

# Is chemistry attractive for pupils? Czech pupils' perception of chemistry

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Chemistry is an important subject due to understanding the composition and structure of the things around us. The main aim of the study was to find out the perception of chemistry by lower secondary school pupils. The partial aims were to find out the influence of gender, year of study and favorite subject on the perception of chemistry. The sample size comprised 379 Czech lower secondary schools pupils. The questionnaire was used as a research tool. It consisted of 25 5-point Likert type items. Items were, after application of factor analysis, divided into four categories: 1. The interest in chemistry, 2. The relevance of chemistry, 3. The future life and chemistry, 4. Chemical aids and laboratory experiments. Reliability of the research tool was determined by Cronbach's alpha which had value  $\alpha = 0.87$ . For the data evaluation the methods of inferential statistics were used, concretely analysis of variance (ANOVA). Pupils had low positive perception of chemistry. Statistically significant differences between boys and girls and also between 8<sup>th</sup> and 9<sup>th</sup> graders were not found out. In the conclusion part the possibilities of next research and also recommendations for practice are presented.

*Keywords:* Czech Republic, inferential statistics, lower secondary school pupils, perception of chemistry

## INTRODUCTION

In chemistry it is essential to understand the nature processes and the behaviors of different elements in our life. We apply most of the elements in our everyday life, so it is a necessity to know chemistry. Chemistry helps us understand the composition and structure of the things around us, it is important for us to be aware of the reactions happening in our kitchen and virtually everywhere. On the previous facts, it is evident that chemistry is important for society. However, pupils considered chemistry an unimportant and uninteresting subject (Broman, Ekborg & Johnels, 2011; Risch, 2010). One of the reasons can be that many of the concepts used in chemistry are abstract, and are inexplicable

without the use of analogies or models. Similar ideas are described in the study of Gabel (1999). Turner, Ireson & Twidle (2010) wrote in their study the reasons why pupils disliked chemistry in a more detailed form. To more frequent reasons belong: writing too many sheets of paper; too many words to learn; complicated experiments; room smells; hard homework. Also, the authors wrote the reasons why the chemistry is popular among pupils (for example, it is practical and fun).

When pupils see chemistry as hard and not understandable, their achievement in this subject deteriorates. Therefore, it is important to find out their perception of chemistry, because these findings show to researchers, why chemistry is uninteresting and unimportant for pupils.

In general, boys perceived science subjects more positive in comparison with girls (Cokadar & Kulce, 2008; Trankina, 1993; Weinburgh, 1995). According to Trankina (1993) greater percentages of females than males agreed with the statement "science breaks down people's ideas of right and wrong". For example, Breakwell & Robertson (2001) conducted a longitudinal study to examine the change in attitude towards science over a period of ten years in students between ages 11

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**State of the literature**

- The perception of chemistry is investigated mainly among high school pupils. Previous studies showed that there was a difference between boys and girls. Boys perceived the chemistry more positive in comparison with girls.
- Previous studies also showed that the age has got the influence on the perception of chemistry. With the higher age, the positive perception of chemistry decline.
- The method for the finding of perception was a scaled questionnaire and the data evaluation was conducted by using of methods of descriptive and inferential statistics.

**Contribution of this paper to the literature**

- There were not found significant differences between genders and year of study. But an interesting finding was observed: girls achieved a higher score in comparison with boys.
- Pupils do not see the connection of chemistry with their future life.
- This is one of the first investigations in the Czech Republic with international impact.

to 14 years. The results indicated that boys had more positive attitude and better performance in science as compared to girls. However, it is possible to find some investigations with an opposite result. Anwer, Iqbal & Harrison (2012) found out that Pakistani girls had more positive attitudes toward science in comparison with boys, but in the majority of cases, the boys had more positive attitudes toward science than girls. Pupils' attitudes toward science decrease with age in lower secondary schools and also in high schools (Osborne, Simon & Collins, 2003; Ramsden, 1998). The similar finding is possible to observe in the work of Hilbing & Barke (2000). From the previous facts it is evident, the most investigated variable is gender, except of this and grade level are investigated parental education (Mordi 1991), socio-economic status (Okebukola & Jegede, 1990), home environment, amount of homework, parents' education (Walberg, 1984), curriculum ((Nieswandt, 2005) and others.

