JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898

RESULTS OF PISA AND EVALUATION OF COMPUTER SCIENCE EDUCATION

Ján Záhorec,
Alena Hašková,
Michal Munk,
Martin Bílek

Abstract. *In the PISA scientific literacy monitoring carried out in 2006 and 2009 Slovak students achieved results below the OECD average scores while Czech students achieved significantly better results. Following the PISA results there was carried out a research aimed at evaluation of the current state of computer science education/informatics teaching at an upper secondary school level in both countries and moreover also in Belgium. In all three concerned countries a lack of textbooks of an appropriate quality was identified as a main weakness. Further identified weaknesses were: in Slovakia a problem of a lack of tasks attractive for students, in the Czech Republic a weak attractiveness of the teacher's presentation of new material for students and identically to Belgium a lack of engagement of students in tasks solved in class. Positively evaluated was: in Slovakia attractiveness of the curriculum and methods of new material presentation by teachers, and in the Czech Republic and Belgium clarity of the teacher's presentation of new curriculum.*

Key words: *monitoring of students` scientific literacy, current state of computer science education, evaluation of informatics teaching, strengths and weaknesses of informatics teaching, international comparison.*

Ján Záhorec
Slovak University of Agriculture, Nitra, Slovak Republic
Alena Hašková, Michal Munk
Constantine the Philosopher University, Nitra, Slovak Republic
Martin Bílek
University of Hradec Králové, Hradec Králové, Czech Republic

Introduction

Since 2006 the scientific literacy has been a part of the PISA international monitoring of school achievements (*Programme for International Student Assessment*). In three year cycles the OECD study PISA tries to bring new information on the level of scientific literacy in the OECD member countries and other participating countries, based on testing the skills and knowledge of 15-year-old students. Within this monitoring the scientific literacy is defined as the ability to use scientific knowledge and processes not only to understand the natural world but also to participate in decisions that affect it.

In both carried out cycles of the PISA scientific literacy monitoring (2006, 2009) Slovak students achieved results, which were below the OECD average scores (OECD 2007a, 2007b; OECD 2010). To compare with the year 2006, in 2009 the average score of the Slovak students rose insignificantly up to 2 points and reached 490 value at the average OECD score 501. In the ranking of the participating OECD countries this meant 23rd – 29th place and among the all 65 PISA participating countries it was 29th – 37th place. On the one hand this evoked a great discussion on dissatisfactory with the PISA results and the quality of natural science teaching at both primary and secondary schools. But on the other hand in practice the position of natural science teaching became worse than it had been: a school reform decreased the number of compulsory natural science lessons per week in newly created State educational programme and some further cuts of the relevant subjects have been done at schools through their school educational programmes.

Although the scientific literacy cannot be identified with the computer or digital literacy, nowadays one has to be computer/digital literate to develop his/her scientific literacy (Luu & Freeman, 2011). Computer literacy can be understood as a prerequisite or a component part of the scientific literacy. The question of the relation of scientific and computer literacy can be perceived also as a consequence of the issue of computer science incorporation among natural or technical sciences (Alexandrov, Alexandrov, & Ramirez, 2012). Usually computer science is not perceived as a part of natural sciences (in this sense as not equal to biology, chemistry, physics neither mathematics) but in its nature it is a subject of technical and mathematical nature. Moreover, as it has been already mentioned, it creates a platform and at the same time it is an integral part of the technical education (De Jong, 2007; Hus & Aberšek, 2007; Vishkurti, Spahiu, & Paci, 2011). This fact is reflected also in the four areas on which the scientific literacy (or specifically scientific knowledge) PISA monitoring was aimed at: the role of science and technology, relation between science and technologies, basic notions and important principles (OECD 2010, Olsen, Prenzel, & Martin, 2011).

Research Problem

The unsatisfactory results of Slovak students in the two cycles of PISA monitoring (2006, 2009) and the issue of computer education as an integral part of technical education or as a platform for one's scientific literacy development evoked an intention to carry out a research aimed at evaluation of quality of informatics teaching in the Slovak Republic and its comparison with the situation in other countries. As PISA assesses not only how far students near the end of compulsory education have acquired the relevant knowledge and skills (in terms of mastery of the school curriculum) but also how able they have been to use them in practice and for full participation in society (in terms of important knowledge and skills needed in adult life), it was decided to set the intended assessment on the students' point of view of the related issues.

Methodology of Research

General Background of Research

The main goal of the research was to evaluate the current state of teaching informatics at the upper secondary school level of the system of education in the Slovak Republic (SK) (ISCED 3A; 16 – 19 year age students). Additionally to this it was decided to evaluate, in the same way and based on the same criteria, also the situation in the Czech Republic (CZ) and Belgium (BE).

The Czech Republic was chosen because of two reasons. One reason was the common roots and development of the both national systems of education in frame of previous Czechoslovakia (1914 – 1992). The second reason was the results of PISA monitoring which showed that the Czech Republic had significantly better results than the Slovak Republic. Based on the results of the PISA monitoring (Palečková et al., 2007), Czech students belong to ones with above-average results in the science test (mean OECD – 498 points, Czech students – 513 points, Slovak students – 488 points) as well as in the mathematical part of the test (mean OECD – 500 points, Czech students – 510 points, Slovak students – 492 points) (Palečková &Tomášek, 2005; Frýzková & Palečková, 2007; Palečková, Tomášek, & Basl, 2010).

Belgium, as another comparative country with which the situation in Slovakia was compared, was chosen in regard to accessibility.

Due to the diversity of secondary schools and with this diversity connected wide range of specific implementation of computer science education, we focused our attention on a single type of school in this category: in Slovakia and the Czech Republic on grammar schools, and in Belgium on general secondary schools (ASO) representing an equivalent to them. In these schools computer science education is based mainly on the school subject informatics taught as a compulsory subject aimed at acquisition of a "general informatics education", i.e. at acquisition of basic knowledge and skills to work with digital technologies to search, process and present information which is necessary to solve different tasks.

