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MOTIVATION AS A PREDICTOR OF PUPIL'S ACHIEVEMENT IN CHEMISTRY

Abstract: This work is based on the fact that the problem of the (lack of) pupil's motivation for learning chemistry has been explored insufficiently. Thus, the aim of this study is to review the impact of different dimensions of motivation on achievement in chemistry. The sample consisted of 236 grammar school pupils attending the third grade. The results showed that there is a significant positive correlation between grades in chemistry and pupil's motivation. The identified fact that individuals with high perceived self-efficiency in learning have higher achievements is part of a range of evidence that pupil's motivation makes a reliable predictor of academic success. The data obtained are instructive for practitioners in education because they clearly suggest that there is a need for promoting academic motivation among pupils. Some of the ways to realize this goal are strengthening the sense of self-efficiency, facilitating the implementation of active learning strategies, connecting teaching content of chemistry with practical application of knowledge, and focusing pupils on learning rather than on the achievement.

Keywords: motivation, teaching chemistry, achievement in chemistry, self-efficiency.

Introduction

The amount of theories on motivation indicates the complexity of the phenomenon of motivation as well as the existence of a large number of factors affecting the (lack of) pupil's motivation. The theoretical basis of this paper for studying motivation for learning chemistry consists of a combination of the constructivist learning theory and the motivation theory according to which the pupils' perceived self-efficiency, the use of active learning strategies, appreciating chemistry as a science, individual learning goal, as well as individual's environment are all important motivational factors (Hsiao-Lin Tuan et al. 2005). Bandura defines the perceived self-efficiency as the individual's assessment of his own capabilities of organizing and realizing the actions necessary to achieve the desired goals (Bandura, 1997). The individual's confidence in his own efficiency affects the

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cognitive, motivational and affective processes, the direction of actions selected, and the choice of challenges and goals. Self-efficiency is the basis of determining the amount of invested efforts and expected outcomes (Bandura, 1997, 2001). Lack of awareness of pupils' own cognitive capacities may limit their abilities to function in situations that require identifying and using new learning strategies (Mirkov, 2005). Pupils with high self-efficiency believe that they are able to realize the given task. To fulfil the requirements they are faced with, they apply different learning strategies that are largely conditioned by motivation. To stimulate pupil's learning motivation it is very important to apply an open and problem-oriented approach towards learning, which should be related to his interests and nature of his curiosity (Nikčević, Milković, 2004). When applying active learning strategies, pupil takes an active role in the use of different strategies for acquiring and understanding new knowledge based on the previous one (Hsiao-Lin Tuan et al. 2005). The term "active learning" has been approached by different authors in different ways, depending on the context. In this study, the starting point is the comprehensive definition of active learning, according to which active learning involves various thought activities that occur in the interaction with teachers, other pupils, or as a result of the pupils' independent efforts (Milin, 2012).

When facing with tasks perceived as valuable and meaningful pupils are drawn by them investing higher intellectual effort to reach the goal. However, when they fail to see any value in the task, they use a surface approach to learning, such as memorizing (Pintrich & Schunk, 1996). It can be argued that teaching chemistry requires developing pupils' ability to solve problems, encouraging them to think, and emphasizing the importance of science in everyday life. This will make pupils more motivated to learn chemistry.

The scope of pupil's participation in learning process depends on whether his motivation is focused on learning or achievement. Depending on his motivation, different learning outcomes can be interrelated – not just school success, but also feelings about school, use of learning strategies, experience of efficiency, and affective responses to success and failure (Mirkov, 2008). When pupils set achievement as a goal, they are struggling to get a positive assessment for their work, demonstrate their superiority in order to receive a positive assessment for their competence, or avoid negative assessments or evaluations by others (Mirkov, 2008; Vizek Vidović et al. 2003). Thus, learning the teaching content is a means to achieve the goal (Mirkov, 2008). Learning-oriented pupils believe that the main objective of schooling is to master the task and achieve competences in what is taught in school, improve the own knowledge, master the teaching content, i.e. understand the material (Vizek Vidović et al. 2003; Mirkov, 2008). Therefore, learning the teaching content is believed to be a self-contained goal (Mirkov, 2008). The focus on achievement leads to the application of superficial and short-term learning strategies: pupils are focused on being better than the others, as well as superficial properties of the task instead of thinking of how to understand the material and relate it to what they already know (Vizek Vidović et al. 2003).