In this part there is an effort to provide some studies which concern attitudes toward chemistry. The amount of studies which are focusing on the lower secondary school pupils attitudes toward is low, therefore, the studies where the sample is obtained from high schools and colleges are provided. Khan & Ali (2012) found out relatively neutral attitudes of Pakistani high school students toward chemistry. They showed, attitudes are strongly influenced by teachers and their methods of teaching. Dara & Charles (2012) were trying

to find out some correlations of college students attitudes toward chemistry. The researcher wondered whether the following five variables may influence attitudes toward chemistry: students' occupational aspiration; teachers' method of teaching; students' intelligence; influence of family on the students; teachers' qualification. Only the last one did not have a significant effect. Coll, Dalgety & Salter (2003) described in their study Chemistry Attitudes and Experiences Questionnaire (CAEQ) developed to measure first year university chemistry students' attitude towards chemistry, chemistry self-efficacy, and their learning experiences. Data from the learning experiences component suggest that first year university chemistry students prefer a more structured class style. Demircioglu & Norman (1999) were focused to find out the factors that affect chemistry achievement and chemistry attitudes of 11th grade students, by investigating some student related variables such as gender, school type, and father education. Only the school type was the variable which influenced students' attitudes toward chemistry. The authors used a scaled questionnaire among Turkish students. Bennett & Hogarth (2009) found out that the subject chemistry was much more positively evaluated by boys in comparison with girls and the perception of chemistry decreased by age (from 11 till 16 years old pupils). The influence of gender and study specialization was analyzed in the study of Salta & Tzougraki (2004). The authors analyzed the 4 dimensions of a questionnaire (difficulty, interest, usefulness and importance of chemistry). In all dimensions Greek boys achieved a higher score in comparison with girls and students who would like to study chemistry in the future achieved also a higher score in comparison with the second group of students. Work by Cheung (2009) put emphasis on influence of gender and year of study by Hong Kong high school students. The research tool was constituted as a scaled questionnaire and this scale was divided into four dimensions – liking of theory lessons, liking of lab works, evaluative beliefs and behavioural tendencies by students with respect to its difficulty and importance. Boys achieved higher score in comparison with girls. The effect of year of study is very hard to interpret, because the year of study is evaluated within the gender. In the majority of cases the method of scaled questionnaire was used. Exceptionally, the method of semantic differential was used in the work of Bauer (2008), who found out relatively positive perception of chemistry.

From the facts mentioned above it is obvious that the research in the lower secondary schools is not so frequent and in the conditions of the Czech Republic was not such research conducted (with an international impact). If the research was realized, it was focused only on the ranking of subjects and it was published in local

language. So the investigation has the importance mainly because of these two facts. Next purpose of the research realization was to find out the influence of variables like gender, year of study and favourite subject on the perception of chemistry and comparison of this influence with other studies, if the influence is similar or dissimilar like in other countries.

Next part is focused on the brief information about Czech curriculum regarding to chemistry, due to better understanding of the school context regarding to chemistry. The teaching subject chemistry belongs to educational area Man and Nature together with biology, geography and physics. The educational area includes a range of topics associated with the investigation of nature. It provides the pupil with the tools and methods for a deeper understanding of natural facts and their inherent laws, thus giving him/her the necessary foundation for a better grasp and utilisation of modern technologies and helping the pupil better orient himself/herself in everyday life.

In this educational area, the pupil is given an opportunity to become acquainted with nature as a system whose constituents are interconnected, interact with and affect one another. Such knowledge is moreover the basis for the understanding of the importance of maintaining the natural balance of the extant living systems, including humans. Furthermore, the educational area significantly supports the creation of open thinking (willing to consider alternative viewpoints), critical thought and logical thinking.

The chemistry is taught in the last two years of lower secondary education in the Czech Republic (8th and 9th year of study) and it is taught two hours per week in both years of study. In the 8th year is taught general and inorganic chemistry and in the 9th year of study is taught organic chemistry and biochemistry. The practical (experimental) hours are once a month, but it depends on the every school.

