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Assessment of Selected Aspects of Teaching Programming in SK and CZ

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Abstract. Authors of this paper carried out a broader international research aimed at assessing the computer science education at upper secondary level of education – ISCED 3A. The assessed school subjects were informatics and programming as the most common school subjects taught at secondary schools within computer sciences. The assessment was based on the students' evaluations, their points of view and opinions, what was a specific feature of the research. The paper presents main findings and results for the school subject programming obtained in Slovakia (SK) and the Czech Republic (CZ). As a weakness of teaching programming in both countries inadequate quality of textbooks or a lack of appropriate textbooks in general was identified. As strength of the programming teaching in the Czech Republic attractiveness of the content of the school subject programming (its curriculum) was identified and in Slovakia it was the clearness of teachers' presentations of teaching material.

Keywords: teaching programming, grammar school, quality of teaching, factors influencing the quality of the education process, strengths and weaknesses of programming teaching.

1. Introduction

During the period of the years 2010–2012 we carried out a broad research aimed at assessing the computer science education at upper secondary level of education (ISCED 3A) in Slovakia (SK), Czech Republic (CZ) and Belgium (BE). Due to a variety of school subjects related to computer science taught at the secondary schools we limited our attention only to teaching informatics and programming which are two basic school subjects relevant to this area. Due to the diversity of focus in secondary school level and a wide range of specific implementation of computer science education in these schools, we focused our attention on a single type of school in this category: in Slovakia and the Czech Republic 4-year and 8-year grammar schools, specifically students in the 16 to 19 year age range, and in Belgium on general secondary schools (ASO) representing an equivalent to grammar schools in Slovakia and the Czech Republic.

The school subject informatics taught at most of schools at the secondary level of education is usually taught as a compulsory subject with different number of allocated hours and is conceived mainly as a "general informatics education". This means that in informatics lessons students acquire basic knowledge and skills to work with digital technologies to search, process and present information which is necessary to solve different tasks given them (Kalaš, 2001; Stankovský and Hauser, 2008; Hauser, 2008a; Hauser, 2008b). A part of the informatics subject matter can be related also to algorithmisation issues. In Slovakia there are five main topics included in the informatics curricula at secondary schools. These are:

- Information around us.
- Communication by the means of ICT.
- Problem solving and algorithmic thinking.
- Basic principles of ICT operation.
- Information society.

Like in Slovakia, teaching informatics in the Czech Republic is carried out as well as a kind of "information and communication education" with the goal to prepare students to find, verify, use, interpret and present information in various forms and to develop students` critical appreciation of information and making informed judgment as users of information (Kvasňa, 2007). The main topics included in the informatics curricula in the Czech Republic are similar to the above-mentioned in Slovakia:

- Informatics, information.
- Computer as a mean for the work with information.
- Internet, communication, computer networks.
- Text editors, text processing.
- Presentation technologies.
- Spreadsheets.
- Database systems.
- Additional recommended topics.

In Belgium, from the content standards` point of view, it is the curriculum of informatics taught at the general secondary schools (ASO) which are representing an equivalent content to the mentioned one taught at grammar schools in SK and CZ. The subject content is structured into following 5 topics:

- Computer technology and computer networks.
- Familiarization with a selected software environment (development of key competencies; system software; application software – text editor, spreadsheets, presentation and database software).
- Communication through ICT.
- Solutions in simple development environments.
- Social and ethical aspects of ICT.

Unlike informatics, programming as a separate school subject is not taught in each school, what is e.g. the kind of the general secondary schools (ASO) in Belgium. If programming is not taught as a separate school subject, some topics can be included in the informatics curriculum. Usually in such a case the number of lessons allocated to these topics is very small, and they (i.e. algorithmisation and programming) are taught only on a very informative level. For example in Slovakia the range of subject matter devoted to algorithmisation and programming within the compulsory subject informatics is included in the topic *Problem solving and algorithmic thinking*.

If programming is taught as a separate school subject it can be taught as a compulsory subject but very often it is offered to students as an optional one or in a form of several optional alternative subjects. The curricula content in these subjects use to be focused on teaching theory of formalized languages and their grammars, theory of automates and their operation systems, and mainly on acquisition knowledge and skills in programming in a particular programming language. As the most suitable language, facilitating structured programming, Pascal was taught in many secondary schools in Slovakia in the past. This alternative was one of the most effective, but the environment which has still been used in some schools presents already an obsolete DOS development environment Turbo/Borland/Free Pascal based on text user interface. Currently the trends are to make students familiar with event ruled programming, which they use in algorithmisation as well as in acquiring knowledge and skills in programming methods. Following these trends Object Pascal, and on it based development environment Borland Delphi, is more and more taught programming language within programming lessons at upper secondary schools (Cápay and Magdin, 2012). It is also due to the fact that Object Pascal is a natural Pascal successor and moreover currently it presents the most elaborated and probably for school conditions the most suitable RAD tool to create applications in Microsoft Windows environment. A very similar situation is also in the Czech Republic. But unlike Slovakia, in the Czech Republic some schools leave Delphi environment because of license and financial reasons and they move to Lazarus and FreePascal or the programming language C.

As it has already been mentioned the whole research was focused on assessment of selected aspects of both school subjects related to computer sciences, informatics and programming. Both parts of the research were carried out at the same time by the same methodology, using the same research samples and data collection questionnaire (in one administration of the questionnaire its items asked on the school subject informatics and aspects of its teaching, and in the second case the respondents expressed their opinions again to the same items but this time in relation to the subject programming and its teaching).

Relevant research results obtained for the school subject informatics taught in Slovakia, the Czech Republic and Belgium we published in Informatics in Education (Záhorec *et al.,* 2012). In this paper we present main findings obtained for the subject programming and its teaching in Slovakia and the Czech Republic. Belgium is not involved here, as in the observed (ASO) type of the secondary schools in Belgium, relevant to the observed Slovak and Czech grammar schools, programming is not taught independently as a separate school subject. Additionally to the main results obtained for the subject programming, we present also their comparison with the results of the assessment of the same aspects of informatics teaching (see in the part Conclusion).

