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Postoje žáků k výuce fyziky v České republice – vybrané výsledky

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Abstrakt

Článek se zabývá vybranými výsledky dotazníkového šetření, které bylo provedeno v letech 2006 až 2008 v České republice. Šetření se zúčastnilo téměř 1900 žáků druhého stupně základních škol (příp. odpovídajících ročníků víceletých gymnázií) a více než 2000 studentů středních škol. Respondenti vyjadřovali své názory pomocí čtyřstupňové Likertovy škály na tvrzení, která se týkala příčin, proč se učí fyziku, a obecných témat a aktivit, které by chtěli (nebo nechtěli) dělat v hodinách fyziky. Odpovědi byly analyzovány podle typu školy a pohlaví respondentů. Hlavní nálezy a závěry jsou zmíněny a diskutovány v článku.

Klíčová slova: postoje k učení se fyzice, dotazník, důvody proč se učit, aktivity ve výuce fyziky.

Selected Attitudes of Students to Physics at School in the Czech Republic

Abstract

The article deals with some of the results of questionnaire research conducted during the years 2006–2008 in the Czech Republic. Almost 1900 students of lower secondary schools and more than 2000 students of upper secondary schools scaled their opinions on statements about reasons why they learn physics and about general topics and activities which they would like (or dislike) to do in their physics lessons. The answers were analyzed according to the type of school they attend and their sex and were scaled using 4-point Likert scale. Main findings and conclusions are mentioned and discussed in the contribution.

Key words: attitudes to physics learning, questionnaire, reasons why to learn, activities in physics lessons.

1 Introduction

Although physics is one of the most important fields for the development of our civilisation, it is one of the least popular subjects at schools in many European countries (European Commission, 2004). It is obvious that the study itself of this field motivates students little for their future career in the field of natural sciences and technical disciplines.[1] Universities focusing on the study of natural sciences and above all physics face a decreasing number of applicants. We encounter this phenomenon also at the Faculty of Mathematics and Physics at Charles University in Prague (Czech Republic).

The indicated trend of the decreasing interest in physics, technical study fields and natural science can be traced for many years in the original states of the European Union. It is indicated mainly by the decrease of people choosing their professional career in the field of natural sciences and technologies (European Commission, 2004). As it is stated by Kennedy (1993) there is "a clear association between economic performance and the numbers of engineers and scientists produced by a society". As there is a need to increase the number of students who choose their future profession in the field of natural sciences or technical professions, the research of the students' attitudes towards the mentioned study areas comes to the forefront.

2 Theoretical Background and State of the Art

According to Gardner (1975) it is necessary to distinguish between "attitudes towards science" and "scientific attitudes". Scientific attitudes means eg. (Osborne, 2003) respect to logic, a demand for verification etc. These attitudes include various cognitive skills. Attitudes towards science include (Osborne, 2003):

- the perception of science teachers,
- anxiety toward science,
- the value of science,
- self-esteem in science,
- motivation towards science,
- enjoyment of science,
- attitudes of peers and friends towards science,
- attitudes of parents towards science,
- the nature of the classroom environment,
- achievement in science
- fear of failure in course.

Previous studies mainly from Europe (The Relevance of Science Education, 2006; Sjøberg, 2006; Jenkins, 2006) focused on the indication of attitudes towards natural sciences and technical disciplines from different viewpoints. According to these viewpoints, we can classify the examined attitudes into three groups:

[1] Natural sciences and technical disciplines are further in the text denoted only with NS and TD.

- *attitudes, opinions and perception of NS and TD generally*, including opinions on scientists, perception of research and its importance for the society and every-day life;

- *attitudes, opinions and perception of NS and TD at school*, it means attitudes towards subjects closely connected with NS and TD;

- *attitudes to career in NS and TD.*

An inseparable part of the research results is also the gender viewpoint.

Various kinds of research conducted in Europe focusing on the attitudes and motivation to the study of NS have been dealing mainly with the following questions:

1. Do students have different attitudes towards particular subjects (such as biology, chemistry and physics) within NS?

2. Do they perceive these subjects as interesting or difficult?

3. Which topics connected with NS are perceived by students as interesting?

4. Is the attitude to NS generally and to NS learnt at school different?

5. Do students perceive the subject matter presented at school as useful for their future life and career?

3 Research Aims and Questions

The Department of Physics Education at the Faculty of Mathematics and Physics at Charles University has been dealing, in the framework of the national grant project of the National Research Programme II of the Ministry of Education, Youth and Sports[2] (No. 2E06020) with the question what are the factors that make physics to be rather an unpopular subject.

The aim of the whole research mentioned above focused on the interest, experience and attitudes towards physics and classes of physics is to increase the interest of students in physics. In the research monitoring the present state, we try to find ways to make physics more attractive and interesting, and to be perceived by students as a source of useful information for their every-day life. We would like the students to see physics not only as a necessary evil, as they perceive it in many cases unfortunately.

The main goal of this study is to determine opinions of students regarding physics lessons with a closer focus on the follwoing areas:

- reasons why students learn physics,

- general topics which students would like (or dislike) to do in physics classes,

- learning activities which students would like (or dislike) to do in physics classes.

[2]The original abbreviation for 'the National Research Programme II of the Ministry of Education, Youth and Sports' is 'NPVII MŠMT'.

In all three cases, experts in the fileds of Pedagogy and Didactics of Physics formulated relevant contents of the given areas, i. e. relevant reasons, topics and activities, to which students should make comments. Within the research, the students expressed the extent of they approval (or disapproval) with the particular statements.