To help pupils focus on learning, teachers should convince them that the true purpose of education is knowledge, rather than just getting high grades. This can be achieved by emphasizing the practical importance of studied material and reducing the importance of grades and other kinds of awards. Using challenging and meaningful exercises that are

related to everyday life encourages pupils to embrace the idea of focusing on learning procedure instead of achievement (Vizek Vidović et al. 2003).

Research methodology

The aim of the study is to investigate the relation between the pupils' motivation for learning chemistry and their achievement in chemistry (as measured by obtained grades and the achievement on a knowledge test), as well as to examine the differences in pupils' motivation as a function of gender and the parents' level of education. The basic assumption of this paper is that there is a positive correlation between the pupils' motivation for learning chemistry and their achievements, and that differences in pupils' motivation are statistically insignificant regarding the variables of 'gender' and 'parents' level of education'.

Research instruments

Two instruments were applied in the study. The pupils' motivation for learning chemistry was measured using the SMTSL questionnaire (Student's motivation toward science learning; Hsiao-LinTuan et al. 2005), which has been adapted for the purpose of this research. The questionnaire applied in this study contains 29 items which measures five dimensions of motivation for learning chemistry in school based on their self-assessment. These dimensions are defined as *self-efficiency*, *active learning strategy*, *appreciation of importance of chemistry as a science*, *achievement-oriented motivation* and *learning-orientated motivation*. Pupils responded by circling a number on a five-point scale ranging from strongly agree (coded 5) to strongly disagree (coded 1). As argued by the authors of the questionnaire (Hsiao-LinTuan et al. 2005), the SMTSL questionnaire has high internal consistency (Cronbach's alpha coefficient: 0.89). In this study, the value of the calculated Cronbach's alpha coefficient is 0.91. Metric properties of scales that correspond to specific dimensions of motivation for learning chemistry are shown in Table 1.

Table 1: Metric properties of scales

	minimum	maximum	mean	standard deviation	asymmetry coefficient	coefficient of skewness
self-efficiency	9.00	35.00	24.94	6.22	-0.48	-0.55
active learning	13.00	40.00	30.92	6.06	-0.79	0.13
appreciating chemistry	5.00	25.00	16.76	4.39	-0.38	-0.13
achievement orientation	4.00	20.00	15.08	2.84	-0.79	0.92
learning orientation	5.00	25.00	21.37	3.56	0.82	-0.96

For the purpose of this research a knowledge test has been created of inorganic chemistry in order to investigate the possibility of predicting pupil achievement based on their motivation. The test consisted of seventeen questions and covered the material presented according to the current curriculum for the second grade of grammar school –

natural science studies. The weight of the knowledge test applied is average (AS = 7.90, SD = 3.84). Descriptive indicators of the test are shown in Table 2.

Table 2: Descriptive indicators of the knowledge test in inorganic chemistry

Mean	7.90
Median	7.50
Standard deviation	3.84
Minimum	1.00
Maximum	16.00
Skewness	0.29
Kurtosis	-0.84
α	0.78

Normality of distribution of the obtained results using the above instruments has been assessed based on indicators of skewness and kurtosis. Since these values are in the appropriate range, the assumption of normal distribution has been confirmed (Tabachnick & Fidell, 2007).

Sample

The sample included 236 third grade high school pupils during the school year 2013/2014, from seven grammar schools with curricula comprising general science teaching subjects as well as natural science teaching subjects from the territory of Novi Sad, Sremska Mitrovica, Stara Pazova and Novi Bečej. There were 98 (41.5%) males, and 138 (58.5%) females.