2. Research Methodology

The quality of teaching in a subject is usually assessed through analysing its content, the students' achievements, and the level of teaching. We decided to assess the current state of teaching programming from the perspective of the students, based on their opinions. Therefore, we tried to determine how certain factors which influence and determine the quality of teaching programming are viewed by students. Specifically, we took these 14 factors into account:

P1 – the popularity of a subject (in meaning, whether it is a favourite subject).
P2 – the applicability of 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 used by teachers 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 for students.
P14 – sources of concern related to the subject.

These factors were found important in our previous experience and research results, in professional literature in this area (Kurland *et al.,* 1989; Holmboe *et al.,* 2001; Lapidot and Hazzan, 2003; Ragonis *et al.,* 2010; Van Diepen *et al.,* 2011; Saeli *et al.,* 2012) and in communications with other experts (both research workers and informatics and programming teachers from various types of schools and with various durations of teaching experience).

Data collection was done through a questionnaire, in which the individual questionnaire items corresponded to the aforementioned 14 factors and in which students expressed their views and opinions on this factors.

Research samples in the observed countries (Slovakia – SK, Czech Republic – CZ) were, due to our limited opportunities, based on the availability of schools. The schools from both countries involved in the research, however, represented different regions as well as different sizes of towns. The total number of respondents was 238; 177 respondents were from Slovakia and 61 respondents from the Czech Republic. The Slovak respondents were from 8 different grammar schools and the Czech respondents represented 6 grammar schools. The schools were selected from different towns, both bigger and smaller, located in different regions either of Slovakia or the Czech Republic, and they varied also in their size (numbers of students attending the schools). With regard to the sample coverage of students and their study profiles, it is important to note that in both groups (SK, CZ), students were attending classes with a curricular focus on informatics or programming.

3. Data Collection

We based the evaluation of the factors, which affect the quality and attractiveness of programming teaching in schools, on the students' assessments. We are aware that due to this fact (i.e. the lack of evaluation of programming education by teachers as well as the evaluation of teachers by other observers), our findings cannot be taken as general. However, we consider students' reviews important and telling in the context of identifying the strengths and weaknesses of any subject.

Based on what has already been stated, students evaluated programming both in terms of their subjective relationship to the subject (for example, the popularity of the subject, attractiveness of the content, future application of the subject) and also in terms of their view of the implementation of the subject's curriculum (for example, clarity of textbooks used, method of interpretation/presentation of the curriculum by teachers, use of teaching aids in classroom, attractiveness of used teaching aids). Relevant attitudes and opinions of students were surveyed in a questionnaire in which the individual questionnaire items corresponded to the aforementioned 14 factors.

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

In the 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 the following:

P7 – the kind of explanation preferred by the student:

a) *teacher explains the subject matter without using 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 also other teaching aids used during the lessons of programming in addition to computers (P11a) and in case of a positive answer, the assessment of 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 to the teacher who writes the notes on the blackboard or presents electronic notes using a data projector*;
c) *a part of the written notes we do according to 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 by ourselves on the basis of the teacher's 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 of whether note taking method 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 the student would prefer more (P13b).

P14 – possible reasons for feeling scared or nervous before programming lessons:

a) *I am not afraid of anything*;
b) *unpreparedness/I am not prepared properly*;
c) *oral examination*;
d) *practical tests*;
e) *getting a bad grade*;
f) *fear of repeated lack of understanding the presented subject matter*;
g) *other, state what*.

4. Data Processing

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 $\alpha = 0.84$, calculated using the Cronbach alpha, indicates a high inner consistence of this measuring tool as a tool for relevant reliable research data collection.

Data obtained for each questionnaire item were processed to test the effect of the factor COUNTRY. Statistical processing of the collected data was based on *chi*-square tests, calculating the contingency coefficient, analysis of variance for repeated measurements ANOVA, Greenhous-Geisser and Huynh-Feldt corrections for repeated measures in the analysis of variance, and on graphical visualization.

The analysis of variance for repeated measures (RM-ANOVA) was used in tests of differences between two or more dependent samples – repeated measures. RM-ANOVA was used when, apart from the factor which determines the repeated measure in particular objects – dependent samples, such as items P1–P6, P8–P10, there are also factors such as COUNTRY which divide the objects into several groups – independent samples. If the independent samples are compared, this factor is called a between-groups factor (COUNTRY). If the dependent samples are compared – repeated measures of the same objects – the factor is called a 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.

To be able to use the tests, following assumptions have to be satisfied:

- Normal distribution of the dependent variable in the groups according the factor levels.
- Assumption of the covariant matrix assumption of sphericity – equal variances and covariances in the covariant matrix for the repeated measures.

To find out relations between two nominal variables, analysis based on contingency tables was used. Hence, the contingence analysis was used to analyse nominal items dependences (P7, P11a, P12, P13a, P14 x COUNTRY). The group of the non-parametric tests belonging to the contingency analysis is based on the contingency table. This analysis tests the null hypothesis, which states that the variables are independent opposite to the alternative that variables are dependent.

For the analysis of tables with multiple fields we used the *chi*-square test of independence. The *chi*-square test of independence represents an enhancement of the *chi*-square test of goodness of fit and results from the contingency 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 are those that fulfil the null hypothesis of the independence of two variables. The expected frequency of the relevant field is equal to the product of the relevant observed frequency of the line and column divided by the total number of the observations.

$$e_{ij} = \frac{r_i \, s_j}{n} \tag{1}$$

The *chi*-square test verifies whether the differences between the observed and expected frequencies are random (the variables are independent) or statistically significant (the variables are dependent).

$$\chi^2 = \sum_{i=1}^{R} \sum_{j=1}^{S} \frac{(a_{ij} - e_{ij})^2}{e_{ij}} \tag{2}$$

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

To assess the degree of dependence between two nominal variables the contingency coefficients (Pearson, Cramer V) were used. These represent 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.