ISSN 1648–3898

Instrument and Procedures

The quality of teaching a school subject is usually assessed on the basis of its curriculum content analysis and students` learning outcomes. We decided to set the evaluation of current state of informatics teaching on students` opinions and their evaluations of this state. The evaluation was done based on following 14 selected specific factors gauging the students' point of view:

P1 – the popularity of the subject,
P2 – the applicability of the gained knowledge in the students' future,
P3 – attractiveness of the curriculum content,
P4 – the demands of the curriculum,
P5 – the clarity of presentation of new material,
P6 – the attractiveness of curriculum presentation by teachers,
P7 – the suitability of particular methods for curriculum presentation,
P8 – the engagement level of tasks to be solved,
P9 – the clarity of textbooks used,
P10 – the usability of knowledge for solving practical problems,
P11 – the attractiveness of teaching aids used,
P12 – the way in which students make written notes of the presented subject matter,
P13 – the appropriateness of specific methods in written notes preparation,
P14 – sources of concern related to the subject.

Specification of the factors resulted from our previous experiences and research results (Hašková, 2003; Záhorec, Hašková, & Munk, 2010), professional literature in this area (Vári, 1997; Hrabal, 1989; Šebeň & Jakubov, 1997; Bálint & Nogová, 2003; Ross & Genevois, 2006; Ribeiro & de Gusmão, 2010) and consultations with other experts (both research workers and computer science teachers from various types of schools and various practice duration). The data collection was carried out using a 14-item questionnaire, in which its particular items corresponded with the above-mentioned investigated factors P1 – P14 corresponding with the quality of computer science education/informatics teaching.

In the used questionnaire the respondents expressed their answers (evaluations of the relevant assessed factors) according their opinions to the ordinary items P1, P2, P3, P4, P5, P6, P8, P9 and P10 using a 7-point scale (1 – most negative assessment/attitude; 4 – neutral, emotionally indifferent assessment/attitude; 7 – most positive assessment/attitude).

In the nominal questionnaire items P7 and P11 – P14 the respondents were asked to choose among several given alternatives the most suitable answer for them. The offered alternatives to the particular items were these following:

P7 – the kind of explanation preferred by the student: *a – teacher explains the subject matter without using visual teaching aids; b – teacher explains the subject matter using various teaching aids; c – teacher involves also students in the explanation of the new subject matter; d – teacher gives individual tasks to students and supervises their progress; e – if other, state what you like*;

P11 – positive or negative answer to the question whether there are used also other teaching aids during the lessons of informatics in addition to computers (P11a) and in case of a positive answer evaluations how interesting the used teaching aids are for the students (P11b): *a – very uninteresting*; *b – uninteresting; c – rather uninteresting; d – neither uninteresting nor interesting; e – rather interesting; f – interesting; g – very interesting*;

P12 – the way in which students are asked to make their written notes: *a – the teacher dictates us the notes; b – we do our written notes according the teacher who writes the notes on the blackboard or screens the notes in an electronic way using a data projector; c – a part of the written notes we do according the notes made by the teacher and a part of the notes we do from the textbooks ourselves; d – we make our written notes completely ourselves on the basis of the teachers' explanation; e – we make all our written notes from the textbook ourselves at school; f – we make all our written notes from the textbook ourselves at home; g – we do not* *make written notes of the presented subject matter at all*;

P13 – positive or negative answer to the question whether the used way of taking the notes is convenient for the student (P13a) and in case of a negative answer indicating the one, from the same alternatives as stated in P12, which would the student prefer more (P13b);

P14 – possible reasons to feel scared or nervous before the informatics lessons: *a – I am not used to be afraid of anything; b – unpreparedness/I am not prepared properly; c – oral examination; d – practical tests; e – getting a bad mark; f – fear of repeated lack of understanding the presented subject matter; g – other, state what*.

The questionnaire reliability was proved through identification of its suspicious items by the means of the analysis of the questionnaire/item analysis. The final total questionnaire reliability α = 0.84, calculated using the Cronbach alpha, indicates a high inner consistence of this measuring tool as a tool for relevant reliable research data obtaining.

Data obtained for each questionnaire item were processed in a dependence on the factor COUNTRY, GENDER and combination of the factors COUNTRY*GENDER. Statistical processing of the obtained data was based on the use of *chi*-square test, contingency coefficient, analysis of variance for repeated measurements ANOVA, Greenhous-Geisser and Huynh-Feldt corrections for repeated measures in the analysis of variance and graphical visualization.

Sample of Research

The research sample of the upper secondary school level (ISCED 3A; 16 – 19 year age students) was limited to 4-year and 8-year grammar schools (SK and CZ) and to them relevant general secondary ASO schools (BE – Algemeen Secundair Onderwijs). Research samples in the observed countries were, due to our limited opportunities, based on the availability of the schools. Even though, the schools from the Slovak and Czech Republic involved in the research (SK – 8 different grammar schools, CZ – 6 different grammar schools) represented various regions as well as different sizes of towns. Only the Belgium research sample cannot be taken as a representative one, as the respondents involved in research have represented only one school. The total number of the respondents was 368 (SK – 246, CZ – 70, BE – 52) from which 222 were boys (SK – 154, CZ – 39, BE – 29) and 146 girls (SK – 92, CZ – 31, BE – 23).

Ordinary/Scale Items Analysis

Analysis of variance for repeated measures (ANOVA repeated measures) was used in tests of differences between two or more dependent samples – repeated measures. Analysis of variance repeated measures was used when, apart from the factor which determines the repeated measure at particular objects – dependent samples (case of the items P1 – P6, P8 – P10), there are also factors (COUNTRY, GENDER) which divide the objects into several groups – independent samples. If the independent samples are compared, this factor is called between-groups factor (COUNTRY, GENDER). If the dependent samples are compared – repeated measures of the same objects, the factor is called within-group factor (ITEM). Calculations of the tests of significance are different for these different types of factors but the interpretation of their results is the same (Munk, 2011).

The model of the analysis of variance with repeated measure without any group distribution is described by the formula:

$$Y_{ij} = \mu + \alpha_j + \beta_i + \lambda_{ij} + e_{ij},$$

where μ is a mean of the dependent variable, α_j is the effect of the *j*-th repeated measure, β is the effect of the *i*-th object, λ_{ij} is an interaction between the repeated measure *j* and the object *i*.

