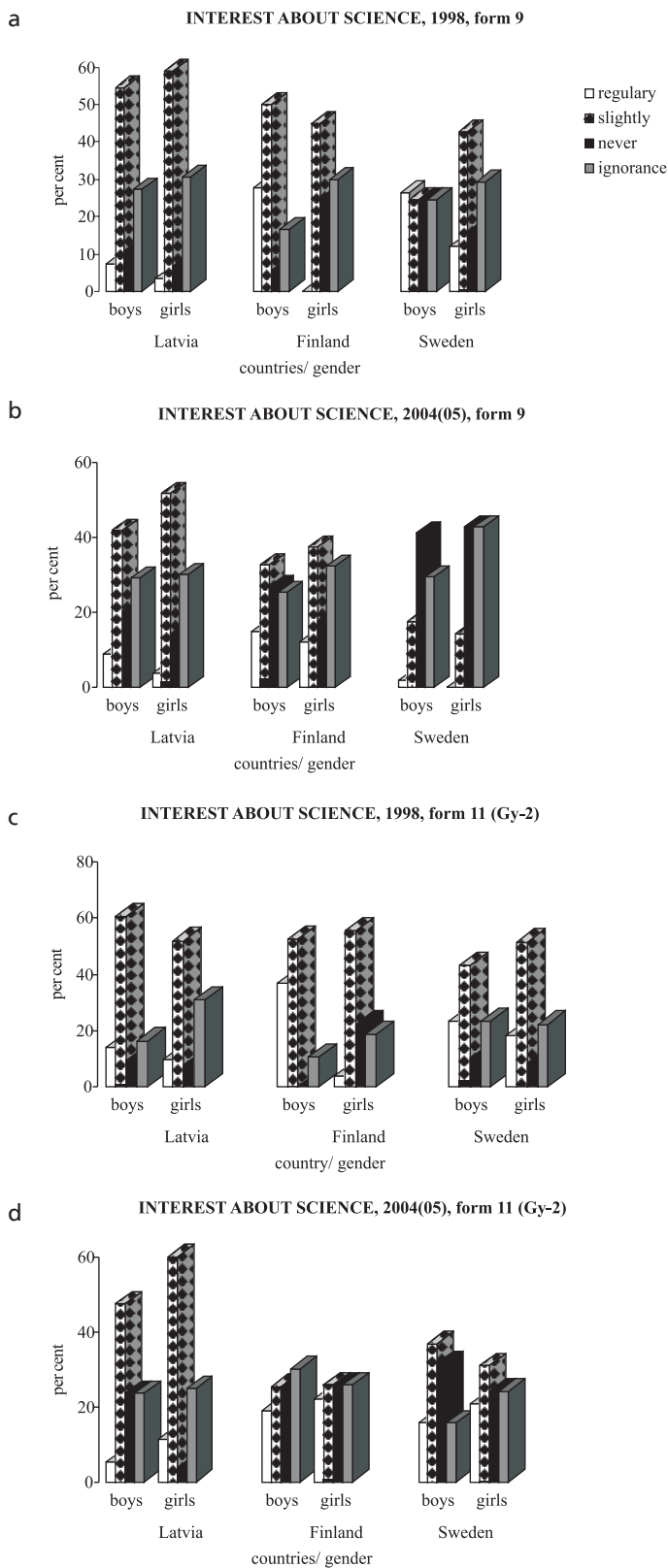


Figure 2. Interest about science outside school.



The situation can be further illuminated by the analysis of the answers to the question: "Do you agree that natural sciences must be studied by all upper secondary school students?" The respondents could choose one of the 6 alternatives (see Table 3). E.g.

It is enough to have an insight into general natural sciences course,

All students must study all natural sciences subjects,

It should be a free choice of students,

Separate subjects first, then the general course and the alternative suggested by the student him/herself.

**Table 3. Studies in science subjects at upper secondary school.**  
Number<sup>1</sup> of respondents, per cent (rounded)

Alternatives of answers	Latvia		Finland		Sweden	
	9	11	9	Gy-2	9	Gy-2
General science course	14/19	14/22	<b>31/10*</b>	<b>15/3*</b>	23/18	43/55
All science subjects for all students	18/20	<b>7/23*</b>	21/32	57/43	<b>26/5*</b>	22/15
Students' free choice	45/38	<b>61/37*</b>	<b>29/9*</b>	<b>21/9*</b>	23/18	18/19
Other	23/23	18/18	19/49	7/45	28/59	17/11

<sup>1</sup> The first number indicate the results from 1998, the second number - the data from 2004/ 2005 year.