More detailed information on the conceptual and methodological bases of the research and the pilot verification of the administered questionnaire reliability was published in (Záhorec and Hašková, 2011).

5. Analysis and Interpretation of Research Results

5.1. *Analysis and Interpretation of the Results of the Ordinary Items*

The plot of averages and confidence intervals (Fig. 1) illustrates the results of the evaluation of questionnaire items P1 to P6 and P8 to P10 as a whole, dependant on the COUNTRY factor. From the graph, we can see a tendency for Slovak students to assess programming teaching more positively than the Czech students. Slovak respondents achieved an overall score (mean score for all monitored items) of 4.63. Czech respondents achieved a slightly lower overall average of 4.39. Interval estimates of the average responses of the two groups of respondents overlap, thus confirming the statistical independence of the respondents' answers to the questionnaire items as a whole from the COUNTRY factor (as confirmed by the results of multidimensional analysis of variance for repeated measures presented in Table 1; note the achieved value of $p > 0.05$). On the other hand, we observed that, in terms of this statistical indicator of answers to each monitored factor (questionnaire items), there was greater variability in the group of Czech students than among Slovak students.

After investigating the overall score of the questionnaire (items P1, P2, P3, P4, P5, P6, P8, P9 and P10), we tested which items have significant differences in the responses in terms of the COUNTRY factor.

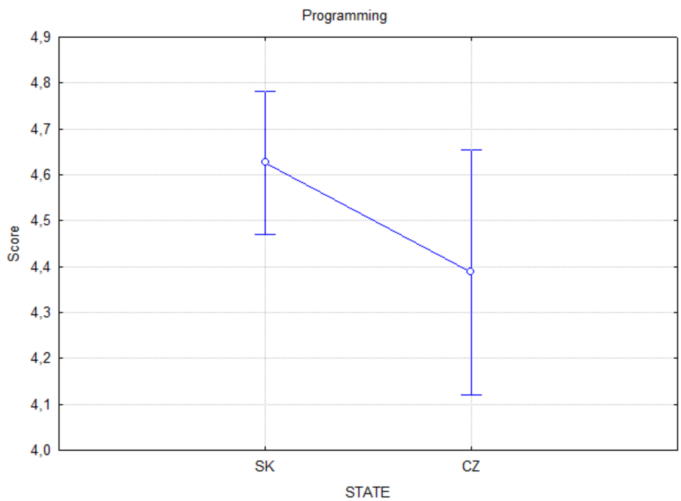

Fig. 1. Averages and confidence intervals of scores in questionnaire items according to the COUNTRY factor.

Table 1

Multidimensional analysis of variance for repeated measurements

	Sum of Squares	Degrees of freedom	Mean Square	F-statistic	p-value
Absolute value	33177.90	1	33177.90	3302.846	**0.000000**
COUNTRY	23.23	1	23.23	2.312	0.129698
Error	2370.68	236	10.05		

An assumption for the repeated measures ANOVA is the equality of variance and covariance in the covariance matrix of repeated measures. This assumption is called the covariance matrix sphericity condition. If the condition of sphericity is not satisfied, type I error increases. In such cases, degrees of freedom used for the F-test are adjusted using certain corrections, thus achieving the declared level of significance.

Due to the violation of the conditions of sphericity of the covariance matrix, we used the Greenhouse-Geisser and Huynh-Feldt correction (Lower Bound) for repeated measure analysis of variance to find the statistical significance of differences in the responses of the respondents (Table 2).

The test results of the respondents' answers to items P1 to P6 and P8 to P10, according to the Greenhouse-Geisser and Huynh-Feldt-correction (Lower Bound) for repeated measures of variance analysis (Table 2) confirmed the statistical significance ($p < 0.01$) of differences between item ratings. On the other hand, differences between responses to the questionnaire items, depending on the nationality of the respondents (COUNTRY), were not significant ($p = 0.121 > 0.05$).

Table 3 presents the results of the identification of homogeneous groups in the evaluation of individual items without differentiation into groups according to the COUNTRY factor, but depending on the factors observed (questionnaire items). Homogeneous groups are obtained through multiple comparisons of pairs.

The respondents in the three identified homogenous groups responded the items of the correspondent group almost identically regardless of their nationality. There was no confirmed statistical significance in the differences of the responses to the items within each homogeneous group.

Test results confirmed the significance of the P4 and P9 items (third homogeneous group), in which there were statistically significant differences in the evaluation of students' responses in comparison with all other tested items. We visualize this observation

Table 2

Greenhouse-Geisser and Huynh-Feldt correction (Lower Bound) for repeated measures of variance analysis

	Lowr.Bnd Epsilon	Lowr.Bnd Upr.sv1	Lowr.Bnd Upr.sv2	Lowr.Bnd Upr.p
ITEM	0.125000	1.000000	236.0000	**0.000001**
ITEM*COUNTRY	0.125000	1.000000	236.0000	0.120666

Table 3
Identification of homogenous groups

ITEM	Average	1	2	3
P4	3.823529			****
P9	3.869748			****
P8	4.432773		****	
P2	4.710084	****	****	
P6	4.760504	****	****	
P1	4.815126	****		
P10	4.827731	****		
P3	4.903361	****		
P5	4.945378	****		

in Fig. 2, where the average interval estimates overlap for these two items while they do not overlap with the remaining items.

The second identified homogenous group (P8, P2 and P6) overlaps with the first homogenous group (P2, P6, P1, P10, P3 and P5) at the level of items P2 and P6. Also, from the data in Table 1, we can see a noticeable shift in the positive evaluation of the items in the first homogeneous group compared to the items in the third homogeneous group.