We are interested in the null hypothesis, which is:

$\mathrm{H0}\!: \mu_1 = ... = \mu_I$ (the means of the repeated measures are equal).

For the use of the tests following preconditions have to be fulfilled:

normal distribution of the dependent variable in the groups according the factor levels,

ISSN 1648–3898

precondition of the covariant matrix assumption of sphericity – equation of the variances and covariances in the covariant matrix for the repeated measures.

Nominal Items Analysis

To find out relations between two nominal variables, the contingence analysis was used, i.e. the contingence analysis was used to analyse nominal items dependences (P7, P11a, P12, P13a, P14 x COUNTRY, GENDER). The group of the distribution-free tests belonging to the contingence analysis is based on the contingence table. These tests verify the null hypothesis, which states that the variables are independent:

H0: $P(X \wedge Y) = P(X)P(Y)$ opposite to the alternative *X*, *Y* are dependent.

For the purpose of the more-field table analysis the *chi*-square test of independence was used. The *chi*-square test of independence represents enhancement of the *chi*-square test of goodness of fit and results from the contingence table of the observed frequencies, where the observed frequency a_{ij} is the frequency of the combination $x_i \wedge y_j$.

The expected frequencies $e_{ij} = \frac{r_i s_j}{n}$ are those which fulfil the null hypothesis on the two variables independence. The expected frequency of the relevant field is equal to the quotient of the conjunction of the relevant observed frequency of the line and column and the total number of the observations.

The *chi*-square test $\chi^2 = \sum_{i=1}^{R} \sum_{j=1}^{S} \frac{(a_{ij} - e_{ij})^2}{e_{ij}}$ verifies whether the differences between the actual and expected frequencies are stochastic (the variables are independent) or statistically significant (the variables are dependent).

The *chi*-square test can be used only in the case when the expected frequencies are big enough. In a case when the expected frequencies are not big enough, the Fisher test can be used, but this is applicable only for the four-field tables.

To assess the relation level between two nominal variables the contingence coefficients (Pearson, Cramer V) were used. These are values from the interval <0, 1>, where 0 means no relation and 1 means an ideal relation. Their significance was tested by the means of the *chi*-square test of independence. (For more detailed information on the conceptual and methodological basis of the research and the pilot verification of the administered questionnaire reliability see Zahorec & Haskova, 2011.)

Results of Research

Ordinary/Scale Item Research Results

Table 1 shows summarized results of the analysis of repeated measures calculated for the ordinary items of the administrated questionnaire (P1 – P6 and P8 – P10). The analysis was used to test the effect of COUNTRY and GENDER, both as independent factors, as well as their interaction on the aggregate questionnaire score (score of the relevant items). The factors of COUNTRY reached a p-value of less than 0.01, which means that responses to the items are significantly affected by the factor COUNTRY and they are not affected by the factor GENDER nor by the interaction of COUNTRY*GENDER ($p > 0.05$). Despite the fact that differences in the responses of boys and girls are not statistically significant, figure 3 shows a tendency of boys to evaluate individual factors higher than girls.

Table 1. Repeated measures analysis of variance.

	SS	df	MS	F	p
Intercept	48096.23	1	48096.23	8235.616	0.0000
Country	86.47	2	43.24	7.403	0.0007
Gender	7.08	1	7.08	1.213	0.2714
Country*Gender	0.03	2	0.01	0.002	0.9977
Error	2114.09	362	5.84		

As there was proved a significant difference among the respondents' answers in dependence to the factor COUNTRY, the question was between which groups there is the significant difference in the assessment of the particular items. The homogeneous groups according the factor COUNTRY were found out by the means of the multiple comparisons of the relevant couples. The results of this multiple comparisons are summarised in table 2. The results show that the first homogeneous group consists of the Czech and Belgian students and the second one of the Slovak and Belgian students. Within these groups the respondents' responses to the particular questionnaire items did not differ, i.e. within these groups the answers were almost the same irrespective of the respondents' GENDER (within the subgroups created according the COUNTRY factor). The answers to the ordinary items as a whole were rather positive. The highest final overall score (average score for all monitored items) was achieved in Slovakia (4.95) while the Czech Republic recorded the lowest score (4.51). Belgium shows final average results that are essentially similar to Slovakia's (a score of 4.87). Statistically, a significant difference in the responses to the items P1 – P6 and P8 – P10 as a whole was reached between the groups of Slovak and Czech respondents. The statistical significance of the remaining differences was not proved.

Table 2. Homogeneous groups identification.

Factor COUNTRY	Average score	1	2
Czech Republic	4.514	****	
Belgium	4.874	****	****
Slovak Republic	4.948		****

After investigation of the ordinary items total score, we tested which items have significant differences in the assessment without differentiating the respondents into groups and in dependence on the followed factors (figure 1). The findings were verified by the means of the Greenhouse-Geisser and Huynh-Feldt corrections for repeated measures of the analysis of variance to eliminate the problems with the covariance matrix assumption of sphericity (table 3). The results of the testing of differences in respondents' answers to individual items, based on the Greenhouse-Geisser and Huynh-Feldt corrections (Lower Bound) for repeated measures ANOVA, confirmed the statistical significance ($p < 0.05$) in relation to the factor of COUNTRY.