\* differences are significant

The results show that, for example, students in Latvia preferred the opportunity to choose the subject by him/herself. Students in Sweden, Gy2 in particular, accepted a general science course. Finnish students, in their turn, supported a general science course (the 9<sup>th</sup> form) and a chosen alternative course (Gy2). The Latvian situation can be explained by the fact that the optional subjects system had been introduced in 90's in Latvia. It was substituted by a programme optional system only in the beginning of the new century.

The programme optional system is well known and has been used in Sweden for several decades. In addition, natural sciences as a core subject have been included in practically into all the programmes of the upper secondary school. The Swedish students do not see any special advantage of choosing separate subjects. Meanwhile, in Finland the system of selecting separate subjects in all natural sciences works successfully. It is distinctly reflected in the Gy2 group in Finland. (Table 3, alternative No 2). Occasionally the recommendations for integrated natural science courses appear, but for different reasons they have not acquired overall acknowledgement. (Gedrovics & Wäreborn, 1999). In the research, 12% of the students at the 9<sup>th</sup> form have indicated the general (partly integrated) course in natural sciences as an alternative to the choice of separate subjects.

The same point of view is expressed by only 2-5% of the respondents in Finland and in Sweden. We have to admit that in the present research in 2004/05 the number of such students has decreased to 8% in Latvia and to 2% in Sweden. In Finland, on the contrary, the number of the students who would like to study a general course in natural sciences is going up to 37% at the form Gy2 and up to 41% at the 9<sup>th</sup> form.

It may be mentioned that during the 6 years research period statistically significant differences were observed in the students' answers at the 11<sup>th</sup> form in Latvia as well as in Finland, partly also in Sweden at the 9<sup>th</sup> form respondents' group.

In the present research, the respondents have also been asked to describe their favourite subject in the group of natural sciences. (*Like subject very much, quite much, do not like it very much, do not like it at all*). They were also asked to characterize their knowledge. (*Good, average, bad*). Within the different countries and forms correlation coefficients have been calculated. We found for 1998 13 significant ( $p < 0.01$  or  $p < 0.05$ ) cases of correlation between *knowledge* and *liking* and 4 non-significant, and for 2004/2005 14 significant cases and 3 non-significant.