Another goal of the study is to outline how the found opinions can be used to support students' motivation to study physics.

Design of the research draws attention to the students' opinions and falls in the so called "student voice", as it is percieved by Jenkins (2006), when citing Reiss (2000): "School science education can only succeed when pupils believe that the science they are being taught is of personal worth to themselves."

Research questions of this study are:

1. What are the strongest and the weakest reasons (from the offered) students learn physics?

2. To which of the offered general topics would students like to concentrate in physics lessons?

3. Which of the offered activities would students like to undertake in physics lessons?

For each of the above mentioned questions, we investigated differences between various age groups of students and differences between boys and girls. Age and gender seems to be most significant variables which influence to the greatest extent pupils' attitude to science. Gardner (1975) says that "probably sex is the most significant variable related towards pupils' attitude to science". Jenkins (2006) considers as more dominant age when talking about younger elementary school pupils. According to previous studies (see Osborne, 2003), the age when there is a deep decrease in the interest in science was identified as 11 and 14 years.

4 Methods

We decided to use questionnaire as a research method.[3] The participating students were offered statements formulated and chosen by experts from the areas of Pedagogy and Didactics of Physics. The statements were based on previous research conducted in Europe (Lavonen et al.; Jenkins, Williams, ROSE project).

The investigation was conducted in the framework of the project called "Physics Education for a Versatile Preparation and Development of Human Resources at the Primary and Secondary School Level", which is a part of the National Research Programme II. The research team is from the Department of Physics Education MFF UK. The survey took place from October 2006 to March 2008 in the following phases:

- creation of the first version of the questionnaire

- inner review of the first version

[3]The whole questionnaire contained about 150 items which were concerning several parts: topics and activities which students would prefer in physics lessons, motivation towards physics learning, occupation connected with physics or technology, etc. Results concerning only several parts are mentioned below. Other results are presented for example in (Dvořák, et al., 2008).

- external review of the adjusted version
- selection and addressing of schools
- pilot study (at lower secondary schools[4] one-level, at upper secondary schools[5] two-level)
- administration (spring 2007)
- statistical processing
- interpretation of the obtained data

The aim of the selection of respondents was to obtain a representative sample of students of lower secondary schools and students of upper secondary schools in the Czech Republic, where it is probable that the students will choose their future career in the field of NS and TD. The most suitable schools meeting this criterion are above all grammar schools (included in LSS or USS, according to the age of students) and schools of technical field (included in USS). The elementary schools (included in LSS) were chosen from all regions of the Czech Republic and towns of various size.

Table 1: The selection of schools, classes and students

number of	**LSS**	**USS**	**sum**
schools	42	47	89
classes	84	99	183
students	1 886	2 348	4 234
notices	from all 14 regions of the Czech Republic villages and towns of various size	27 grammar schools, chosen from Bohemia, Moravia and Prague 20 schools of technical field	

The sample of respondents we obtained is representative in term of the age of students, type of school, and locality.

Using methods of statistics, we investigated (for each item)

- **arithmetic mean** of evaluation of every item made by students
- **standard deviation** of evaluation of every item made by students
- **statistical significance of the differences** in the average evaluation made by various groups of students using Kolmogorov-Smirnov test (Anděl, 2003; Marsaglia, G. et al., 2003).

[4]Lower secondary schools (students at the age from 12 to 15 years) is further in the text denoted only with LSS.

[5]Upper secondary schools (students at the age from 16 to 19 years) is further in the text denoted only with USS.

5 Findings

5.1 Reasons Why Students Learn Physics

5.1.1 Introduction

The part of the questionnaire, which was used to obtain data about reasons why students learn physics, included the following statements: I learn physics because — I want to have good marks; my parents want me to have good marks; I will need physics later on when studying at secondary school or university; I like physics; I think that physics is important; my parents think that physics is important; I want to know how things around me work; I will need physics in my future profession. These statements were formulated and chosen by experts from the areas of Pedagogy and Didactics of Physics and based on previous research in Europe.

Table 2: The statements in the questionnaire — reasons why students learn physics

I learn physics because...	I agree very much	I rather agree	I rather disagree	I completely disagree
I want to have good marks (R1)				
my parents want me to have good marks (R2)				
I will need physics later on when studying at secondary school or university (R3)				
I like physics (R4)				
I think that physics is important (R5)				
my parents think that physics is important (R6)				
I want to know how things around me work (R7)				
I will need physics in my future profession (R8)*				

The questionnaires designed for LSS students do not include the last statement R8 (*). The respondents expressed their rate of agreement or disagreement with the statements using the four-level Likert Scale:
I agree very much – 1
I rather agree – 2
I rather disagree – 3
I completely disagree – 4

5.1.2 General Focus

Table 3 presents arithmetic means and standard deviations for particular statements – reasons "why I learn physics" (R1 to R7), starting with the smallest one (the most agreeing evaluation).

Conclusion 1: *The strongest* reasons are *I want to have good marks* ($R1$) and *My parents want me to have good marks* ($R2$). *The weakest* reasons are *I like physics* ($R4$) and *My parents think that physics is important* ($R6$).

Table 3: Evaluation of particular reasons made by all students

reason (strongest first)	**arithmetic mean**	**standard deviation**
$R1$	1.83	0.82
$R2$	2.08	1.00
$R3$	2.33	1.06
$R5$	2.33	0.90
$R7$	2.43	1.06
$R6$	2.61	0.97
$R4$	2.70	1.03

The obtained information differs regarding particular groups of students. We assumed that there were differences between students depending on

- students' sex in relation to the type of school
- type of school (between LSS and USS).