### Aims and research questions

The main aim of the study was to find out the perception of chemistry by lower secondary school pupils. The partial aims were to find out the influence of gender, grade and favorite subject on the perception of chemistry in lower secondary school pupils. The influence of favorite subject was investigated in a slightly different way (more information about it can be found in the subchapter Analysis of data).

The research questions were followed:

1. Is there any difference in the perception of chemistry with respect to gender?
2. Does the grade have an influence on the perception of chemistry?

## METHODS

### Participants

The participants were 379 Czech lower secondary schools pupils. The ratio of girls and boys was similar (number of girls  $n = 209$ ). The chemistry is taught in the 8<sup>th</sup> and 9<sup>th</sup> grade in lower secondary schools (last two years of lower secondary school). The number of younger pupils was higher ( $n = 236$ ). According to the favorite subject the pupils were divided into two groups. The first group was created by pupils with science as a favorite subject (biology, chemistry, geography and physics) and the second group was created by pupils with a different favorite subject than the science subject. The first group was called "science majors" and the second one "science non-majors". The names "science majors" and "science non-majors" are only working; the author knows these terms are typical for US university students. In this form are only for the purposes of the study. The number of respondents was higher in the second group ( $n = 279$ ).

### The instrument

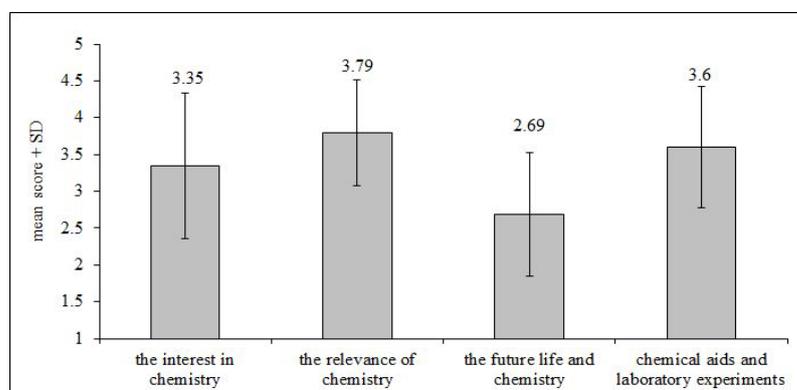
The questionnaire was used as a research tool. It consisted of 25 5-point Likert type items. The questionnaire was adapted from the biology attitudes questionnaire (Prokop, Tuncer & Chuda, 2007). The original form of the questionnaire was developed in the Czech language and then was translated into English for publication purposes with the assistance of a native speaker. The questionnaire was divided into two parts. The first part included demographical variables (gender and grade level) and the second part included 25 items divided into four dimensions. The dimensions are described in the chapter "Analysis of data". The items were presented in a random order; they were not grouped together with other items having a similar character. Items were rated by the participants from 1 (strongly disagree) to 5 (strongly agree). There were items worded both positively ( $n = 15$ ) (e.g. "I like chemistry more than other subjects") and negatively ( $n = 10$ ) (e.g. "Chemistry lessons are demanding for me"). Negative items were reversed in scoring.

The questionnaires were distributed among pupils by their teacher of chemistry, who learned about distribution of questionnaires. Pupils were reassured that the questionnaire was anonymous, that it was not a test but rather a research attempt to explore their perception of chemistry. No time limit was given for the filling out of the questionnaire, but the longest time taken to complete it was approximately twenty minutes.