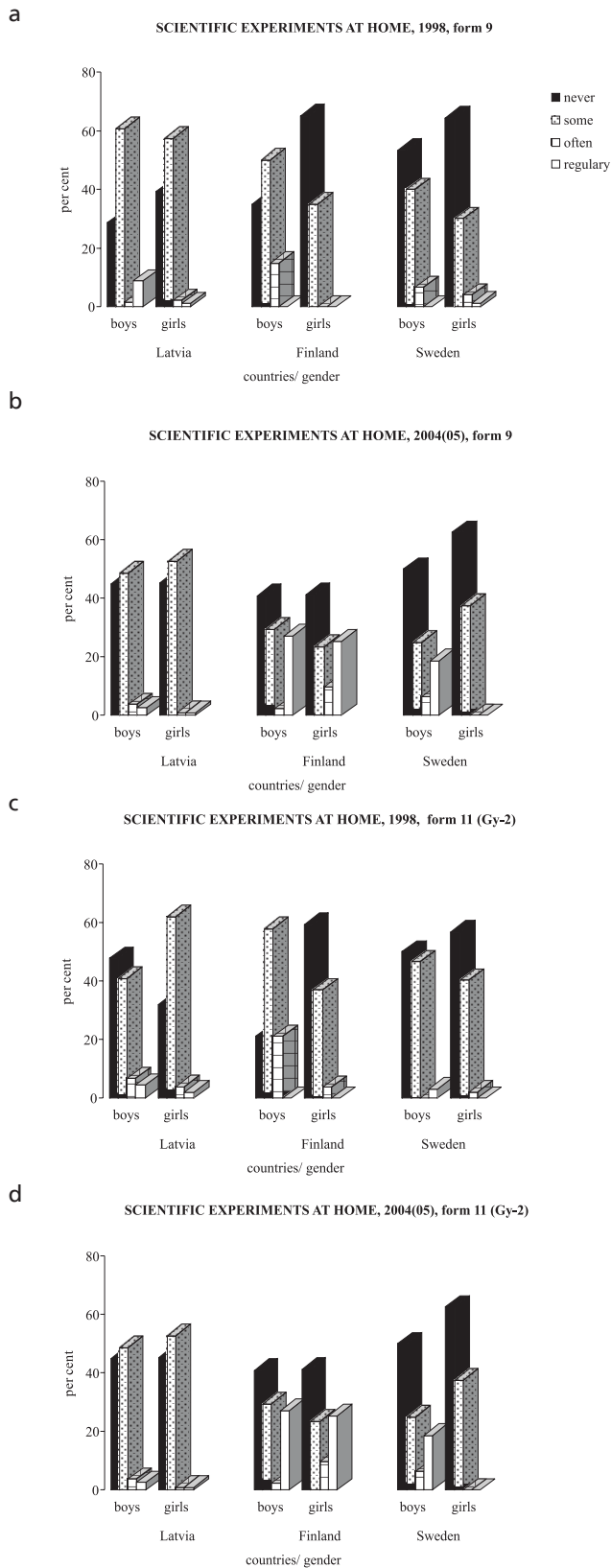


Figure 3. Scientific experiments outside school.





significant ( $p < 0.01$  or  $p < 0.05$ ) cases of correlation between *knowledge* and *liking* and 4 non-significant, and for 2004/2005 14 significant cases and 3 non-significant.

Thus, according to these results, self-evaluation of student's knowledge correlates with the respondents' favourite subject in natural sciences. Liking may here be synonymous with interest in a subject; the positive or negative attitude toward a subject is not exactly the same, because attitude may also depend on the students opinion about how important the subject is for his/her career.

The last question which was asked the respondents at different study levels was: "Would you like to become a nature scientist or engineer?" (Table 4).

**Table 4. Future job as scientist or engineer.**

Number<sup>1</sup> of respondents, per cent (rounded)

Alternatives of answers	Latvia			Finland			Sweden			
	9	11	ROSE <sup>2</sup>	9	Gy2	ROSE	9	Gy2	Gy3	ROSE
Yes	9/11	11/14	<b>25</b>	7/13	15/19	<b>20</b>	19/9	24/19	-/35	<b>20</b>
No	49/47	58/47	-	51/31	49/25	-	50/70	39/52	-/35	-
I don't know	42/42	32/35	-	42/56	36/56	-	31/22	37/29	-/29	-

<sup>1</sup> The first number indicate the results from 1998, the second number - the data from 2004/ 2005 year.

<sup>2</sup> Data from International comparative project ROSE (Schreiner & Sjøberg, 2004).

The results show that at the 9<sup>th</sup> and 11<sup>th</sup> form (Gy2) students expressed the wish to become a scientist or an engineer quite rarely. A big number of the students have marked the answer – *I do not know if I want to become a scientist or an engineer*.

It has to be said that the figures obtained from the Internationally Comparative Project ROSE (Schreiner & Sjøberg, 2004) give affirmative answers of the similar questions and confirm the idea expressed above – in industrially highly developed countries young people do not show a sufficient interest in studies and future work in many scientifically capacious spheres (Schreiner & Sjøberg, 2005).

## Discussion

The findings of this study indicate that attitudes of the Lower and Upper secondary school students from Latvia, Sweden and Finland toward natural science subjects have not changed much during the last 6 years.

The findings here are similar as presented by Dahlbom (1988) who investigated students' perception of Physics. She writes that there are different reasons for the stability of attitudes toward Physics: *developmental psychological reasons (the importance of early education), pedagogical reasons (content in and methodology of School Physics), and socio-psychological (and other) environmental factors*. The same basic reasons can, maybe, also to be applied students' attitudes toward the other natural science subjects. As it has been shown in a former research (Gedrovics, 1999) student-teachers and even teachers preserve conceptions created in their early youth. That is why it is especially important that the development of the perception of natural sciences is based on the conceptions of natural sciences didactics and its



research. High quality teacher's work is extremely important.