These differences are discussed in the following text.

5.1.3 Comparison Based on Students' Sex in Relation to the Type of School

Table 4: Arithmetic means of evaluation made by four groups — LSS girls, LSS boys, USS girls, and USS boys

reason	**LSS**		**USS**	
	girls	**boys**	**girls**	**boys**
$R1$	1.58	1.65	1.89	2.08
$R2$	1.82	1.76	2.44	2.23
$R3$	2.09	1.87	2.92	2.39
$R4$	2.73	2.29	3.12	2.66
$R5$	2.38	2.06	2.61	2.27
$R6$	2.41	2.20	3.04	2.72
$R7$	1.97	1.79	3.19	2.63
$R8$	–	–	2.11	1.90

Conclusion 2: *The strongest* reasons of girls attending LSS and boys attending LSS are the same — *I want to have good marks* ($R1$) and *My parents want me to have good marks* ($R2$). *The weakest* reasons at LSS boys and LSS girls are also the same — *I like physics* ($R4$) and *My parents think that physics is important* ($R6$).

There is not a difference in LSS as it is between girls and boys in USS: *The strongest reason* stated by girls in USS is *I want to have good marks* ($R1$) followed by the reason *I will need physics in my future profession* ($R8$). Regarding boys, the order of the strongest reasons is other way round. *The weakest reasons* for girls in USS are *I want to know how things around me work* ($R7$) and *I like physics* ($R4$), while boys in USS consider the weakest reason *my parents think that physics is important* ($R6$) and *I like physics* ($R4$). Table 4 outlines that the evaluation of girls of LSS and USS is (except for $R1$) worse than in comparison with boys of LSS and USS. In the following part, the statistical significance of the differences is calculated.

Table 5: Statistical significance of the differences in the average evaluation made by LSS girls (group 1; 843 students) and LSS boys (group 2; 931 students)

reason	max. negative difference	max. positive difference	p-level	arith. mean 1	arith. mean 2	stand. dev. 1	stand. dev. 2
$R1$	-0.03	0.00	> 0.100	1.58	1.65	0.71	0.80
$R2$	0.00	0.04	> 0.100	1.82	1.76	0.92	0.89
$R3$	0.00	0.13	< 0.001	2.09	1.87	0.92	0.92
$R4$	0.00	0.20	< 0.001	2.73	2.29	1.04	1.08
$R5$	0.00	0.17	< 0.001	2.38	2.06	0.89	0.90
$R6$	0.00	0.12	< 0.001	2.41	2.20	0.95	0.94
$R7$	0.00	0.11	< 0.001	1.97	1.79	0.91	0.91

Conclusion 3: Based on the Kolmogorov-Smirnov test, we can say that the agreement with all reasons except reasons $R1$ and $R2$ between LSS girls and LSS boys is from the statistical point of view significantly different ($p < 0.001$). *LSS girls agree with the reasons $R3$–$R7$ less than LSS boys.*

Table 6: Statistical significance of the differences in the average evaluation made by USS girls (group 1; 957 students) and USS boys (group 2; 1 268 students)

reason	max. negative difference	max. positive difference	p-level	arith. mean 1	arith. mean 2	stand. dev. 1	stand. dev. 2
$R1$	-0.09	0.00	< 0.001	1.89	2.08	0.78	0.86
$R2$	0.00	0.10	< 0.001	2.44	2.23	1.02	0.98
$R3$	0.00	0.23	< 0.001	2.92	2.39	1.04	1.02
$R4$	0.00	0.22	< 0.001	3.12	2.66	0.89	0.97
$R5$	0.00	0.19	< 0.001	2.61	2.27	0.86	0.87
$R6$	0.00	0.15	< 0.001	3.04	2.72	0.87	0.91
$R7$	0.00	0.25	< 0.001	3.19	2.63	0.87	0.95
$R8$	0.00	0.12	< 0.001	2.11	1.90	0.80	0.79

Conclusion 4: Based on the Kolmogorov-Smirnov test, we can say that the agreement with all the reasons between USS girls and USS boys is from the statistical point of view significantly different ($p < 0.001$). *USS girls agree with reasons $R2$–$R8$ less than USS boys. Girls more agree with reason $R1$ — I want to have good marks — than boys.*

5.1.4 Comparison Based on Type of School

Conclusion 5: *The strongest* reasons of students attending LSS and USS are the same — *I want to have good marks* ($R1$) and *My parents want me to have good marks* ($R2$). *The weakest* reasons of students of LSS and USS are *I like physics* ($R4$) and *My parents think that physics is important* ($R6$). At USS students, the weakest reason is also *I want to know how things around me work* ($R7$). Regarding reason $R7$, there is the greatest decrease in the evaluation between LSS and USS — by 1 degree.

Table 7: Arithmetic means of evaluation made by two groups of students — LSS (1 792 students) and USS (2 265 students)

reason	LSS	USS
$R1$	1.62	2.00
$R2$	1.79	2.32
$R3$	1.98	2.62
$R4$	2.50	2.86
$R5$	2.22	2.42
$R6$	2.30	2.86
$R7$	1.88	2.88

Table 7 outlines that the evaluation of students of USS is worse than in comparison with students of LSS. In the following part, the statistical significance of the differences is calculated.