The results of the statistical analysis for the assessment of selected factors affecting the quality and attractiveness of programming classes by students (ordinary questionnaire items P1 to P6 and P8 to P10), obtained separately for each of the questionnaire items (individual factors) without differentiation into groups according to the nationality of the respondents (based on statistically non-significant differences between the responses of Czech and Slovak respondents), are presented in Fig. 2. This graph shows the point and interval estimates of the average ratings of individual items.

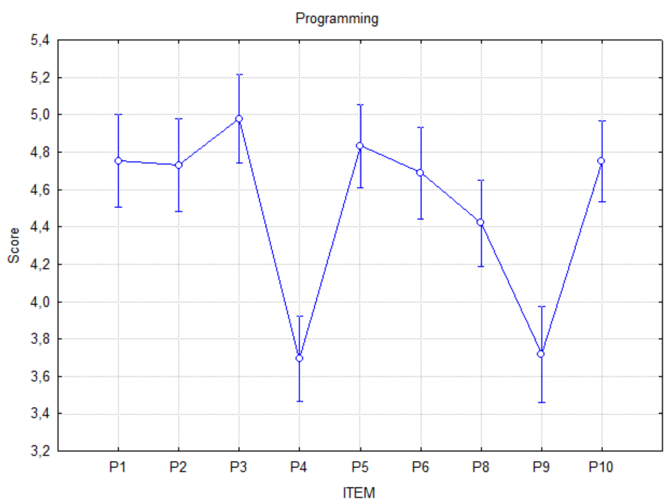

Fig. 2. Visualisation of differences in the evaluation of individual ordinary items.

As can be seen in the data recorded on the graph (Fig. 2), the highest total average scores were recorded in items P3 and P5 (see also data in Table 3). The highest student rating was thus achieved in the factor of attractiveness of the content of the curriculum (5 points means the content is *more attractive rather than unattractive*) and the factor of clarity of the teacher's presentation of new curriculum (also scored 5 points on the scale, i.e. the evaluation of teacher's presentation was *I understand more often than not*). The lowest overall average score was recorded for items P4 and P9, where the averages are significantly lower than the evaluations obtained for other items. These items assessed the difficulty of the curriculum (P4) and clarity of textbooks used (P9). In both cases, the outcome of the evaluation was "neutral" (score 4 on the scale), which, in the case of subject-matter assessment, means *neither difficult nor easy* and in the case of the text-books, *neither satisfactory nor unsatisfactory*.

Despite the fact that the differences between the groups of Czech and Slovak respondents are not statistically significant, a comparison of the statistical processing of the responses to each item, when taking into account the COUNTRY factor (see graph in Fig. 3), shows a tendency for Slovak respondents to assess individual factors in a more positive way than the Czech respondents. Overall, however, the observed differences are very small and the response curves for the two groups are similar to each other, which also confirms the independence of responses from the COUNTRY factor. The graph in Fig. 3 also shows that the results for the overall indicator of variability of responses to individual items reached approximately equal values in the two groups.

Czech students graded the attractiveness of the programming lesson content the highest (P3 mean score 5.1, with a score of 5 meaning the content of the course was *rather interesting*, 4 – *neither interesting nor uninteresting* and 6 – *interesting*). Item P3 achieved the highest average score in the responses of all respondents (see Fig. 2), but achieved a slightly lower rating by the Slovak respondents (4.8). It might be appropriate to think about how to reach students better and help them develop a deeper interest in

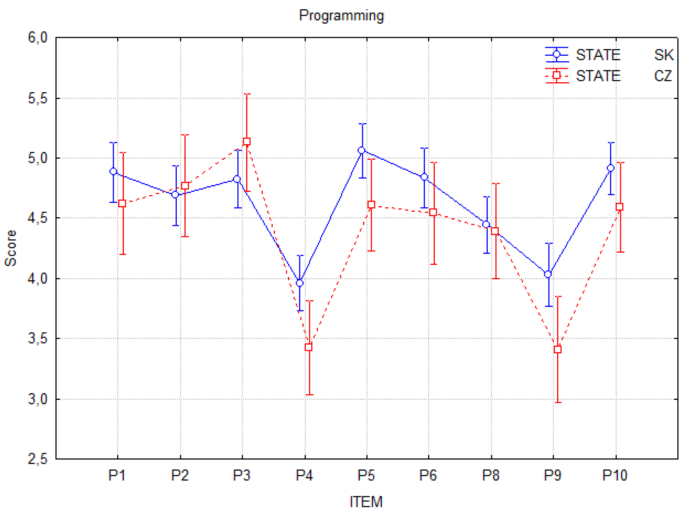

Fig. 3. Average point and interval score of each item, divided by the COUNTRY factor.

the subject, particularly with regard to their age group. It should be noted, however, that each person can interpret the word *interesting* differently. For students in their final year of grammar school, alternative, non-standard algorithmic procedures in problem solving may seem interesting, while beginners and students who are confronted with this issue for the first time might find the decomposition of a problem and the recording of individual commands interesting.

In addition to the attractiveness of the curriculum, Czech students highly rated the importance of the knowledge gained in the study of algorithms and programming for their personal interests and future professional functioning in society (P2 = 4.8, i.e. evaluation reaching a score of 5 on the scale used, which means a rating of *I will probably use the knowledge gained*). They also declared their programming class as rather popular (P1 = 4.6, i.e. closer to *rather popular* than to *neither popular nor unpopular*, within the range used).

An interesting result in the case of the Czech respondents is the highest value of variability (1.75) in item P2, which means the greatest diversity in the statements of the respondents in the examined factor (utilization of knowledge in their own future).