**Table 1** Results of factor analysis

	I	II	III	IV
<b>I THE INTEREST IN CHEMISTRY</b>				
1. I like chemistry more than other subjects.	0.66	0.11	0.00	0.31
4. Chemistry lessons are demanding for me.	0.44	0.01	0.15	0.15
6. I would like to have chemistry lessons more frequently.	0.64	0.05	0.12	0.31
8. I am bored in chemistry lessons.	0.75	0.16	0.10	0.12
10. Lecture in chemistry lessons is interesting for me.	0.56	0.17	0.10	0.35
15. I suppose that chemistry is not important compared with other school subjects.	0.53	0.28	0.29	0.14
20. I do not like chemistry lessons.	0.76	0.07	0.18	0.20
21. I do not like our chemistry teacher.	0.56	0.09	-0.08	-0.16
<b>II THE RELEVANCE OF CHEMISTRY</b>				
3. Chemistry and nature are strange for me.	0.29	0.42	0.29	-0.06
9. Progress in chemistry improves our life.	0.08	0.74	-0.03	0.10
11. Chemical knowledge can help us solve problems with environment.	0.11	0.65	0.06	0.32
17. Nature is an integral part of human life.	0.14	0.65	-0.10	0.04
23. I think that processes occurring in nature are interesting.	0.13	0.57	0.15	0.16
<b>III THE FUTURE LIFE AND CHEMISTRY</b>				
13. Chemistry knowledge is not important for my future life.	0.16	-0.20	0.73	-0.05
18. When I finish my studies I would like to work in the field of science.	0.08	0.26	0.58	0.06
19. Chemical knowledge is not necessary for daily life.	0.15	0.02	0.56	0.21
<b>IV CHEMICAL AIDS AND LABORATORY EXPERIMENTS</b>				
5. I extend my knowledge and skills by chemical laboratory exercises.	0.31	0.30	-0.02	0.53
14. Chemical aids used in chemistry lessons are interesting for me.	0.19	0.16	0.16	0.65
22. We use a lot of chemical aids in chemistry lessons.	0.09	0.07	0.03	0.70
24. Chemical experiments are very interesting.	0.32	0.38	-0.15	0.45
Eigenvalue	6.05	2.21	1.33	1.04
% of variance	24.20	8.83	5.33	4.15
<b>DELETED ITEMS</b>				
2. We do not use teaching aids in chemistry lessons.	0.00	0.5	0.08	-0.05
7. Knowledge of chemistry is important for understanding other school subjects.	-0.31	-0.46	-0.20	-0.28
12. Chemistry is interesting for me because of our chemistry teacher.	0.36	-0.27	-0.09	-0.07
16. I have to concentrate more when I would like to understand chemistry curriculum.	0.13	-0.08	-0.02	-0.17
25. I suppose that chemistry is one of the easiest school subjects.	-0.08	0.16	0.07	0.04

**Note:** Numbers of items are identical with the item numbers in the questionnaire.



**Figure 1.** The mean score for the dimensions

**Table 2.** Values of analysis of variance, mean score and standard deviations with respect to gender

dimensions	F	boys (x)	girls (x)	boys (SD)	girls (SD)
Interest	0.01	3.33	3.33	0.07	0.06
Relevance	9.36	3.66	3.89	0.06	0.05
Future life	1.07	2.64	2.73	0.07	0.06
Experiments	1.44	3.53	3.63	0.06	0.06

*F* – analysis of variance

*x* – mean score

*SD* – standard deviation

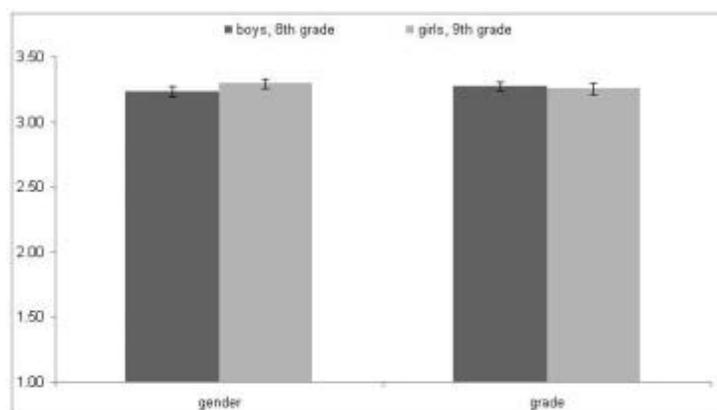
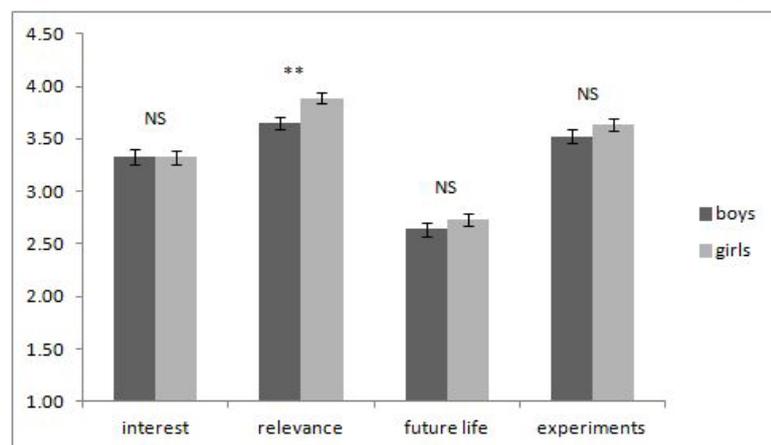
**Table 3.** Values of analysis of variance, mean score and standard deviations with respect to years of study