Table 8: Statistical significance of the differences in the average evaluation made by students of LSS (group 1) and students of USS (group 2)

reason	max. negative difference	max. positive difference	p-level	arith. mean 1	arith. mean 2	stand. dev. 1	stand. dev. 2
$R1$	-0.24	0.00	< 0.001	1.62	2.00	0.76	0.83
$R2$	-0.23	0.00	< 0.001	1.79	2.32	0.90	1.01
$R3$	-0.28	0.00	< 0.001	1.98	2.62	0.93	1.06
$R4$	-0.16	0.00	< 0.001	2.50	2.86	1.08	0.96
$R5$	-0.10	0.00	< 0.001	2.22	2.42	0.91	0.88
$R6$	-0.25	0.00	< 0.001	2.30	2.86	0.95	0.91
$R7$	-0.43	0.00	< 0.001	1.88	2.88	0.91	0.96

Conclusion 6: Based on the Kolmogorov-Smirnov test, we can say that the agreement with all the reasons between LSS students and USS students is from the statistical point of view significantly different ($p < 0.001$). *USS students agree with all the reasons less than LSS students.*

5.2 General Topics and Activities which Students Would Like (Or Dislike) To Do

5.2.1 Introduction

In order to find out motivational acitivities we have analyzed two parts of the questionnaire which concerned general topics which students would like to deal with and acitvities which students would dis/like to do in physics classes. For expressing students' rate of dis/agreement four-level Likert scale have been used (see Table 9).

From the range of statistical methods we used: arithmetic mean of evaluation of every item made by students, statistical significance of the differences in the average evaluation made by various groups of students using Kolmogorov-Smirnov test (Anděl, 2003).

5.2.2 General Focus

In this part of the questionnaire, the students were to express which of the general topics they would like to deal with in classes of physics. Statements which were formulated and chosen by experts are shown below:

Table 9: The questionnaire statements concerning general topics of physics lessons students would like to focus on

During physics lessons I would like to focus on...	I agree very much	I rather agree	I rather disagree	I completely disagree
skills useful for life ($F31$)				
principles of functioning of things around ($F32$)				
essential physical inventions ($F33$)				
topics necessary for entrance examinations for universities ($FZ34$)				
applications in technical fields ($F35$)				
lives of scientists and historical connections ($F36$)				
measure devices and their use ($F37$)				
methods used by scientists ($F38$)				
links with other fields ($F39$)				

The questionanaire for LSS students was adjusted, so that items $F34$, $F35$, $F38$ were ommited.

Table 10 presents arithmetic means for particular statements for LSS and USS students.

Table 10: General focus — evaluation of statements made by LSS and USS students (1 = strongly agree)

statement	**arithmetic mean**	
	LSS	**USS**
$F31$	1.59	1.29
$F32$	1.88	1.62
$F33$	2.05	2.20
$F34$	–	1.98
$F35$	–	2.28
$F36$	2.69	2.91
$F37$	2.16	2.45
$F38$	–	2.49
$F39$	2.37	2.26

Conclusion 7: Students attending LSS and USS are the most interested in activities and topics which concerning everyday life: *During physics lessons I would like to*

focus on skills useful for life ($F31$) and *on principles of functioning of things around* ($F32$). The weakest assessment of students of LSS and USS are *lives of scientists and historical connections* ($F36$).

Table 10 outlines that the evaluation of USS students is in half cases worse in comparison with students of LSS.

The obtained results vary for different groups of students. We were interested especially in differencies between girls and boys. Comparision based on USS students' sex is shown below.

Table 11: General focus — comparision based on USS students' sex (1 = strongly agree)

statement	**arithmetic mean**	
	girls	**boys**
$F31$	1.27	1.31
$F32$	1.65	1.60
$F33$	2.28	2.14
$F34$	1.98	1.98
$F35$	2.69	1.96
$F36$	2.70	3.07
$F37$	2.60	2.34
$F38$	2.52	2.46
$F39$	2.21	2.30

For better overview the obtained results are presented in a graph below.

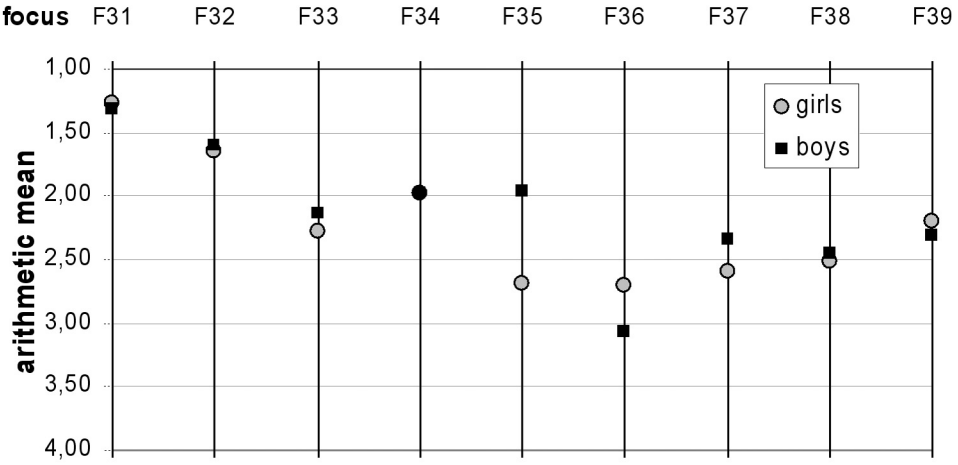

Figure 1: General focus — comparision based on USS students' sex (1 = strongly agree)

Conclusion 8: Girls were in assessment of the statements more negative than boys. Only the item *During physics lessons I would like to focus on lives of scientists and historical connections* ($F36$) they preffered more than boys. The biggest difference is in item $F35$: *applications in technical fields* and already mentioned $F36$ concerning history. There is no difference in preference of topics and activities focused on everyday life ($F31, F32$). Also *links with other fields* ($F39$) and topic about *methods used by scientists* ($F38$) are interested the same way for boys and girls.