ISSN 1648–3898

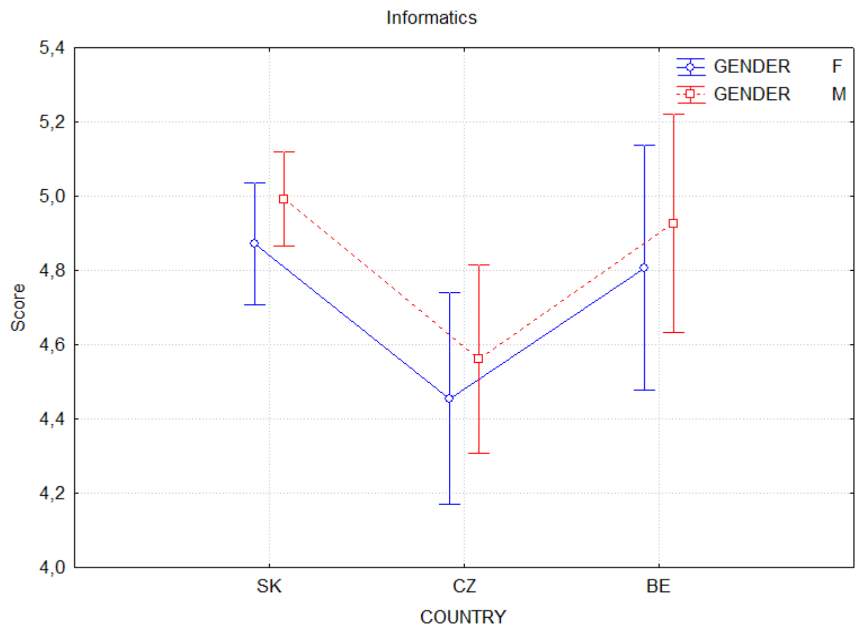

Figure 1: Average score and confidence interval of the ordinary items according to a combination of the COUNTRY and GENDER factors.

Table 3. Greenhouse-Geisser and Huynh-Feldt corrections (Lower Bound) for repeated measures ANOVA.

	Lower Bound Epsilon	Lower Bound Adjusted df1	Lower Bound Adjusted sv2	Lower Bound Adjusted p
ITEM	0.1250	1.0000	362.0000	0.0000
ITEM*COUNTRY	0.1250	2.0000	362.0000	0.0000
ITEM*GENDER	0.1250	1.0000	362.0000	0.1194
ITEM*GENDER*COUNTRY	0.1250	2.0000	362.0000	0.2630

The graph in figure 2 shows results obtained for each ordinary item (the average score and interval score of the average assessment of the items) separately for groups of Slovak, Czech and Belgian respondents. Figure 3 shows results obtained separately for each item apart for the respondents – girls and respondents – boys in each of these countries.

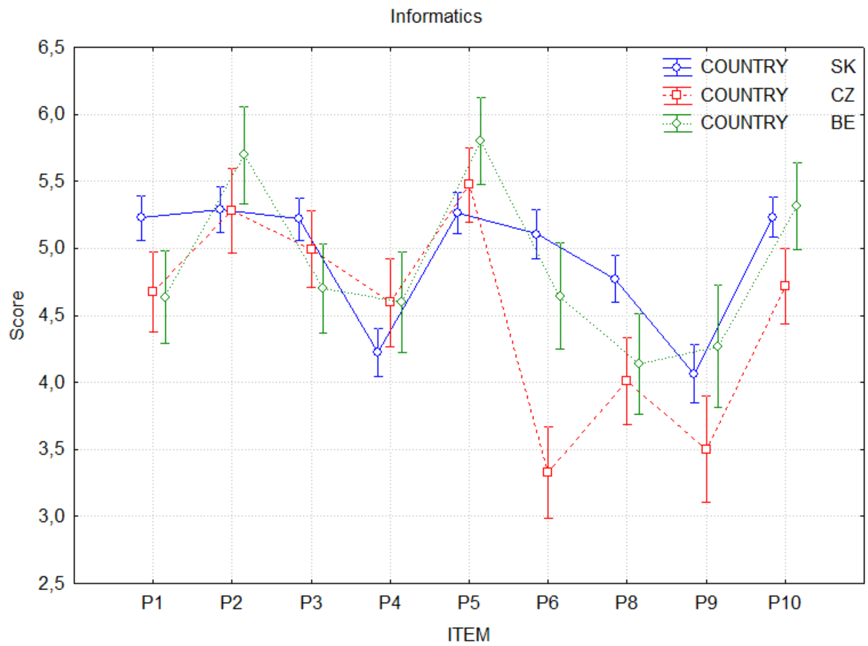

Figure 2: **Ordinary items' average score and interval score based on the factor COUNTRY.**

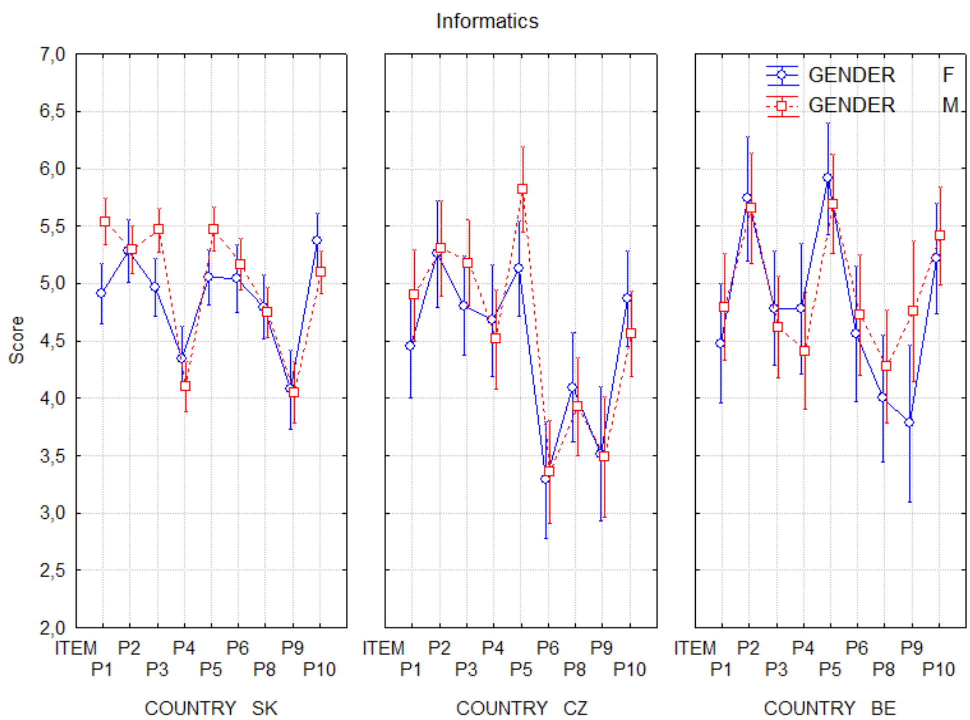

Figure 3: **Ordinary items' average score and interval score based on the COUNTRY and GENDER factors.**

ISSN 1648–3898

Nominal Item Research Results

The null hypotheses to each nominal item were statements that the answer on the relevant item does not depend on the factor COUNTRY / GENDER / COUNTRY*GENDER. Most of the null hypotheses were confirmed. The differences between the respondents' responses in dependence on some of the observed factors were statistically significant only in following cases (table 4):

- item P7 in relation to the factor GENDER,
- item P11a in relation to the factor COUNTRY,
- item P12 in relation to the factor COUNTRY,
- item P14 in relation to the factor COUNTRY,
- item P14 in relation to the factor GENDER.