Statistical analysis

The relationship and predictive value of motivation in terms of the pupils' performance on the knowledge test in inorganic chemistry has been examined using regression analysis. The structure of differences in motivation between the groups formed based on the variable of 'grade in chemistry' has been investigated using discriminant analysis. Gender-related differences in levels of motivation were investigated using the t-test for independent samples, while differences in motivation as a function of parent's level of education were studied using one-factor analysis of variance. The above analyses were conducted using the IBM SPSS Statistics 20 software package.

Research results

The level of pupil motivation for learning chemistry

The data collected on motivation for learning chemistry, measured through five dimensions of motivation, were subjected to descriptive analysis. The main results of this analysis, transformed into comparable values are shown in Table 3.

Table 3: Descriptive indicators of motivation for learning chemistry

dimension of motivation	M	SD
self-efficiency	3.56	0.89
active learning	3.86	0.76
appreciating chemistry	3.35	0.88
achievement orientation	3.77	0.71
learning orientation	4.27	0.71

As indicated by the results, pupils' motivation measured with five dimensions is in the range from 3.35 for the dimension of appreciation of chemistry as a science, to 4.27 for the dimension of learning-oriented motivation. At the individual level, items with the lowest scores are "I think studying chemistry is important because I use it in everyday life" and "I think studying chemistry is important because it's thought-provoking." The highest scoring item is, "I feel satisfied when I am sure of my knowledge."

Comparing motivation based on the variable of 'gender'

Descriptive indicators of the levels of pupils' motivation for learning chemistry along the variable 'gender' are shown in Table 4. The sample (236 pupils) consists of 98 male and 138 female pupils. Using the t-test for independent samples, results obtained for motivation of male and female pupils were compared.

Table 4: Descriptive indicators of pupil motivation as a function of variable 'gender'

dimension of motivation	gender	M	SD	standard error
self-efficiency	1	25.43	6.57	0.66
	2	24.59	5.95	0.51
active learning	1	30.00	6.76	0.68
	2	31.58	5.44	0.46
appreciating chemistry	1	16.22	4.42	0.44
	2	17.14	4.34	0.37
achievement orientation	1	14.91	2.95	0.30
	2	15.19	2.76	0.23
learning orientation	1	20.61	4.01	0.40
	2	21.91	3.10	0.26

1- males; 2 - females

The results obtained using the t-test showed that there is a significant difference in motivation between male and female pupils along the dimension of learning-oriented motivation (Table 5). Also, there is an observable marginal significance along the dimension of active learning.

Table 5: Results of t-test for independent samples

dimension of motivation	Levene's test (r)	t	df	p	standard error
self-efficiency	0.05	1.02	234	0.31	0.82

active learning	0.00	-1.91	179	0.057	0.82
appreciating chemistry	0.73	-1.59	234	0.11	0.58
achievement orientation	0.48	-0.77	234	0.44	0.37
learning orientation	0.01	-2.69	174	0.01	0.48

The significance level of Levene's test (Table 5) is lower than 0.05 along the dimensions of active learning and learning-orientation. The above fact indicates that groups formed on the basis of variable 'gender' are not uniform. Therefore, the assumption of equality of variance is not satisfied. However, the program calculates an alternative value, compensating for the fact of variance inequality. Values obtained in this way are shown in Table 5. However, in order to test the obtained statistical significance, the nonparametric Mann-Whitney test has been applied, which has confirmed the existence of statistical significance along the dimension of learning-orientation (Table 6).

Table 6: The Man-Whitney test of differences of motivation between male and female pupils

	active learning	learning orientation
Mann-Whitney	5915.50	5508.00
Z	-1.64	-2.45
p	0.10	0.01

As indicated by data provided in Table 6, differences identified in motivation along the dimension of learning-orientation between male (Md = 105.70, N = 98) and female (Md = 127.59, N = 138) pupils using the Mann-Whitney test are in favour of female pupils.

Differences in pupils' motivation by grades in chemistry

The relation between pupils' motivation for learning chemistry was investigated using the correlation coefficient along the total number of respondents – 221 (Table 7).