These conclusions were made based on result of statistical investigation by Kolmogorov-Smirnov test. Results about statistical significance of the differencies are calculated in a table below.

Table 12: Statistical significance of the differences in the average evaluation made by USS girls (group 1) and USS boys (group 2)

reason	**max. negative difference**	**max. positive difference**	**p-level**	**arith. mean 1**	**arith. mean 2**	**stand. dev. 1**	**stand. dev. 2**
$F31$	-0.02	0.00	> 0.100	1.27	1.31	0.52	0.56
$F32$	0.00	0.05	> 0.100	1.65	1.60	0.66	0.65
$F33$	0.00	0.07	< 0.025	2.28	2.14	0.78	0.81
$F34$	-0.06	0.03	< 0.050	1.98	1.98	1.01	0.92
$F35$	-0.00	0.37	< 0.001	2.69	1.96	0.87	0.87
$F36$	-0.18	0.00	< 0.001	2.70	3.07	0.96	0.87
$F37$	0.00	0.15	< 0.001	2.60	2.34	0.81	0.83
$F38$	0.00	0.03	> 0.100	2.52	2.46	0.87	0.86
$F39$	-0.05	0.00	> 0.100	2.21	2.30	0.92	0.91

Conclusion 9: Based on the Kolmogorov-Smirnov test, we can say that the agreement with five items ($F31, F32, F38, F39$) between boys and girls is from the statistical point of view significantly different ($p < 0.050$).

5.3 Activities

In this part of the questionnaire, the students were to express which activities they would dis/like to do in classes of physics. Statements which were formulated and chosen by experts of pedagogy and didactics of physics are shown in Table 13.

This part of the questionanaire for LSS students stayed almost the same, only items $A44$ and $A45$ were linked together.

Table 14 presents arithmetic means for particular statements for LSS and USS students. Table 15 presents activities ordered according to the average obtained score.

Conclusion 10: The evaluation of the offered activities, which students would dis/like to do in classes of physics, is again *very positive* in total for both levels. Only one activity (*Solving problems including calculations* ($A48$)) for LSS level and three activities for USS (*learning to estimate measurement deviations* ($A43$); *deducing formulae, not only memorizing them* ($A49$) and *solving problems including calculations* ($A48$)) have below-average evaluation.

For detailed comparision of assessment between LSS and USS students we compared the rank of the statements evaluation. The part of questionnaire for USS contained one item more ($A45$) which we omitted for the purpose of ordering. Differencies in rank of the statements evaluation between LSS and USS students are shown in Table 16.

Conclusion 11: The biggest difference in assessment of the items is for *Inventing and discovering* ($A411$) and *Learning to classify and systemize data* ($A415$). Although USS students would prefer hands-on experiments they prefer inventing and discovering ($A411$) much less than LSS students. On the other hand they are much more interested in classifying and systemizing data.

Table 13: The statements in the questionnaire

During physics lesson I would like	I agree very much	I rather agree	I rather disagree	I completely disagree
Obtaining better estimation of distance, time, etc. (*A*41)				
Learning to measure (*A*42)				
Learning to estimate error of measurement (*A*43)				
Utilisation of computers for measurements (*A*44)				
Utilisation of computers for data processing (*A*45)				
Construction of simple devices, toys, etc. (*A*46)				
Hands-on experiments (*A*47)				
Solving problems including calculations (*A*48)				
Deducing formulae, not only memorizing them (*A*49)				
Doing laboratory work (*A*410)				
Inventing and discovering (*A*411)				
Watching experiments performed by teachers (*A*412)				
Searching for information on the Internet (*A*413)				
Participating in excursions, lectures of experts, etc. (*A*414)				
Learning to classify and systemize data (*A*415)				
Dealing with problems where there is no clear way of solution (*A*416)				

Table 14: Activities — evaluation of statements made by LSS and USS students (1 = strongly agree)

statement	**arithmetic mean**		**statement**	**arithmetic mean**	
	LSS	**USS**		**LSS**	**USS**
*A*41	2.03	1.98	*A*49	2.47	2.65
*A*42	2.22	2.30	*A*410	1.85	2.24
*A*43	2.23	2.51	*A*411	1.74	2.24
*A*44	1.68	1.96	*A*412	1.76	2.06
*A*45	–	1.77	*A*413	1.82	1.93
*A*46	1.73	1.92	*A*414	1.97	2.21
*A*47	1.49	1.74	*A*415	2.22	1.79
*A*48	2.89	3.04	*A*416	2.15	2.24