Table 4. Results of *chi*-square test of independence for items with proved differences in dependence on factor COUNTRY or GENDER.

ITEM / FACTOR	Pearson's chi-square test			Contingency coefficient	Cramer coefficient
	χ^2	sv	p	χ^2	χ^2
P7 (5) / GENDER (2)	12.41715	4	0.0145	0.18067	0.18369
P11a (2) / COUNTRY (3)	7.01785	2	0.02993	0.09449	0.09491
P12 (7) / COUNTRY (3)	146.54410	12	0.0000	0.39834	0.30709
P14 (7) / COUNTRY (3)	45.77430	12	0.0000	0.23558	0.17141
P14 (7) / GENDER (2)	13.93940	6	0.0303	0.19104	0.19462

Figure 4 shows the differences of the responses to the item P12 in dependence on the COUNTRY factor, which is the case of the highest significance level.

Graphs in figure 5 present a summary of the responses to the item 14 according the factor COUNTRY and GENDER, which was a case with proven dependence on the both factors.

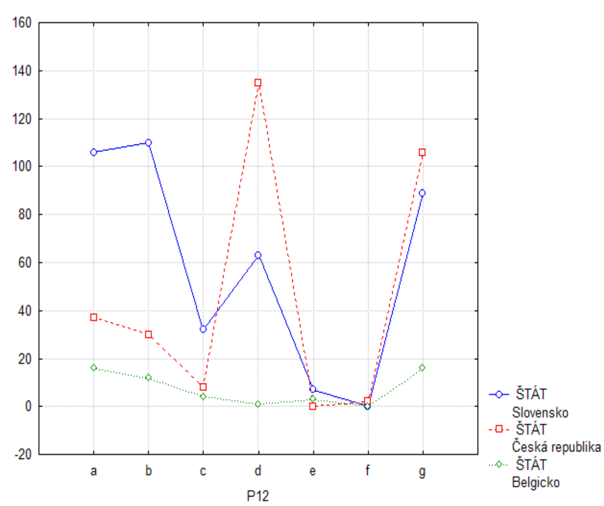

Figure 4: Interaction graph for the item P12 according to the factor COUNTRY.

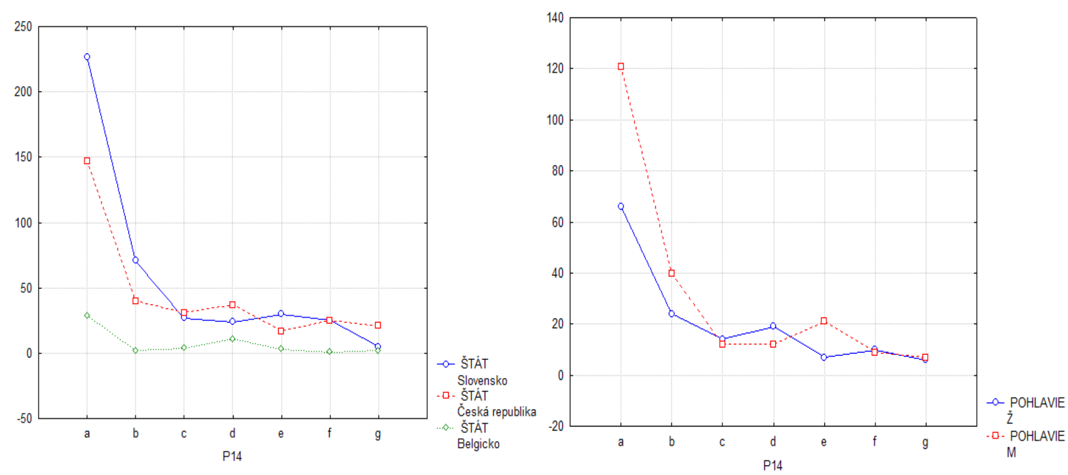

Figure 5: Interaction graph for the item P14 according to the factor COUNTRY and GENDER.

Discussion

Discussion of the Ordinary/Scale Item Research Results

The results presented in figure 2 show that the level of informatics teaching from the student's perspective at almost all observed factors is rated the highest in the Slovak Republic. The only two exceptions are items P4 and P5, which in case of Slovak respondents obtained significantly lowest scores (4.2 for P4 and 5.3 for P5). Slovak students rated informatics as a slightly more difficult subject (P4) than the Czech and Belgian students. The average Slovak student rated this subject *as neither demanding nor easy*, while Czech and Belgian students rated it as *rather easy*. This may be closely related to the item P5 results, in which students reflected on the clarity of the teacher's presentation of new material. While the Czech and Belgian students *usually understand* their teacher's presentation, Slovak teachers often present material not just appropriately, so students are not entirely clear on what is being presented to them (the mean score of the Slovak respondents' P5 rating was 5.3, i.e. the rating *I rather understand* than *don't understand*). This factor – the clarity of presentation of new material by teachers – might be seen, on the background of our research results, as a weakness in informatics teaching in the Slovak Republic. However paradoxically teachers in Slovakia, in comparison with Czech and Belgian teachers, are able to engage their students the most (see the outcome of the item P6). Respondents rated the attractiveness of the teacher's presentation of the Slovak class curriculum with an average score of 5.1. This means that Slovak teachers present the material in such a way that students, according to our rating scale, rate it as a *rather interesting* way of presenting curriculum. Belgian students rate the presentation of new material by their teachers between *neither interesting nor uninteresting* and *rather interesting* (final average score was 4.7). From this aspect, informatics teachers in the Czech Republic were rated as the worst of the three countries. According to the Czech respondents, the way teachers present the subject matter is *rather uninteresting* (the value of the final average score was 3.3). An analogous situation exists with regard to the evaluation of the engagement level of tasks that teachers solve with their students during informatics classes in the three countries we studied (see the results of the questionnaire item P8). Slovak teachers – again, paradoxically, judging by the results of the questionnaire item P5, which states that students only *rather understand* their presentations – give students tasks they considered them to be *rather interesting*. In comparison with Slovak teachers,

ISSN 1648–3898

Czech and Belgian informatics teachers obtained significantly worse ratings even in this aspect of their assessment (see results for the items P6 and P8). The tasks assigned by these teachers weren't considered to be interesting (mean score CZ – 4.0, BE – 4.2 represents the rating *neither interesting nor uninteresting*).