Table 7: Correlation coefficient along the dimensions of motivation and grades in chemistry

	self-efficiency	active learning	appreciating chemistry	achievement orientation	learning orientation
grade in chemistry	0.57**	0.30**	0.23**	0.25**	0.06*

**p*< 0.05; ***p*< 0.01

A high positive correlation (Pallant, 2011) has been calculated between grades in chemistry and the perceived self-efficiency. A low positive correlation (Pallant, 2011) has been obtained along the dimensions of active learning, appreciation of chemistry and achievement-orientation.

Results of the discriminant analysis aimed at examining the structure of difference in motivation between groups formed on the basis of grades in chemistry are presented in Table 8.

Table 8a: Results of discriminant analysis

function	Wilks' lambda	χ^2	df	p	Rc
1	0.64	97.37	15	0.00	0.59
2	0.97	5.72	8	0.68	0.13
3	0.99	1.98	3	0.57	0.10

Table 8b: Structure matrix

dimension of motivation	correlation
self-efficiency	0.95
active learning	0.32
appreciating chemistry	0.45
achievement orientation	-0.01
learning orientation	0.21

Table 8c: Group centroids

grade of respondents	function 1
2	-0.94
3	-0.72
4	0.07
5	0.82

Based on the results shown in Table 8a, it is obvious that one discriminant function is significant at level of $p < 0.01$, while the coefficient of canonical correlation shows a high correlation, $R_c = 0.59$. As indicated by the structure matrix (Table 8b), the function is the most saturated by scores on scales of self-efficiency, appreciation of chemistry and active learning. Group centroids point to the fact that pupils with grade 5 have achieved the highest scores on the discriminant function (Table 8c).

Correlation between pupils' motivation and achievement in inorganic chemistry

Correlation between motivation and achievement in chemistry, as measured by the knowledge test of inorganic chemistry has been studied using regression analysis.

Table 9: Regression analysis: pupils' motivation in predicting achievement in inorganic chemistry

	R	R^2	adapted R^2	standard error	F	df	p
model 1	0.39	0.15	0.13	3.58	8.09	5. 230	0.00

Results show that 13% of the variance in criteria has been explained based on the set of predictors (five dimensions of motivation).

Table 10: Partial contributions of achievement predictors in inorganic chemistry

dimension of motivation	β	t	p
self-efficiency	0.21	2.43	0.02

active learning	0.18	1.90	0.058
appreciating chemistry	0.07	0.98	0.33
achievement orientation	-0.08	1.21	0.23
learning orientation	0.01	0.17	0.86

After examining the partial contributions of predictors (Table 10), it can be clearly seen that self-efficiency ($\beta = 0.32$, $p < 0.01$) significantly contributes to the prediction of achievement in inorganic chemistry, while the significance of active learning strategies is marginal. Other dimensions of motivation were statistically insignificant predictors of pupils' achievement in inorganic chemistry.

Differences in levels of motivation as a function of parents' level of education

Differences in levels of pupils' motivation as a function of parents' level of education were examined using the single factor analysis of variance (ANOVA). The obtained results using the above statistical analysis are presented in Table 11.

Table 11: Single factor analysis of variance of pupil motivation as a function of mother's level of education

Dimension of motivation	Levene's test (r)	F	df_1	df_2	p
self-efficiency	0.45	0.58	3	231	0.63
active learning	0.40	0.40	3	231	0.75
appreciating chemistry	0.22	0.88	3	231	0.45
achievement orientation	0.86	0.84	3	231	0.47
learning orientation	0.13	2.63	3	231	0.05

As shown by the results, there is a statistically significant difference along the dimension of motivation of learning-oriented pupils between groups formed based on mother's level of education. In terms of mother's level of education, pupils were divided into the following groups: Group 1 – mothers with maximum primary education; Group 2 – mothers with maximum secondary education; Group 3 – mothers with maximum university education; Group 4 – mothers with post-graduate education. The results of subsequent comparisons of pupils' motivation conducted using the Tukey HSD test are shown in Table 12.