dimensions	F	8th grade (x)	9th grade (x)	8th grade (SD)	9th grade (SD)
Interest	0.50	3.36	3.29	0.06	0.08
Relevance	0.03	3.78	3.77	0.05	0.06
Future life	0.07	2.69	2.67	0.05	0.07
Experiments	2.60	3.65	3.51	0.05	0.07

*F* – analysis of variance

*x* – mean score

*SD* – standard deviation

**Figure 2.** The distribution of score with respect to gender and grade**Figure 3.** Distribution of the score in the dimensions with respect to gender

### Analysis of data

The obtained data were undergone to explorative factor analysis with Varimax rotation. The factor analysis was used for the determining of construct validity. The KMO test with the value 0.88 and Bartlett

test of sphericity ( $\chi^2 = 4224.21$ ;  $p < 0.001$ ) allowed to use the factor analysis. Items were, after application of the factor analysis, divided into four dimensions (see table 2): 1. The interest in chemistry (8 items), 2. The relevance of chemistry (5 items), 3. The future life and chemistry (3 items) and 4. Chemical aids and laboratory

experiments (3 items). These dimensions explained 42.16 % of total variance, and the most was explained by the first dimension (24.20 %). The critical value for the inclusion item to dimension was the value of factor score 0.40. From the next analyses the 5 items were eliminated, which did not achieve factor score 0.40 (the value was lower). The results of the factor analysis are shown in table 1. The construct validity was also determined by the next method, the inclusion of the item into questionnaire, where the pupils could write their favourite subject. The science majors pupils ( $x = 3.56$ ;  $SD = 0.07$ ) achieved higher score in comparison with science non-majors pupils ( $x = 3.21$ ;  $SD = 0.03$ ). The difference was statistically significant ( $F = 23.05$ ;  $p < 0.001$ ). This finding supported the construct validity of the research tool.

Reliability of the research tool was determined by Cronbach's alpha which had value  $\alpha = 0.87$ . According Nunnally (1978), if the score of Cronbach's alpha is higher than 0.70, the research tool is considered for reliable

The inferential analysis was used for the data analysis, concretely analysis of variance (ANOVA). The score from the attitude part of the questionnaire was created as a dependent variable and demographic variables (gender, grade) were as independent variables. The Kolmogor-Smirnov test was used for the determination of data normality and its value ( $d = 0.06$ ;  $p > 0.20$ ) allowed to use the parametric methods of data evaluation

## RESULTS

The pupils achieved mean score 3.27 ( $SD = 0.54$ ), which indicated relatively positive attitudes of lower secondary school pupils toward chemistry. By the evaluating of the dimension it is possible to see that the

pupils had got interest in chemistry, they saw relevance of chemistry and they perceived positively the chemical experiments and using chemical aids. Only one dimension which was perceived negatively was "The future life and chemistry" (figure 1).

Next, the influence of gender and grade on the attitudes toward chemistry was found out. The girls achieved a higher score ( $x = 3.28$ ;  $SD = 0.04$ ) in comparison with boys ( $x = 3.23$ ;  $SD = 0.04$ ) (figure 2), the difference between boys and girls was not statistically significant ( $F = 1.35$ ;  $p = 0.25$ ). Younger pupils achieved a higher score ( $x = 3.27$ ;  $SD = 0.03$ ) in comparison with older pupils ( $x = 3.25$ ;  $SD = 0.04$ ) (figure 2), the effect of grade was also not significant ( $F = 0.13$ ;  $p = 0.72$ ).