Table 15: Activities — ordered according to the average obtained scored

activities (the most preferred first)			
LSS	**mean**	**USS**	**mean**
Hands-on experiments (*A*47)	1.49	*Hands-on experiments* (*A*47)	1.74
Utilisation of computers for measurements and data proccessing (*A*44)	1.68	*Utilisation of computers for data processing* (*A*45)	1.77
Construction of simple devices, toys, etc. (*A*46)	1.73	*Learning to classify and systemize data* (*A*415)	1.79
Inventing and discovering (*A*411)	1.74	*Construction of simple devices, toys, etc.* (*A*46)	1.92
Watching experiments performed by teachers (*A*412)	1.76	*Searching for information on the Internet* (*A*413)	1.93
Searching for information on the Internet (*A*413)	1.82	*Utilisation of computers for measurements* (*A*44)	1.96
Doing laboratory work (*A*410)	1.85	*Obtaining better estimation of distance, time, etc.* (*A*41)	1.98
Participating in excursions, lectures of experts, etc. (*A*414)	1.97	*Watching experiments performed by teachers* (*A*412)	2.06
Obtaining better estimation of distance, time, etc. (*A*41)	2.03	*Participating in excursions, lectures of experts, etc.* (*A*414)	2.21
Dealing with problems where there is no clear way of solution (*A*416)	2.15	*Dealing with problems where there is no clear way of solution* (*A*416)	2.24
Learning to measure (*A*42)	2.22	*Doing laboratory work* (*A*410)	2.24
Learning to classify and systemize data (*A*415)	2.22	*Inventing and discovering* (*A*411)	2.24
Learning to estimate error of measurement (*A*43)	2.23	*Learning to measure* (*A*42)	2.30
Deducing formulae, not only memorizing them (*A*49)	2.47	*Learning to estimate error of measurement* (*A*43)	2.51
Solving problems including calculations (*A*48)	2.89	*Deducing formulae, not only memorizing them* (*A*49)	2.65
		Solving problems including calculations (*A*48)	3.04

The obtained results can differ regarding particular group of students. We were interested in differencies between girls and boys. Comparision based on USS students' sex are shown in Table 17.

For better overview the obtained results are presented in a graph Figure 2.

Conclusion 12: Girls assessed the statements in a more negative way than boys. Only one activity: *obtaining better estimation of distance, time, etc.* (*A*41) according to comparision of arithmetic mean values they would prefer more than boys but the difference is not statistically significant. Only two items in the group of boys have below-average evaluation. For the group of girls the number is three.

These conclusions were made based on result of statistical investigation by Kolmogorov-Smirnov test. Results about statistical significance of the differencies are calculated in Table 18.

Table 16: Activities — Difference in rank of the statements evaluation between LSS and USS students

statement	**difference (rank LSS − rank USS)**
Hands-on experiments (*A*47)	0
Construction of simple devices, toys, etc. (*A*46)	0
Participating in excursions, lectures of experts, etc. (*A*414)	0
Learning to estimate measurement deviations (*A*43)	0
Deducing formulae, not only memorizing them (*A*49)	0
Solving problems including calculations (*A*48)	0
Dealing with problems where there is no clear way of solution (*A*416)	1
Learning to measure (*A*42)	−1
Watching experiments performed by teachers (*A*412)	−2
Searching for information on the Internet (*A*413)	2
Utilisation of computers for measurements (*A*44)	−3
Doing laboratory work (*A*410)	−3
Obtaining better estimation of distance, time, etc. (*A*41)	−4
Inventing and discovering (*A*411)	−7
Learning to classify and systemize data (*A*415)	10

Table 17: Activities — comparision based on USS students' sex (1 = strongly agree)

statement	**arithmetic mean**	
	USS girls	**USS boys**
*A*41	1.95	2.00
*A*42	2.33	2.27
*A*43	2.64	2.41
*A*44	2.22	1.76
*A*45	1.98	1.61
*A*46	2.04	1.82
*A*47	1.81	1.69
*A*48	3.14	2.98
*A*49	2.74	2.58
*A*410	2.28	2.21
*A*411	2.28	2.21
*A*412	2.21	1.96
*A*413	1.94	1.93
*A*414	2.30	2.15
*A*415	1.81	1.78
*A*416	2.25	2.22

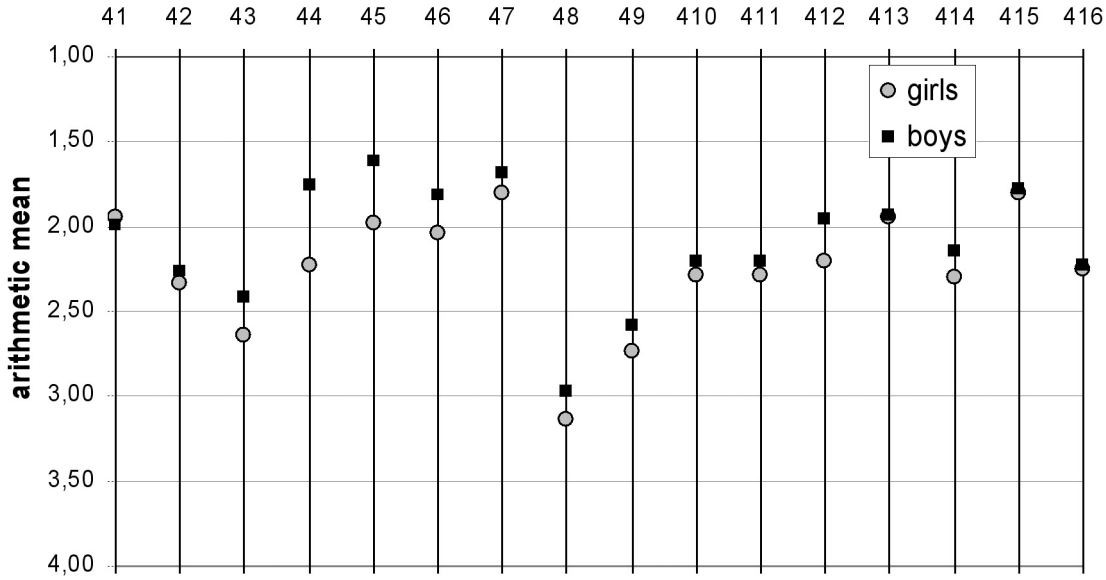

Figure 2: Activities — comparision based on USS students' sex (1 = strongly agree)