Table 12: The results of the Tukey HSD motivation test as a function of mother's level of education

pupil groups		mean differences	standard error	p
1	2	-0.62	1.79	0.98
	3	0.79	1.79	0.97
	4	0.13	1.84	1.00
2	3	1.43	0.51	0.02
	4	0.77	0.66	0.64
3	4	-0.66	0.65	0.74

Subsequent comparisons using the Tukey HSD test (Table 12) indicate that the mean difference between pupils from Group 2 – mothers with maximum secondary education ($M = 22.14$, $SD = 2.87$) and Group 3 – mothers with maximum higher or university education, ($M = 20.71$, $SD = 3.87$) is statistically significant.

Differences in motivation for learning chemistry as a function of father's level of education were identified using the same statistical analyses as in the previous case, and the results are shown in Tables 13 and 14.

Table 13: Single factor analysis of variance of pupils' motivation as a function of father's level of education

dimension of motivation	Levene's test (r)	F	df_1	df_2	p
self-efficiency	0.16	4.90	3	232	0.00
active learning	0.14	1.19	3	232	0.31
appreciating chemistry	0.69	0.59	3	232	0.62
achievement orientation	0.20	0.14	3	232	0.93
learning orientation	0.93	2.10	2	232	0.10

Table 14: The results of the Tukey HSD motivation test as a function of father's level of education

groups		mean differences	standard error	p
1	2	-3.76	3.09	0.62
	3	-3.96	3.09	0.58
	4	-7.55	3.17	0.08
2	3	-0.19	0.88	0.99
	4	-3.78	1.13	0.00
3	4	-3.59	1.13	0.01

A statistically significant difference of pupils' motivation has been obtained along the dimension of self-efficiency as a function of father's level of education. As indicated by subsequent comparisons using the Tukey HSD test (Table 14), the mean value of Group 4 pupils – fathers with post-graduate education (M = 28.05, SD = 4.66) were significantly different from the mean value of Group 2 – fathers with maximum secondary education (M = 24.26, SD = 6.25) and Group 3 - fathers with maximum university education (M = 24.45, SD = 6.41).

Discussion

The overall objective of this study was to examine the relationship between pupils' motivation for learning and achievement in chemistry, i.e. examining the differences in motivation as a function of gender and parents' level of education.

According to the results, different dimensions of pupils' motivation for learning chemistry are present in varying degrees. Items with the highest scores indicate that pupils believe that it is important to learn the teaching material because it is the path towards improving and developing individual competencies necessary for advancement in nowadays society. The resultant data clearly indicate a positive attitude towards school and learning new teaching contents. Learning-oriented pupils are prone to opting for challenging tasks (Vizek Vidović et al. 2003) and using different strategies for acquiring new knowledge (Hsiao-LinTuan et al. 2005). The above statements are confirmed by the results obtained in this research.

The fact that the lowest scoring items are those related to appreciating the importance of chemistry as a science is very interesting and illustrative. This means that pupils participating in this research believe that knowledge of chemistry is irrelevant to the problems of everyday life. In order to overcome the situation presented, one possible solution is that teachers should emphasize the wonders of the subject-matter and its practical importance. Applying challenging, meaningful and practical exercises may stimulate pupils to accept science as something valuable.

When considering gender differences in levels of motivation for school learning, previous research findings are inconsistent (Trogrlić, Šarcević and Vasić, 2013; Meece & Jones, 1996). This study revealed no differences in motivation between male and female pupils along the dimensions of self-efficiency, achievement-orientation and appreciation chemistry as a science. This finding is different than those of some previous studies according to which there are differences in perceived self-efficiency (Britner, 2008; Meece & Jones, 1996). According to some authors, these differences are reflected in a more explicit confidence in the own abilities displayed by male pupils (Meece & Jones, 1996), while other authors suggest that a higher sense of self-efficiency was recorded for female pupils (Britner, 2008). In this study, gender differences were confirmed along the dimension of learning-orientation. Thus, it is proved that female pupils show higher levels of motivation for learning activity.