The overall assessment of programming education as rather popular by the Slovak (P1 = 4.9) and Czech (P1 = 4.6) groups of respondents can be considered as highly positive when seen in the context of domestic and foreign research (Bílek, 2008; Höfer and Svoboda, 2005; Bílek *et al.,* 2006; Dopita and Grecmanová, 2008). This research found overall trends to reduce the popularity of natural science subjects in today's youth (not only in Slovakia and the Czech Republic, but also in other EU countries) as well as a constantly declining interest in pursuing studies in science and engineering. However, this result can be related to the academic focus of the respondents in both groups (their study programmes), since we analysed students in either 8-year grammar schools in classes focused on programming, or students in a 4-year grammar school with extended informatics classes. The overall assessment of students' relationship to the subject may be influenced by the study program in the grammar schools that puts a greater emphasis on informatics, programming or mathematics, which, in addition to the hourly load of the course, may influence also the level and the clarity of teaching instruction (see the average scores of the item clarity of teacher's presentation of new curriculum P5 = 5.1 and the attractiveness of curriculum presentation P6 = 4.8 in the group of the Slovak respondents). Indirectly, this result may reflect also the overall level of professional and career training for future informatics and programming teachers provided by the universities in Slovakia and the Czech Republic (Gergelová *et al.,* 2009).

The achieved results in the P3 items of both groups of respondents indicate how important it is to include current problems in the curriculum. Students then see that they are expected to learn something meaningful for their future life and not just for a grade in school. In teaching programming, the most important aspect is the selection of a modern platform, programming language, and the associated development environment. Students need to be aware that the course does not teach them something obsolete, but that they are learning to program in the language and development environment that are applicable in their possible future professional direction. Modern platforms with rich and easy-to-use libraries of classes contribute to the overall attractiveness of programming from the perspective of students. The selection of a modern platform and a language, however, is not the only thing that makes the study of programming attractive. The inclusions of practical and interesting tasks in the curriculum, i.e. tasks that allow students using their creative potential, also increase the attractiveness of programming classes. Setting programming tasks that are useful for students and exciting in their application is the means by which students can express their creativity, develop their ability to solve more challenging tasks, and become motivated to their further self-education. Offering students the opportunity of programming tasks, such as selecting all prime numbers from a randomly generated list, finding the greatest common denominator of two given numbers, or solving quadratic equations, will not appeal to students very much. We believe that interesting tasks involve the programming of interactive multimedia applications or even simple games.

We consider the average score in item P5 in the Slovak group of respondents as a positive result in regards to the quality of programming teaching. The value of 5.1 means that students grade the clarity of the teachers' presentations of new curriculum as essentially positive, because this value represents an assessment of *rather understanding* at our scale. Of course, this depends on the knowledge that was attained in preceding classes, and its links to the current curriculum. Nevertheless, practical and applied aspects of programming education should not be forgotten. Therefore, we consider it important that during lessons, teachers do not present the subject matter in an artificial way, but rather through interesting application presentations, which thoroughly explain the essence of the problem and its algorithmic implementation in the relevant source code (programming language). For example, the explanation of programming structures should not be limited only to the presentation of general command syntax and notation. It is important to try and find some interesting application problems that can be used in explaining the curriculum. Students then have the opportunity to learn not only the algorithmic structures themselves, but also their real significance and impact in solving specific problems.

The lowest average score, which was significantly lower compared to the other items, was the same in both groups – item P4 (the demands of the curriculum) and P9 (clarity of textbooks used).

Czech students consider the curriculum in programming to be *rather difficult* (P4 = 3.4), while Slovak students evaluated it as *neither difficult nor easy* (P4 = 4.0). This raises an interesting aspect of our findings. It is the fact that the Slovak respondents generally, on the one hand, characterize programming as a subject they consider to be rather popular (P1 = 4.9) and its content interesting (P3 = 4.8) and teachers' presentation of curriculum as basically easy to follow (P5 = 5.1, i.e. a score of 5 – the teacher's interpretation of the new curriculum is *rather understandable*), but on the other hand, they declare an essentially neutral stance on the complexity and difficulty of the subject (P4 = 4.0, i.e., a score of *neither difficult nor easy*). Of course, it is possible that the evaluations of items P1, P3 and P5 are heavily influenced simply by the "moderate difficulty level" of the programming curriculum (a score of *neither difficult nor easy*). An analogous situation can be observed in the group of Czech respondents. The results of the research, on the one hand, suggest a close relationship between the evaluation of the attractiveness of the subject content (P3) and the popularity of the subject (P1), but, on the other hand, do not support the conclusion that students consider favorite subjects to be explicitly easy. It is assumed that the basis for mastering the curriculum of algorithms and programming is logical thinking, which is associated with the practical nature of this subject. Programming is not about learning something by heart, but rather about understanding the logical essence of the problem and designing students' own programs using a systematic approach.

As for the questionnaire item P9, the group of Czech respondents assessed the textbooks used in programming classes by their clarity, catchiness, and attractiveness of content as *rather unsatisfactory* (P9 = 3.4) and the Slovak respondents rated them as *neither satisfactory nor unsatisfactory* (P9 = 4.0). In the case of Slovak respondents, however, this item recorded the highest value of variance (1.79), which shows the greatest variability in the statements of the respondents. These wide-ranging differences of opinions can be attributed to the inconsistent choices and use of textbooks and supplementary teaching materials in various schools in Slovakia (in our case, grammar schools) in programming classes.

It is possible to diagnose P4 and P9 as factors adversely affecting the quality of programming teaching. This is mainly the case of the item P9. As shown by the results of our research, the use of programming textbooks is rather unsatisfactory for the students in some aspects. This can be influenced by examples used in the textbooks that address only trivial, uninteresting, or unattractive problems for students. Some textbooks can be too academic for this age group (16–19 years). The problem of ensuring proper quality programming textbooks needs to be addressed by analysing the current state and separate needs for the Slovak and Czech education systems. The selected textbooks should, on the one hand, present students with examples based on their experience, and, on the other hand, explain the techniques in the programming language used for solve the task in a systematic way.