The knowledge students gain in informatics classes is considered to be *rather necessary* by both Belgian and Slovak students. A significantly more negative outcome was recorded in the evaluation of computer science education in the Czech Republic. Czech respondents ranked knowledge taught in informatics school curriculum as *neither necessary nor unnecessary* more often than *rather necessary* (P10 average score 4.7). Based on the aspect of attractiveness (P3 questionnaire item), the curriculum covered in informatics classes was rated by all three groups as *interesting*. Also noteworthy is the fact that the higher is the average rating by a group, the smaller is the variance of the majority of answers (see figure 2 for the minimum size of variance in the majority of answers for the group of Slovak respondents, for which the average score in this item was 5.3 – the highest one of the three groups, and greater variance of the majority of responses in the case of the Belgian respondents, for whom the average score was 4.7 – the lowest one).

The weakest aspect of teaching informatics at the upper secondary level (ISCED 3A) in all three countries has proven to be the quality of textbooks, or rather, their scarcity. The final evaluation of the textbook clarity factor (item P9), or the quality of textbooks used in a broader sense, certainly cannot be taken lightly, especially given the size of the examined sample and student diversity of the residential schools surveyed. Therefore, if we are to formulate recommendations for practical utilization of our research results in practice with the goal to increase the level of computer science education (informatics teaching) at schools, the main attention should be drawn to this area. In light of the assurance of proper quality of computer science/informatics education at schools, results from all three countries showed the need for a deeper analysis of textbooks. However, we must point to the fact that the problem of ensuring the quality of textbooks may, in some cases, actually be a problem of ensuring the availability of any textbooks.

On the background of the problems with textbooks, we can rate the performance of informatics teachers very high in all three countries, but mainly in Slovakia. Despite the highly unfavourable textbook situation, students rate the performance of teachers, in regard to the clarity of curriculum interpretation, as very high (see figure 2 – results of the item P5). In all three countries, it is precisely this factor that has the highest score. What is more, the Slovak teachers obtained relatively high ratings pertaining to the evaluation of their presentation of new material in terms of attractiveness. Only slightly worse, but still good, is their score in the category assessing the tasks they give students during class (see figure 2 – items P6 and P8). An interesting result is the evaluation of informatics teachers in the Czech Republic. Their performances in terms of providing an intelligible interpretation of the new curriculum to students can basically be described as their strong feature. But on the other hand, attractiveness of the presentations of new material given by them is, among the factors studied, clearly identified as a weakness of informatics education. Moreover also the engagement of tasks, which are implemented during informatics lessons by Czech teachers, was identified as a weakness (figure 2 – item P8). This factor is a weakness of informatics education in Belgium as well.

Despite the fact that respondents in all three countries recognize the importance of informatics knowledge acquisition for everyday life and as an integral part of education (see the results for the item P2), deficiencies in the attractiveness of curriculum presentation, uninteresting tasks solved, and especially the challenges faced by the lack of proper quality books all these contribute to the fact that informatics as a subject is, in all three countries, considered to be a subject, which is *neither popular nor unpopular*, or rather, only *more or less popular*. On the other hand, in the context of continually retrogressive attitudes towards science-oriented subjects, this result can be regarded as essentially a positive one.

Discussion of the Nominal Item Research Results

Although the intersexual differences in relation to the preferred ways of new subject matter explanation (P7) were proved, the significance of the difference between the responses of the two groups is statistically minimal as it shows the value of contingency coefficient (0.18). Most of the boys and girls identically prefer explanation done by the teacher himself using various teaching aids (alternative *b* – shared by 48.6 % of the total number of 222 boys and 62.3 % of the total number of 146 girls). The way of explanation, when the teacher involves also students in it (alternative *c*),was marked by 30.6 % boys and 25.3 % girls.

A very negative finding is that except computers, any other teaching aids are used very rarely in teaching informatics, and this regards all three concerned countries. In the Slovak and Belgian group, this response was given more or less by the same percentage of respondents (51.3 %, and 51.9 %). A significantly higher percentage of negative responses are in case of the respondents from the Czech Republic (61.0 %). Given the criticism faced by Slovak teachers following the results of the PISA international monitoring, this can be in principle a positive finding for Slovak teachers, as they use teaching aids on a level comparable with the situation in Belgium and even on a significantly higher level than teachers in the Czech Republic (Capay, Magdin, & Tomanova, 2012). For all that, the Belgian education system is rated higher than the education system in Slovakia or in the Czech Republic, and the funds earmarked for the education sector in Belgium are higher in comparison with Slovakia or the Czech Republic.

The minor part of the respondents (44.7 % from the total number), who stated that their informatics teachers use also other teaching aids than computers in their lessons, in the second part of the questionnaire item P11 assessed how interesting for them are these other used teaching aids (P11b). The distribution of negative and positive critical reviews given by the respondents was very asymmetrical with a predominance of positive responses (from *rather interesting* – 9.9 % to *very interesting* – 3.2 %), very high frequency of the neutral statement occurrence (*neither uninteresting nor interesting* – 11.6 %) and the highest frequency of the general positive assessment (*interesting* – 12.5 %).