In context of the problem studied, the marginal significance of differences in the application of active learning strategies makes a significant finding, pointing to higher values obtained by female pupils. The assumption that the degree to which female pupils apply meaningful learning strategies is higher is confirmed by previous studies (Meece & Jones, 1996).

Further analysis has shown that the grade in chemistry is significantly correlated with subscale that measures pupils' self-efficiency in learning chemistry. Likewise, high levels of subjectively perceived self-efficiency in learning chemistry are accompanied with high grades in chemistry. A significant correlation exists between grades in chemistry and subscales that measure the use of active learning strategies, achievement orientation and learning orientation. Generally, there is a significant positive correlation between grades in chemistry and pupils' motivation. These findings are consistent with the results of previous similar studies (Hsiao-LinTuan et al. 2005), as well as with the reports in the literature according to which motivated pupils apply higher intellectual efforts, have higher levels of thought activity and better concentration which leads to better results (Lungulov, 2010).

Analyzing the structure of motivation-differences between groups based on grades in chemistry, there is a difference in terms of the expressed sense of self-efficiency, the use of active learning strategies, and appreciating chemistry as a science. The highest scores on the subscales that measure these dimensions of motivation are those of pupils who are graded five in chemistry; as the level of pupils' motivation decreases, so decreases the grade in chemistry. Likewise, pupils confident in their abilities use active learning strategies and appreciate chemistry as a science and have high achievement in chemistry – as measured by obtained grades. Further results show that pupils who are graded 5

have high level of motivation, pupils who are graded 4 four have average motivation; in all other pupils' motivation is absent. From the perspective of an educator, behaviour of pupils graded 2 and 3 clearly indicates lack of motivation. Taking this into account, the biggest surprise is the lack of motivation among pupils graded 4.

One possible explanation for the lack of motivation in pupils graded 4 in chemistry is their prominent struggle to get 5 in this perpetual race. Perhaps this is the rationale why these pupils become self-critical and perceive their self-efficiency negatively.

The finding that self-efficiency is a positive predictor of achievement in chemistry is consistent with the results obtained in previous studies (Zimmerman, 2000). The established fact that the individuals with high self-efficiency for learning display higher achievement is a part of a range of evidences that pupils' motivation is a reliable predictor of academic success.

Having in mind previous studies that confirmed the didactic value of active learning (Prince, 2004), the fact that the use of active learning strategies is a marginal positive predictor of achievement in inorganic chemistry is worth attention, regardless of the fact that, strictly speaking, it can be rejected for its marginally significant correlation. The absence of predictability of the remaining three dimensions of motivation (appreciation of chemistry as a science, achievement orientation, and learning orientation) is inconsistent with findings of previous studies (Hsiao-LinTuan et al. 2005).

The further analysis was conducted with the aim of differentiating the specificity of correlations between the parents' level of education and pupil motivation. As indicated by the obtained results in the research field which is conceptualized in this way, there are differences in the pupils' perceived self-efficiency as a function of fathers' level of education, while as for mothers' level of education these differences reached statistical significance in terms of motivation of learning-oriented pupils.

Conclusion

The present research considered studying the differences in expressed levels of motivation for learning chemistry among pupils of the third grade of grammar school. From a set of predictor variables, the pupils' perceived self-efficiency in learning chemistry has a statistically significant partial contribution to their achievement in chemistry, which indicates that pupils who are more confident in their own abilities respond easier to the challenges of learning activity.

The data obtained are instructive for educators because they clearly suggest that there is a need for promoting academic motivation among pupils. Some of the ways to realize this goal are strengthening the sense of self-efficiency, facilitating the implementation of active learning strategies, connecting the teaching content of chemistry with practical application of knowledge, and focusing pupils on learning rather than on the achievement.

Finally, findings of this study should be considered with caution given the relatively small sample size and the fact that the analysis was conducted on data that were obtained by the pupils' self-declaration.

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