5.2. *Analysis and Interpretation of the Results of Nominal Items*

The null hypotheses for each nominal item were expressed in such a way that the answer to the relevant item does not depend on the factor COUNTRY, against the alternative that it depends on. Most of the null hypotheses were disproved (see the p-values smaller than 0.05 shown in Table 4). The differences between the respondents' answers depending on the factor COUNTRY were statistically significant in the following cases:

- Item P7 in relation to the factor COUNTRY.
- Item P11a in relation to the factor COUNTRY.
- Item P12 in relation to the factor COUNTRY.

With the P7 item we aimed at finding ways of curriculum presentation that best meet the needs of the students (Fig. 4). In the group of Slovak respondents, the most frequent response as the most appropriate method of presentation of the new curriculum by teachers was the choice *c – teacher involves the students in the presentation of the new curriculum* as *well* (45.8%), while the second most frequently recorded answer was *b – the teacher explains the curriculum himself/herself, using various teaching*

Table 4

The results of the *chi*-square test of independence for nominal items according to the COUNTRY factor

ITEM / FACTOR	Pearson's *chi*-square test			Contingency coefficient	Cramer coefficient
	χ^2	sv	p	χ^2	χ^2
P7 (5) / COUNTRY (2)	13.1936	4	**0.0104**	0.2292	0.2354
P11a (2) / COUNTRY (2)	4.9161	1	**0.0266**	0.1423	–0.1437
P12 (7) / COUNTRY (2)	15.7321	5	**0.0077**	0.2490	0.2571
P13a (2) / COUNTRY (2)	0.4971	1	0.4808	0.0457	0.0457
P14 (7) / COUNTRY (2)	6.5097	6	0.3686	0.1632	0.1654

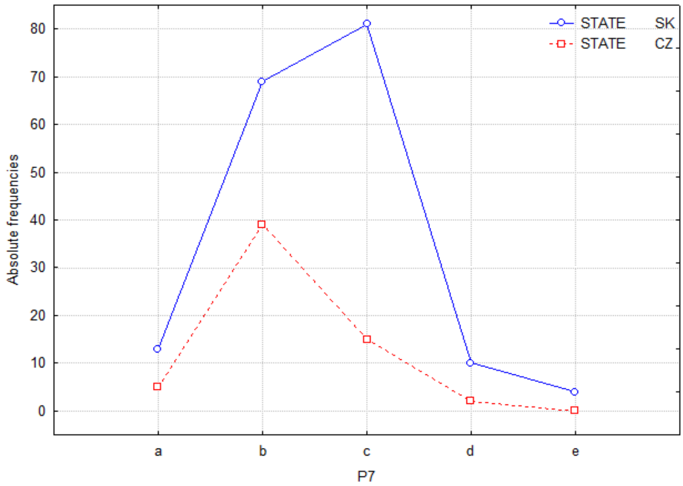

Fig. 4. Absolute frequencies of answers a–e for the item P7 according to the COUNTRY factor.

aids (39%). In the group of Czech respondents, the most frequent response was option *b* (63.9%) and the second most frequent response was option *c* (24.6%). Other options didn't exceed the level of 9.0% (*a* – SK = 7.3%, CZ = 8.2%; *d* – SK = 5.7%, CZ = 3.3%; *e* – SK = 2.3%, CZ = 0.0%).

Item P11a was designed to determine the use of other teaching aids in teaching programming (aside from computers). The vast majority of respondents (56.7% out of 238 in total) stated that during programming lessons, teaching aids are not used. In terms of differentiating by the COUNTRY factor (Fig. 5), a *no* answer was given (*we use no teaching aids aside from computers*) by 68.9% of Czech respondents and by 52.5% of Slovak respondents. The Slovak result can be viewed as a positive finding in regards to the level of programming teaching at Slovak schools.

The graph in Fig. 6 shows the differences in the responses of Czech and Slovak students for item P12 (*Which method of note-taking do you use in programming class*), which achieved the highest level of significance of differences compared to the remain-

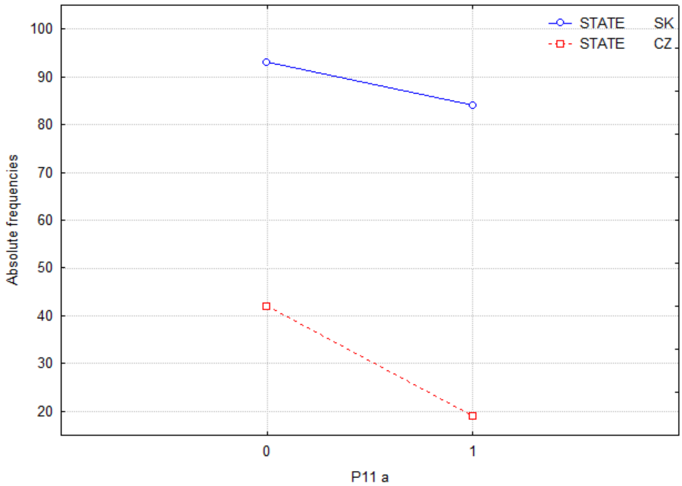

Fig. 5. Absolute frequencies of negative and positive answers for the item P11a according to the COUNTRY factor.

ing contingency coefficients P7 x COUNTRY, P11a x COUNTRY, P13a x COUNTRY, P14 x COUNTRY (contingency index of 0.249). The results of the *chi*-square test are also confirmed by the response curves for the item P12 for each country that are not similar to each other.