Table 18: Statistical significance of the differences in the average evaluation made by USS girls (group 1) and USS boys (group 2)

reason	max. negative difference	max. positive difference	p-level	arith. mean 1	arith. mean 2	stand. dev. 1	stand. dev. 2
$A41$	-0.04	0.01	$p > 0.100$	1.95	2.00	0.77	0.83
$A42$	-0.01	0.05	$p > 0.100$	2.33	2.27	0.78	0.80
$A43$	0.00	0.15	$p < 0.001$	2.64	2.41	0.82	0.87
$A44$	0.00	0.21	$p < 0.001$	2.22	1.76	0.89	0.81
$A45$	0.00	0.20	$p < 0.001$	1.98	1.61	0.87	0.74
$A46$	-0.01	0.12	$p < 0.001$	2.04	1.82	0.94	0.89
$A47$	0.00	0.06	$p < 0.050$	1.81	1.69	0.89	0.82
$A48$	0.00	0.10	$p < 0.001$	3.14	2.98	0.91	0.91
$A49$	0.00	0.07	$p < 0.025$	2.74	2.58	1.05	1.03
$A410$	0.00	0.04	$p > 0.100$	2.28	2.21	1.00	0.98
$A411$	0.00	0.04	$p > 0.100$	2.28	2.21	1.00	0.98
$A412$	-0.01	0.13	$p < 0.001$	2.21	1.96	0.97	0.88
$A413$	-0.01	0.01	$p > 0.100$	1.94	1.93	0.86	0.84
$A414$	0.00	0.08	$p < 0.001$	2.30	2.15	0.92	0.90
$A415$	0.00	0.01	$p > 0.100$	1.81	1.78	0.90	0.89
$A416$	0.00	0.02	$p > 0.100$	2.25	2.22	0.87	0.86

Conclusion 13: Based on the Kolmogorov-Smirnov test, we can say that the agreement between USS boys and girls with seven items is from the statistical point of view significantly different ($p < 0.050$): *Learning to estimate error of measurement* ($A43$), *Utilisation of computers for measurements* ($A44$), *Utilisation of computers for data processing* ($A45$), *Construction of simple devices, toys, etc.* ($A46$), *Hands-on experiments* ($A47$), *Solving problems including calculations* ($A48$), *Deducing formulae, not only memorizing them* ($A49$), *Watching experiments performed by teachers* ($A412$) and *Participating in excursions, lectures of experts, etc.* ($A414$).

6 Discussion and Conclusions

6.1 Discussion and Conclusions Concerning Reasons Why to Learn Physics

Students of particular types of school agree on some of the reasons:

- *I want to have good marks* and *my parents want me to have good marks* belong to the strongest reasons why students learn physics.

- *The weakest reasons* are generally *I like physics* and *my parents think that physics is important.*

USS students add another weak reason which is *I want to know how things around me work.*

USS students agree with particular reasons less (statistical significant differences) than LSS students.

There is a concordance between girls and boys in the following evaluation:

- Both girls and boys of LSS have *the strongest reasons — I want to have good marks* and *my parents want me to have good marks.* They agree also with *the weakest reasons — I like physics* and *my parents think that physics is important.*

Girls and boys do not agree in the following evaluation:

- *Girls of LSS and USS agree less with more of the reasons in comparison with boys.*

- However, there exist three exceptions in that: No statistically significant difference in LSS was found between girls and boys concerning the evaluation of *I want to have good marks* and *my parents want me to have good marks.* The third exception is:

- Girls from USS agree with the reason that *I want to have good marks* more than boys from USS.

The research uncovered gender differences. Generally speaking, we can say that *for learning physics girls are less motivated than boys.* There is also one deviation which is statistically significant in USS: Girls want to have good marks more than boys. This conclusion is probably not surprising for physics teachers. It is a question how to change the relatively low motivation of girls. This may be achieved by textbooks and problems more oriented to girls, by increasing the consciousness about female — scientists in physics, etc.

The main reason why students learn physics is not, at the lower secondary level, the interest in the subject itself. However, in case of the LSS students, it seems that the third strongest reason why students learn physics is the interest in how things around us work. This reason could be considered as intrinsic motivation which seems to be the optimal motivation for learning Lavonen et al., 2005). The USS students are more pragmatic and as second reason why they learn physics they state their future carrier.

6.2 Discussion and Conclusions Concerning General Topics and Activities

- *Topics which are connected with everyday life are the most interesting topics for students regardless of their sex or age.*

- *USS students would like to learn about things which they will need in their future life (during further study, at work, etc.).*

Students perceive as *the most interesting* or important *learning about things and phenomena connected with real, everyday life.* It is apparent that the *USS students think about their future*, as the third in the order is the topic concerning entrance examinations. *The worst* in the evaluation was the topic *lives of scientists and historical connections* for both levels, which is in our opinion a surprising result. We assumed that this topic could be attractive for students which are interested in humanities. It is possible that the evaluation is influenced by the isolation of particular subjects.

- *USS boys perceive topics about application in technical fields as more interesting than girls do. For boys the topic is interesting, for girls not very much.*

Results of the "focus on" part of the questionnaire uncovered gender difference. Generally girls are in evaluation more negative than boys. They prefer topic about history more than boys. But both groups do not perceive the topic as interesting. On the contrary topic about application in technical fields were for USS girls much less interesting than for USS boys. Moreover, it is one of the two topics where according to average assessment the topic is interesting for boys, but not for girls. Conclusions concerning activities are described below.