The trends of the development of students' conceptions of natural sciences are also connected to the fact that many adolescents admit natural sciences to be interesting but not meaningful for them (Jenkins & Nelson, 2005). Young people want to use and use the innovations of contemporary science and technology, but they are not eager to be involved into development processes of these facilities (Rekrutering, 1998). That is why one of the most important tasks still is to organize teaching of natural sciences not only in a more attractive way, but especially to make it meaningful (Schreiner & Sjøberg, 2005).

Of course, it is not easy to define all the reasons why the young people's interest about natural sciences is decreasing. It is not precisely clear what factors and to what extent have effects on the attitudes toward natural sciences or what are the forms of expressing these attitudes. That is why any indicator enhancing the evaluation of attitude changes is to be considered.

The students' wish to study (or not to study) natural science subjects in a secondary school, where selection facilities of subjects and courses or educational programmes are available, could be one of these factors.

We must admit though that some research reports show that students mostly object not to the school subjects as such, but to their content or separate components of the content and the way how the subjects are taught and learned. For example, the students point out that some topics are very strenuous (*Biology, Geography*), there are plenty of complicated concepts and definitions (*Biology, Physics*), too much chemical (*Chemistry*) and mathematical formulas (*Physics*), too few laboratory tasks (*Physics, Biology, Chemistry*) etc. (Lamanauskas, Gedrovics & Raipulis, 2004; Lamanauskas & Gedrovics, 2004). It is shown indirectly by observation that, at the beginning of chemistry studies, students' interest is quite high, but after some time the interest falls (Bartusevica, 2004). The reason is maybe, that chemistry is not only a science of outer, visual effects but also a science of deeper, underlying principles what are difficult to explain in an interesting way.

## Conclusions

1. During the 6 research years, groups of students in Latvia, Sweden and Finland showed a rather stable but quite reserved attitude in general towards the natural science subjects.
2. The boys' interest about acquiring natural sciences subjects is still a bit higher comparing to the girls' almost in all respects, often these differences are, however, not statistically significant.
3. The choice of school subjects is determined partly by the previous studies, experience and the peculiarities of educational system organization in a particular country.
4. The choice of the school subjects, alongside with other factors, can serve as a qualitative indicator of students' attitude towards natural sciences.

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## Резюме

# ВЫБОР ПРЕДМЕТОВ ЕСТЕСТВЕННОНАУЧНОГО ЦИКЛА КАК КРИТЕРИЙ ОТНОШЕНИЯ УЧАЩИХСЯ К ЕСТЕСТВОЗНАНИЮ

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Методом анкетирования изучено изменение отношения учащихся 9-11 классов Латвии, Швеции и Финляндии к естествознанию (1998-2005 гг.). Основной акцент ставился на то, какие из предметов естественнонаучного цикла (*география, биология, физика, химия и естествознание* как частично интегрированный предмет) следовало бы изучать в средней школе в качестве обязательных для всех учащихся. Ответы отражают, как естествознание в целом оценивается данной возрастной группой учащихся.

Результаты исследования свидетельствуют о том, что за период 1998-2005 гг. позитивное отношение к естествознанию уменьшилось среди учащихся 9-х классов как в Латвии, так и в Швеции, т.е. количество учащихся, признающих обязательность этих предметов, в 2005 г. уменьшилось по сравнению с 1998 годом, за исключением *географии*, для которой отмечен незначительный прирост интереса. Резкий спад интереса отмечается у мальчиков, хотя в целом их большая часть все же признаёт обязательность этих предметов в средней школе. Однако в Финляндии среди мальчиков наблюдается увеличение количества тех, кто осознаёт необходимость этих предметов за исключением *естествознания*. Количество положительных ответов девочек в Финляндии в 2005 г. было значительно меньше, чем в 1998 г.

В дополнительном исследовании, проведенном в Латвии, обнаружено, что наименьший интерес к естествознанию проявляют учащиеся 11 (предпоследнего) класса (как мальчики, так и девочки). К концу обучения в средней школе (12 класс) количество учащихся, признающих обязательность этих предметов, снова увеличивается, не достигая, однако, уровня 9-10 классов.



Полученные данные подтверждают не только постоянное увеличение количества респондентов, отвергающих значение естествознания как такового, но и все более и более ярко проявляющееся расхождение между взглядами мальчиков и девочек на значение естествознания.

**Ключевые слова:** отношение к естествознанию, естественнонаучные предметы, пол, различия, опрос.

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