From the interaction diagram (Fig. 6) we see, that while in Slovakia the dominant method of note-taking is to follow teachers' dictation, the Czech students use significantly different ways to record the curriculum content. Making individual notes based on the teacher's presentation is just as frequent as when the teacher dictates notes to stu-

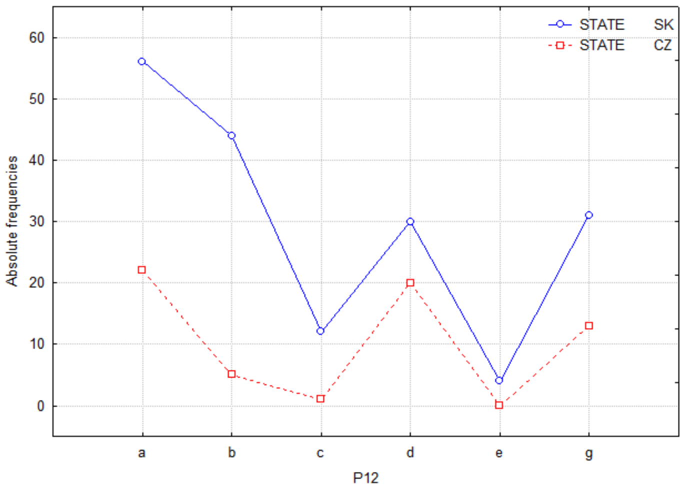

Fig. 6. Absolute frequencies of answers a–g for the item P12 according to the COUNTRY factor.

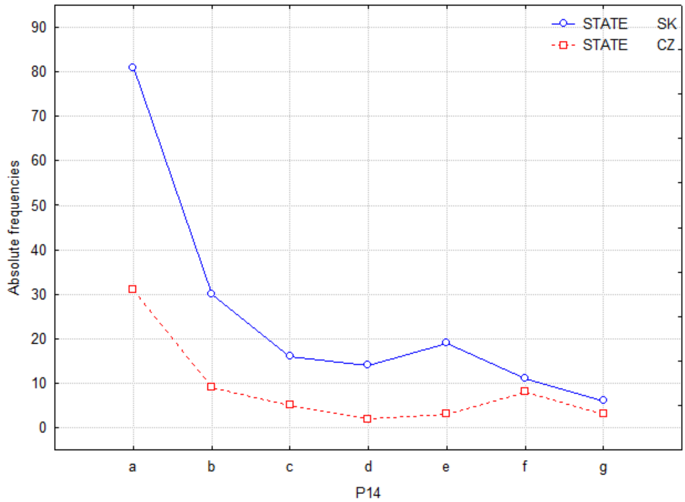

Fig. 7. Absolute frequencies of answers a–g for the item P14 according to the COUNTRY factor.

dents. The subsequent answers of respondents to the question P13a showed that the note taking method required by the teachers is the preferred method in both Slovak (83.1%) and Czech (86.9%) schools.

In the case of item P14, in which we assessed what evokes a sense of fear and anxiety in the surveyed students before a programming class, the most frequent response for both groups of respondents was that they usually have nothing to fear before programming classes. The frequency of potential sources of fear and anxiety before programming lessons for both Czech and Slovak respondents separately is represented on the graph in Fig. 7. The response curves of Czech and Slovak respondents mirror each other, which confirms the results of the *chi*-square test ($p = 0.369$), i.e. the absence of a statistically significant difference between the responses of the groups of respondents to this item.

6. Conclusion

As the presented research results show, the most problematic aspect of programming lessons in both countries is the use of textbooks. Students evaluate the used textbooks of programming from neutral to negative. Ensuring proper quality programming textbooks should therefore be the primary goal for both education communities (SK as well as CZ). In the development of textbooks, close attention should be paid to creating attractive and interesting tasks for students, since the tasks that teachers currently assign do not seem to interest the students (they are rated as *neither interesting nor uninteresting*), and thus students are not very motivated to solve them.

In light of a lack of textbooks of proper quality, the professional performance level of teachers of programming must be highlighted. The clarity of their presentation of new curriculum can be identified as strength of programming teaching, mainly in the monitored schools in Slovakia. Unlike the tasks solved, which the students did not rate as interesting, the teachers' presentations of the curriculum in terms of attractiveness are evaluated by students as fairly positive (*rather interesting)*.

A negative aspect of our results is the found out low usage of various teaching aids in programming classes. On the one hand, due to the nature of the school subject, it is logical that besides own computers, no other teaching aids are used. But on the other hand, inclusion of teaching aids is just one of the possible ways for increasing the attractiveness of classes and students' interest in the assigned tasks and in solving the problems presented to them. Despite the overall low frequency of the use of various teaching aids in programming education in Slovak and Czech schools, the situation in Slovakia can be evaluated as much more favorable, because the results showed a significantly greater rate of the use of teaching aids by Slovak teachers compared to Czech ones.

While the use of teaching aids is rated more positively in Slovakia, the opposite is true when considering the factor of note-taking of new curriculum. In the Czech Republic, students are, in a significant way, led to take their own notes in addition to copying what the teacher dictates. By contrast, the preferred and dominant note-taking method in Slovakia is for the teachers to dictate the exact notes the students should take, which we consider to be a weakness of programming teaching in Slovakia. To a large extent, this may be due to the lack of quality textbooks. On the other hand, the textbook problem has also been identified in the Czech Republic, where teachers, in spite of this, do not forget to develop students' independence even while taking notes.

A gratifying result is the fact that students (both Czech and Slovak) assessed programming as a subject, in which the content is *rather interesting*, and the knowledge they acquired is considered to be *rather necessary* in solving practical tasks in the future. They also assume that this knowledge is *rather usable* in their future day-to-day lives.

Comparing the achieved results for the school subject programming with those obtained for the subject informatics (Záhorec *et al.,* 2012), it can be stated that they are very similar, or in a close approximation one can said that they are the same.