- *Students regardless of their sex or age the most prefer practical activities or working with computers.*

If the results concerning preferencies of activities in physics classes are surprising or not, it is in this case completely subjective and it depends on a concrete expectation. However, we try to provide more objective conclusions. Above all, we would like to draw the attention to the *high popularity of practical activities.* Students would like also to participate in activities including *work with computers.* On the other hand, activities concerning theory of measurement and solving problems including calculations are the least favourite for both secondary levels. Further research may be useful to find whether or how these parts could be made more attractive for students.

- *LSS students also prefer inquiry-based activities in physics lessons.*

- *For USS students to deal with classifying and systemizing data is interesting.*

LSS students prefer as activities inventing and discovering what is with contrast to USS students. Although they would like to be busy with hands-on experiments or constructioning simple devices and tools, they do not prefer so much inquiry-based activities. On the other hand, USS students would like to deal with classifying and systemizing data, what is not so much attractive for LSS students.

Seven items have been evaluated in the same way by boys and girls (according to Kolgomorov-Smirnov statistical test). Above all these three items have been

evaluated also very positively (arithmetic mean is less than two): *obtaining better estimation of distance, time, etc.* ($A41$), *searching for information on the Internet* ($A413$) and *learning to classify and systemize data* ($A415$). It is recommended to involve these three activities into physics lessons if teacher wants to emphasize motivational and gender aspect in educational process.

The results of recently conducted study (S. Owen et. al, 2008) in Great Britain show similar preferences of pupils at the secondary educational level. The study observed the relationship to particular groups from two view points — if the given activity is popular among them and if they consider it as useful. The aim of the reseach, which part is presented here, was to make concrete recommendations for teaching of physics based on the research findings. For this reason, we make students to express their opinions whether they would like to perform particular activities in their lessons of physics. In this way, we merged two observed factors into one. The advantage of this approach is that during the decision process pupils themselves determine their own weights matched to particular factors (usefuleness and popularity) in case of every activity. This approach enables us to formulate practical recommendation which would reflect more the reality eventhough it is not, from the research point of view, analysed in detail. For example, the above mentioned studies show that the given activities are more or less evaluated as very useful and very often popular or rather useless and students do not them (in the plane graph, where there are on the axes marked two factors — usefuleness and popularity, the results are distributed rather along a line than evenly within the whole plane of the graph (S. Owen et. al, 2008, Figure 1).

Students from Great Britain assessed most positively rather practival activities requiring certain manipulative skills (denoted as construct activities), more concretely: *doing experiments*, *making things*. The popularity of these activities can be traced accross the age spectrum of the students (Grade 7–11), which corresponds with the results found out of the research presented in this paper. The comparison of both pieces of research in the field of preferable activities can be made more concretely for the following items: "watching demonstration" — "watching experiments performed by teachers" and "calculations" — "solving problems including calculations". Calculations are, in both pieces of research, not considered as preferable activities (unpopular, too useless).

Based on the conducted analysis, Owen et al. includes this activity into the category of "written activities" together with *copying notes down*, *making graphs and diagrams*, *written excercises* etc. Table 15 shows that Czech pupils do not like also measuring, estimating and calculation of measure mistakes. Considering the general topics to which pupils would like to focus, "measure devices and their use" is the third less popular topic. This can indicate that pupils do not prefer activities connected with mathematics and accuracy. It is interesting that computer measuring is equally rather positively assessed at both educational levels in comparison with the other offered activities. Pupils, probably, persived strongly not only the content of these activities but also the means with which these activities are performed. This is shown also by Owen et al. in their results of the factor analysis.

6.3 Summary and Practical Recommendations

Despite quite positive assessment of most items concerning activities or topics, students learn physics above all because of good marks or needs in futher study. Although it is interesting for students to learn about things around them, it is the

fifth reason why they learn physics. The results suggest that students learn physics rather because of social demands and not because of internal interest in the subject area.

The above mentioned statements outline certain results and conclusions which can serve as a concrete recommendation to teachers to improve classes of physics. If a teacher wants to emphasize motivational aspect he or she can include the mentioned activities or topics in the lessons. LSS and USS students prefer activities that require manipulative and technical skillswhich are closely connected with the everyday life. For LSS pupils consider as the most interesting inquiry-based learning. On the contrary, USS students, in comparison with LSS pupils, prefer more classifying of data. The research indentified topics and activities which are interesting the same way for both USS boys and USS girls. These activities are: *Searching for information on the Internet, Learning to classify and systemize data, Obtaining better estimation of distance, time*, etc. It is not surprising that girls prefer more than boys historic topics, boys then are interested in topics connected with moder technologies

Most of students want to have good marks which they value as very important. For this reason, we assume that teachers should pay to marking (and to assessment generally) attention as it is a very motivating element for learning of physics. The assessment should be made clear in the way that students would know (at least theoretically) how to achieve a success. We believe that students can be aware of this only if teachers assess them according to clear and in advance known rules. The assessment should be balanced with a maximum pursuit of objectivity.

Teachers should focus more on wakening and supporting of pupils' and students' intrinsic motivation. Mitchell (1993) or Krapp (2002) state that this porcess can be divided into two phases: catching and holding situational interest.

Detailed results and recomendations were published in a handbook for physics teachers (Dvořák et al., 2008) which is availaible online in the Czech language on the websites of our department.

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