The highest measure of interdependence showed the item P12, specifically in dependence on the factor COUNTRY (table 4 – contingency coefficient 0.39834). The recorded frequencies (figure 4) showed that students in Slovakia and Belgium make their written notes mainly in a traditional way. The most frequent answers (SK – 60.9 %, BE – 61.6 %) were alternatives *a* and *b* (*a – the teacher dictates us the notes; b – we do our written notes according the teacher who writes the notes on the blackboard or screens the notes in an electronic way using a data projector*). A little less frequency was recorded at the answer *c* (*a part of the written notes we do according the notes made by the teacher and a part of the notes we do from the textbooks ourselves*). These results show that in general students at school are not led to a self-active writing their notes of the studied subject matter. A little bit more positive situation is in the Czech Republic where the possibility *d* (*we make our written notes completely ourselves on the basis of the teachers' explanation*) was chosen by the highest number of the respondents (42.5 %). The answer *g* (*we do not make written notes of the presented subject matter at all*) was recorded by 21.9 % of the Slovak respondents, 33.3 % of the Czech respondents and 30.8 % of the Belgian respondents. But this situation is influenced also by the above-mentioned fact that the teachers do not very often have suitable textbooks of the required quality and they use alternative teaching materials prepared by them or they utilize internet sources.

On the basis of the research results one can say that the ways used at schools to take written notes regarding informatics subject matter are suitable and appropriate for students, they are satisfied with them and do not want to change them, i.e. in each concerned country the students are satisfied with the way which is more or less specific just for their country (p = 0.13000 means that assessment of the items P13a does not depend on the factor COUNTRY, the same result was obtained also in tests of the item P13a dependence on the factor GENDER). Only one fifth (19.8 %) of the total number of the respondents is unsatisfied and would prefer another way.

ISSN 1648–3898

Asking the students about source of concern related to informatics we expected occurrence of students' rather positive responses to this item what was more or less proved as 51.7 % of the total number 368 respondents chose the offered alternative *a* (*I am not used to be afraid of anything*). It was the most frequent answer in all three groups of the respondents. In Slovakia and the Czech Republic this answer was followed by the answer *b* (*unpreparedness, i.e. I am not prepared properly*) given by 17.4 % of the Slovak respondents and 12.6 % of the Czech respondents. In the sample of Belgian students the second most frequent answer was the alternative *d* (*practical tests*) marked by 21.2 % of the respondents. The results show that the Slovak students, unlike the Belgian ones, are not afraid of any theoretical or practical testing of the acquired knowledge. They are rather afraid of being not prepared properly for the lesson what evokes at them fear of threat of a bad mark getting if the teacher examines them (figure 5). Beside the dependence on the factor COUNTRY, the answers to the item P14 showed a trivial degree of dependence also on the factor GENDER (table 4). Although the two most frequent answers were the same in each group (54.5 % mail respondents and 45.2 % female respondents declared that before the informatics lessons they are not used to be afraid of anything, and 18 % male respondents and 16.4 % female respondents declared a weak preparedness as a usual source of their fear before the informatics lessons), the rest of possible reasons of the students' fear before the informatics lessons proved significant differences between boys and girls (the second graph in figure 5). In case of girls the fear of examination is markedly higher. 9.6 % of female respondents are afraid of oral examination and 13 % of practical examination, whereas in case of male respondents these percentages are lower, identically equal to 5.4 % for the both types of examination. On the other hand boys are more afraid of getting a bad mark (9.5 %) than girls (4.8 %).

Conclusions

Based on the presented research results, we can identify strengths and weaknesses of informatics teaching at the upper secondary level of education in each concerned country.

In Slovakia the main weakness seems to be insufficient quality, or rather the lack of relevant textbooks. The results also indicate a large deficit in terms of the attractiveness of tasks that teachers use during informatics lessons. On the other hand attractiveness of the curriculum and methods of new material presentation by teachers (in terms of clarity and engagement) are evaluated positively from the point of students' view.

Opposite to Slovakia, in the Czech Republic the teacher's presentation of new material in terms of its attractiveness and level of engagement for students was identified as the weakest aspect. The level of interest in tasks assigned during class was also rated as a weakness (in Slovakia this item has not been clearly identified as a weakness but as an area with considerable deficiencies). Similarly to the Slovak Republic also in the Czech Republic the insufficient quality, or rather the lack of appropriate textbooks belongs to weaknesses of informatics teaching. The clarity of the teacher's presentation of new curriculum can be described as strength.

In Belgium, the weakest aspect of informatics teaching is the level of engagement, or rather the lack thereof, in tasks covered in class. Another weakness, similarly to Slovakia and the Czech Republic, is the insufficient quality and the lack of textbooks. The strength of informatics teaching is the clarity of a teacher's presentation of new material.

Textbooks have proven to be a weakness in the implementation of teaching informatics in all three countries. To solve this problem means to solve the question of textbook existence, assessment of the adequacy and level of textbooks used, or rather, the assessment of teaching materials used in those books, analysis of needs arising from everyday life and the design of appropriate ways of dealing with this issue. Although it is a common problem of the concerned countries, it cannot be solved globally and must be analysed separately in each of them.

In carrying out our research, our options in creating individual research samples were limited. Moreover the carried out evaluation has been based only on the evaluation of the selected factors affecting the quality and attractiveness of computer science education only from the students' point of view (i.e. the teachers and other experts' points of view are missing). We realize that due to these facts the findings of our research cannot be taken as completely general. Despite that, we believe that our results showed the existence of both certain negative and positive phenomena in teaching informatics in each concerned country and can contribute to increasing the quality of informatics teaching and computer education, and consequently also to the development of scientific literacy and technical education in each of them.

References

Alexandrov, N., Alexandrov, V., & Ramirez, R. (2012). The Role of Computational Science and Emerging Technologies in the Natural Sciences Education at University Level. *Procedia Computer Science, 9,* 1789-1798. Retrieved from http://www.bsc.es/about-bsc.

Bálint, Ľ., & Nogová, M. (2003). How the quality of textbooks influences the quality of education. In Stoffa, J., Czajlik, M., & Ďuračková, B. (Eds.), *Quality Education in European Context and the Dakar Follow-up: Proceedings of the International Seminar* (pp. 40-45). Nitra: Constantine the Philosopher University.