In both cases, to the weakest aspects belong the textbooks. Either the informatics or programming textbooks, they were assessed at average on the level *neither satisfactory nor unsatisfactory* (value 4 of the used scale) or even *rather unsatisfactory* (value 3 of the used scale) equally in Slovakia and the Czech Republic (informatics textbooks: SK – 4.1, CZ – 3.5; programming textbooks: SK – 4.0; CZ – 3.4). A little bit better, but really only a little bit, is the situation with the quality of informatics textbooks used in Belgium (achieved average score 4.3 at the meaning of the value 5 – *rather satisfactory,* but with surprisingly very different assessment of the female and male respondents: F – 3.8, M – 4.8). On the other hand, a very interesting is the fact that at the item focused on the textbooks in case of both subjects informatics and programming, as well as in case of all concerned countries, the respondents' answers are characterised by the greatest variance, contrary to the final values of the standard deviations of the respondent groups for the rest of the items which do not differ markedly. This result shows how difficult it is to create a textbook of computer sciences, unlike other school subjects, which would be suitable in general for most of the students, meeting their different interests, needs, requirements and especially learning styles. Having in mind the application character of computer sciences, it is disputable to speak about the traditional learning styles and from them derived ways of new subject matter explanation. The mentioned facts do reflect also in aspects of attractiveness of the teachers' presentation of the subject matter and capturing the students' interest in it. So as it is difficult to create a suitable textbook either of informatics of programming so difficult it is also for a teacher to prepare a lesson of adequate quality (mainly not having appropriate textbook). And as the both results for informatics and programming show, this has nothing in common with the mastery of teachers. Here we have in mind the different results of assessments of teachers in aspects of clarity and attractiveness of their teaching performance.

In case of informatics in the Czech Republic the attractiveness of curriculum presentation by teachers was assessed significantly worse than the quality of the used textbooks (3.3). The obtained results for programming were more positive (4.5). On the other hand the clarity of the teachers' presentation of the subject matter in programming the Czech respondents assessed this time a little bit lower (INF – 5.5, PROG – 4.6). The Slovak respondents assessed either attractiveness or clarity of the curriculum presentation by teachers approximately equally for the both subjects.

A significant shift was recorded as to the assessment of the demands of the subject curriculum. While informatics demands were assessed by students as *neither demanding nor easy* or *rather easy* (average scores between the values 4–5: SK – 4.2, CZ and BE – 4.6), programming curricula were assessed, mainly by the Czech respondents, as more demanding (SK – 4.0, CZ – 3.4, at the scale value 3 – *rather demanding*). On one hand this result, in regard to the difficulty of the both subjects, one can logically expected. On the other hand, we consider as a very positive result that despite this by the respondents declared different difficulty of the both subjects, the respondents have more or less equally positive attitude to them (SK: INF – 5.3, PROG – 4.9; CZ: INF – 4.7, PROG – 4.6 at the scale points 4 – *neither popular nor unpopular*, 5 – *more or less popular*, 6 – *favourite/popular*). This shows that difficulty of a subject does not result in its unpopularity automatically. Of course, we are aware of the fact that the achieved high values of the average score of the subject popularity is influenced also by the fact that the respondents were attending classes with a curricular focus on informatics or programming where one can expect students with a higher interest in information and communication technologies and computer sciences.

As to the use of various teaching aids in programming education, the very low frequency of their use, with a more positive result for the Slovak Republic, was recorded also in case of informatics education. However in Slovakia the frequency of teaching aids utilized in teaching programming is on the same level as in teaching informatics, the situation in the Czech Republic in case of programming is even worse, i.e. to support teaching programming teaching aids are used at schools even less than to support teaching informatics. On the other hand a positive finding is a shift in assessment of the used teaching aids. The respondents assessed those used in teaching programming more positively than those which teachers used in informatics teaching.

As informatics represents a subject of a more general nature, not so "professionally specific", logically one can expect a higher level of applicability within its teaching acquired knowledge in common life as the knowledge acquired within programming. Also students attending the classes with a curricular focus on informatics or programming are aware of this fact, or may be just these students are aware of it, what is reflected in significantly different assessments given by them to the applicability of the corresponding knowledge in their future. The average score of this item in case of informatics was the same for both Czech and Slovak groups of respondents equal the value 5.3 and in case of programming it was only 4.8 (CZ) or 4.7 (SK). These values show that in case of programming the students connect this school subject with their future professional orientation, about which not all of them have already a clear vision (4 – *hard to judge whether I will use the acquired knowledge*). In case of informatics, as the knowledge is more general and presents key competencies necessary for everyday life either in information or knowledge society, the students are much surer that the acquired knowledge is useful for them and they will apply it in various spheres of their life (5 – *I will likely use the acquired knowledge*).

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Programavimo mokymo Slovakijoje ir Čekijoje kai kurių aspektų vertinimas

Ján ZÁHOREC, Alena HAŠKOVÁ, Michal MUNK

Straipsnio autoriai atliko tarptautinį tyrimą siekdami įvertinti programavimo mokymą aukštesnėse viduriniojo ugdymo mokyklos klasėse – ISCED 3A. Buvo vertinami pagrindiniai kompiuterijos mokymo dalykai: informatika ir programavimas. Vertinimui buvo renkami šie duomenys: mokinių vertinimai, jų atsiliepimai, nuomonės. Šių duomenų parinkimas vertinimui išskiria šį tyrimą iš kitų panašių tyrimų. Straipsnyje pristatomi gauti programavimo mokymo Slovakijos ir Čekijos vidurinėse mokyklose tyrimo rezultatai. Pagrindinės problemos, nustatytos šių šalių mokyklose, yra neadekvatūs vadovėliai, nepakankama jų kokybė, mokymuisi tinkamų knygų stoka. Pagrindinis programavimo mokymo Čekijos mokyklose privalumas yra mokykloje mokomo turinio patrauklumas, o Slovakijoje – aiškus mokymo turinio išdėstymas.