By the analysis of dimensions with respect to gender, a statistically significant difference was found out only in the dimension "The relevance of chemistry". Girls achieved higher score in comparison with boys (figure 3). Girls achieved higher score in all dimensions except the dimension called "The interest about chemistry", where the score was similar. The values of ANOVA and the mean score with standard deviations are showed in the table 2. Boys and girls achieved a similar score nearly in all items. The difference was observed in the item "Chemistry and nature are strange for me". 70 % of all girls did not agree with this statement, but 60 % of boys had negative perception of it. The one third of girls is bored in the chemistry lessons in the comparison with one fourth of the boys. Nearly half of girls agreed with the statement "We use a lot of chemical aids in chemistry lessons", but only according to one third of boys in the chemistry lessons chemical aids are used in a suitable amount. For two thirds of girls processes occurring in the nature are interesting. Similar ideas were observed in the nearly half of the boys. The most positive answers were

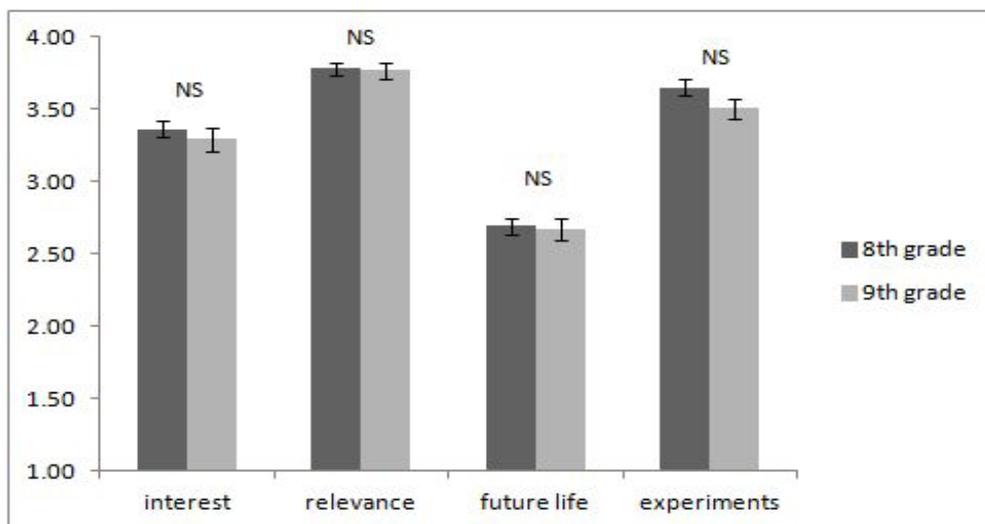


Figure 4. Distribution of the score in the dimensions with respect to grade

NS – non-significant difference, \*\* –  $p < 0.001$

observed in the item “Nature is an integral part of human life”, nearly of 90 % of both genders agreed with this statement.

By the analysis of dimensions with respect to years of study statistically significant differences were not observed in any of the dimensions. As it is possible to see in the figure 4, in all dimensions younger pupils achieved a higher score in comparison with older pupils. The values of ANOVA and the mean score with standard deviations are showed in the table 3. Nearly in all items pupils from 8th grade and 9th grade achieved a similar score except four items, where the differences were observed. For the ¼ of 8th grade pupils chemistry is demanding, in the 9th grade the number of pupils who considered chemistry for a demanding subject is higher (about 35 %). Nearly for two thirds of pupils from the 8th grade chemical aids, used in chemistry lessons, are interesting. They are interesting only for 50 % of older pupils though. Nearly 60 % of the 8th grade pupils considered chemistry an important subject and only 50 % of older pupils agreed with this statement. The last item, where the difference was observed was from deleted ones. Nearly a half of younger pupils considered knowledge obtained in chemistry lessons important to understand other subjects. Only 30 % of older pupils agreed with this statement.

## DISCUSSION

In the previous part of the text the answers of research questions were found out. As the research tool was used the questionnaire with 25 Likert type items. The questionnaire could be used also for the investigation of pupils’ perception of other subjects (not only science subjects). Moreover, the research tool is possible to use among high school and college students. The aim of this study was also to contribute to a not so high amount of investigations focused on the exploring of pupils perception of chemistry, which were found out by a quantitative approach.