Capay, M., Magdin, M., & Tomanova, J. (2012). Education of Primary and Secondary School Teachers in Informatics Supported by Digital Technologies. In Capay, M., Mesarosova, M., & Palmarova, V. (Eds.), *DIVAI 2012: 9th International Scientific Conference on Distance Learning in Applied Informatics: Conference Proceedings* (pp. 53-61). Sturovo: Constantine the Philosopher University.

De Jong, O. (2007). Trends in Western Science Curricula and Science Education Research: a bird's Eye View. *Journal of Baltic Science Education*, *6* (1), 15-22. Retrieved from http://www.jbse.webinfo.lt/2007,Vol.6,No.1.htm.

Frýzková, M., & Palečková, J. (2007). *Přírodovědné úlohy výzkumu PISA*. Praha: Ústav pro informace ve vzdělávání.

Hašková, A. (2003). Quality Education Indicators as a Component Part of the School Assessment. In Stoffa, J., Czajlik, M., & Ďuračková, B. (Eds.), *Quality Education in European Context and the Dakar Follow-up: Proceedings of the International Seminar* (pp. 66-72). Nitra: Constantine the Philosopher University.

Hrabal, V. (1989). *Pedagogicko-psychologická diagnostika žáka*. Praha: Slovenské pedagogické nakladateľstvo.

Hus, V., & Aberšek, B. (2007). Early Science Teaching in the New Primary School in Slovenia. *Journal of Baltic Science Education*, *6*(1), 58-65. Retrieved from http://journals.indexcopernicus.com/abstracted.php?level=5&icid=482293.

Luu, K., & Freeman, J. G. (2011). An analysis of the relationship between information and communication technology (ICT) and scientific literacy in Canada and Australia. *Computers & Education*, *56* (4), 1072-1082. doi:10.1016/j.compedu.2010.11.008.

Munk, M. (2011). *Počítačová analýza dát*. Nitra: Constantine the Philosopher University.

OECD (2007a). *PISA 2006 Science Competencies for Tomorrow's World (1): Analysis*. Paris: OECD.

OECD (2007b). *PISA 2006 (2): Data*. Paris: OECD.

OECD (2010). *PISA 2009 Results: Executive Summary*. Paris: OECD.

Olsen, R. V., Prenzel, M., & Martin, R. (2011). Interest in Science: A many-faceted picture painted by data from the OECD PISA study. *International Journal of Science Education*, *33* (1), 1-6. doi:10.1080/09500693.2010.518639.

Palečková, J., & Tomášek, V. (2005). *Učení pro zítřek: Výsledky výzkumu OECD PISA 2003*. Praha: Ústav pro informace ve vzdělávání.

Palečková, J., Tomášek, V., & Basl, J. (2010). *Hlavní zjištění výzkumu PISA 2009*. Praha: Ústav pro informace ve vzdělávání.

Palečková, J. et al. (2007). *Hlavní zjištění výzkumu PISA 2006*. Praha: Ústav pro informace ve vzdělávání.

Ribeiro, V. M., & Gusmão, J. B. B. de. (2010). An interpretation of the use of quality indicators in education. *Cadernos de Pesquisa*, *40* (141), 823-847. doi:10.1590/S0100-15742010000300008.

Ross, K. N., & Genevois, I. J. (2006). *Cross-national studies of the quality of education: planning their design and managing their impact*. Paris: International Institute for Educational Planning.

Straková, J., & Kašpárková, L. (1999). *Matematická a přírodovědná gramotnost v Třetím mezinárodním výzkumu matematického a přírodovědného vzdělávání*. Praha: Ústav pro informace ve vzdělávání.

Šebeň, V., & Jakubov, R. (1997). Motivácia činnosti žiakov vo vyučovaní fyzika na ZŠ. *Acta Didactica 2* (pp. 71-81). Nitra: Constantine the Philosopher University.

Vári, P. (Ed). (1997). *Are we similar in math and science? A study of grade 8 in nine central and eastern European countries, IEA*. Budapest: IEA- Országos Közoktatási IntézetBudapest.

Vishkurti, S., Spahiu, A., & Paci, M. (2011). Issues of Science Teaching in Higher Education. *Problems of Education in the 21st Century, 28*(2), 123-130. Retrieved from http://journals.indexcopernicus.com/abstracted.php?level=5&icid=939905.

ISSN 1648–3898

Záhorec, J., Hašková, A., & Munk, M. (2010). Impact of Electronic Teaching Materials on Process of Education: Results of an Experiment. *Informatics in education*, *9* (2), 261-281. Retrieved from http://www.mii.lt/informatics_in_education/htm/INFE165.htm.

Zahorec, J., & Haskova, A. (2011).Evaluation of the Current State in Teaching Informatics at Upper Secondary Level of Education (ISCED3A) in the Slovak Republic: Conceptual and Methodical Starting Points. In *IEEE International Symposium on IT in Medicine & Education* (pp. 317-321*)*. China: Guangzhou University. doi:10.1109/ITiME.2011.6130842.

Received: *February 15, 2012* Accepted: *April 10, 2013*

Ján Záhorec	Professional Assistant, Department of Informatics, Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic. Phone: +421 37 6414 196. E-mail: jan.zahorec@uniag.sk Website: http://www.uniag.sk
Alena Hašková	Professor, Department of Technology and Information Technologies, Faculty of Education, Constantine the Philosopher University in Nitra, Dražovská cesta 4, 949 74 Nitra, Slovak Republic. Phone: +421 37 6408 335. E-mail: ahaskova@ukf.sk Website: http://www.ukf.sk
Michal Munk	Associated Professor, Department of Informatics, Faculty of Natural Sciences, Constantine the Philosopher University in Nitra, Tr. A. Hlinku 1, 949 74 Nitra, Slovak Republic. Phone: +421 37 6408 672. E-mail: mmunk@ukf.sk Website: http://www.ukf.sk
Martin Bílek	Professor, Department of Chemistry, Faculty of Science, University of Hradec Králové, Rokitanského 62, 500 03 Hradec Králové, Czech Republic. Phone: +420 493331164. E-mail: martin.bilek@uhk.cz Website: http://www.uhk.cz