The overall pupils’ perception of chemistry was relatively positive, but the value is little bit boundary with neutral perception. Maybe the reason can be explained as follows. Chemistry topics are taught in short sequences, their content is various and due to relative short time (chemistry is usually taught for two years in lower secondary schools) pupils do not have a chance to create strictly positive or negative perception. If this situation is predominant, pupils have not got a chance to create motivational behavior, which can be one of predictor to create positive attitudes toward chemistry. This statement is also possible to find out in the study of Berg (2005). About the significant role of the teacher wrote also Regan & Childs (2003), the teacher have to present the chemical topic in interesting

way, it is the main reason according to authors, why pupils like chemistry as a school subject.

However, when we look at the distribution of the score into dimensions, it is possible to observe that for the pupils chemistry is interesting, they see its relevance and they like lessons, where the chemical aids are used. On the contrary, a low score was observed in the dimension “The future life and chemistry” and this is probably the problem. Teachers may be focused on the explanation of the chemistry topics, but without a connection with the real life pupils do not know, why they should study chemistry at high schools and work in the field, where chemistry is used.

The statistically significant difference was not found out between boys and girls. But it is possible to see that girls achieved a higher score than boys. This difference is possible to notice in the all dimensions; even in the dimension “The relevance of chemistry” statistically significant difference was observed. This is a relatively surprising finding, because nearly all investigations showed that boys perceived chemistry more positively in comparison with girls (Bennett & Hogarth, 2009; Salta & Tzougraki, 2004). Only one study showed a similar finding (Shannon, Sleet & Stern, 1982). So, how can factors cause by the girls that they perceived chemistry more positively than boys? One factor could be the style of teaching and using of teaching methods. Maybe teachers use methods like explanation or apply the elements of lectures in the lessons of chemistry and this type of teaching could be more appropriate for girls. Boys could expect more miscellaneous lessons with the elements of unusual style of teaching with different methods (project, problem learning). And as it was detected, boys expected using of more chemical aids during lessons. If the chemical aids were used in a greater extent, maybe the perception of chemistry by boys would be more positive. But it is necessary to become aware that the equipment of school could be unsuitable for chemical aids and this situation could deteriorate the perception of chemistry. The next factor could be the personality of teacher, which was not the aim of the study, it is only a suggestion for next research. If the teacher is young, for girls chemistry lessons could be more attractive, i.e. due to the teacher, not due to the content of lessons. The personality of teacher as the important factor is mentioned in the study of Berg (2005), where is written about teacher empathy and their effort as the factors, which can form the attitudes toward chemistry.

Pupils from both grades achieved a similar score. The score in the dimensions was also similar with respect to year of study. The similar result, where the score between grade levels of pupils was similar is possible to find out, in the study of Can (2012), but the author did not explain, why this state is present. So the presumption, which was expressed on the basis of other

studies (e.g. Bennett & Hogarth, 2009), was not confirmed. The reason is hard to find out, because the content of the subject is different in the grades. Probably, the same factors affect also here like in the gender, mainly the style of teaching is the most caused factor. If teacher teaches with the same style in his chemistry lessons, pupils perceive chemistry in the same way in both grades, without the influence of content.

## CONCLUSION

The study is partially filling the gap, which is present in the field of chemistry perception among lower secondary school pupils. According to the results, there is space and necessity to improve the perception of chemistry by lower secondary school pupils. As it is possible to observe, the biggest problem is in the lack of understanding the importance of chemistry for future life. One of the recommendations is aimed on the leg-up of importance of education in the field of chemistry. The pupils probably refuse to continue in chemistry learning, because chemistry is too abstract for them and they are not able to imagine their own activity in the field of chemistry. So the task of teachers should be to show pupils how to connect chemistry knowledge with everyday life (e.g. cosmetics, motor industry,...). Next it is possible to apply methods of informal learning in the chemistry instruction. In the informal learning the elements of problem and cooperative learning should be applied. The application of informal learning is supported by Salmi (2003), who contributed to the topic of the influence of informal learning on the intrinsic motivation toward science subjects (Gunay, & Ogan-Bekiroglu, 2014).

The research in this field could turn into the investigation of other factors like the personality of teacher influencing the perception of chemistry or to find out the influence of education of parents on the perception of chemistry. The research is possible to realize in high schools as well.

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