Students' Attitude to Programming in Modern Informatics

A atitude de dez estudantes de programação em informática moderna

Abstract: Informatics is being implemented into education in several ways, often as a separate subject, which creates space not only for the development of digital literacy, but of other important areas such as programming, problem solving and data handling as well. We have been engaged in developing new concept of teaching/learning strategies for informatics as efficient, legitimate and attractive constituent of modern education for a long time. Recently we further this approach (together with other European countries) by a new strategy – Bebras informatics contest, which in one year attracted more than 96 000 students in 9 countries. In our paper, we present the way in which we carry out our concept of modern informatics – accenting programming – through thoroughly prepared tasks of the contest. In particular, we explore the attitude of lower secondary students to key components of informatics education. We observe that at that age there are no significant differences between boys and girls in their interests and performances.

Keywords: Informatics contest. Programming. Educational research.

Resumo: A Informática está sendo implementada na educação de diversas formas, muitas vezes como uma disciplina separada, o que cria espaço não só para o desenvolvimento do letramento digital como também de outras áreas importantes como programação, resolução de problemas e tratamento de dados. Estamos envolvidos com o desenvolvimento de novos conceitos de estratégias de ensino / aprendizagem de informática como um componente eficiente, legítimo e atraente da educação moderna para muito tempo. Recentemente, nós avançamos nesta abordagem (em conjunto com outros países europeus) com uma nova estratégia, o concurso de informática Bebras1, que, em um ano, atraiu mais de 96.000 alunos em 9 países. Neste artigo, nós apresentamos a forma como trabalhamos o conceito de informática moderna – com ênfase na programação – através de tarefas minuciosamente preparadas para a competição. Em particular, exploramos o comportamento de estudantes do ensino secundário inferior com componentes-chave na formação em informática. Observamos que na idade desses alunos não há diferenças significativas entre meninos e meninas em seus interesses e desempenhos.

Palavras-chave: Concurso de informática. Programação. Pesquisa em educação.

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1 Introduction

In our department we have been engaged in implementing informatics as a separate subject[1] for nearly two decades – first at upper secondary level, recently also at lower secondary and primary levels. If the process of informatization of the whole learning process accepts such subject, new space is created for quality development not only of *digital literacy*, but also of other important components of informatics and competencies such as *programming*, *problem solving* and *data handling*. Recently, we have presented our conception of informatics in Papert's constructionist sense in (KALAS; WINCZER, 2008) and (KALAS, 2006).

We consider programming a key component of informatics education and irre-placeable instrument for digital skills. However, we think of *creative construction-ist programming* – not lessened by any misconceptions or bad practices, not twist-ed to teaching a

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1 Besides advocating integration of DT into all subjects.

programming language, not taught by teachers who do not understand it. We try to develop this competency as a means for *exploring, model-ling, controlling, communicating and expressing oneself.* We are developing strat-egies, which should result in *programming for everybody* – for boys and girls, as a part of general education appropriate to contemporary creative society.

2 Primary and Additional Teaching/Learning Strategies

Striving to fulfil our ambitious goals in developing modern informatics education, we are engaging various strategies. Some of them have already been briefly men-tioned above. Beside these, we also count on some additional strategies. One of them is organizing range of contests for all student age groups. In this paper, we exclusively concentrate on one of them – the most influential *Bebras contest.*

2.1 Nationwide Informatics Contest as a Learning Strategy

Bebras is an international contest for students of lower and upper secondary levels, for more details see e.g. (DAGIENE, 2006). It has a 5-year tradition and massively growing interest of students – which validates its main goal: *promote interest in ICT as well as Informatics ... to **all school students**[2].*

In Slovakia (similarly to other involved countries) we strive to implement the contest as nation-wide and efficient tool, acting as a kind of "conspiratorial message" sent to thousands of students and hundreds of teachers saying: this is informatics, this should be its contents, forms and problems to be solved – by boys and girls. Beside this, we are getting large collections of data about contestants. In our paper, we address the only aspect of this process: how do we present programming in the contest and how students of **lower secondary education** cope with it.

2.2 Four Components of Informatics Education in the Contest

When preparing actual year of the contest we drew on the characteristics of appro-priate tasks from (DAGIENE; FUTSCHEK, 2008). To be able to deeply analyze students' solutions and properly interpret resulting observations, we decided to categorize tasks for benjamins and cadets into four *components of informatics education*:

> **digital literacy** – *basic knowledge and concepts of informatics and computers – computer literacy, working with applications – ethical and legal issues, security, history of computing and informatics*
>
> **programming** – *formal description of a solution, process, behaviour, progress – understanding, analyzing, interpretation and assembling such descriptions – algorithms, algorithmic thinking*
>
> **problem solving** – *logical reasoning, justification, argumentation – puzzles, riddles, problems – strategies for problem solving*
>
> **data handling** – *representations, coding, patterns, structures – mathematical basics of informatics, combinatorics – data and data structures, information and data processing*

Each task can be categorized as fitting into *one or two* components listed above.

2.3 Tasks Belonging to Programming Component

In the latest year of the contest we signified our priority in programming by the distribution of all 15 tasks and 80 points[3] into four components: 5 tasks with 25 points (for benjamins) and 6 tasks with 31 points (for cadets) fell into program-ming component either completely or partly, see also Figures 2 and 3. So that the reader could better understand our conception of programming in informatics education and also analysis of the results offered in section 3, herein we present complete wordings of three tasks. First of them fully fits into *program-ming* and was solved by both benjamins and cadets; second one belongs to *pro-gramming* and *data handling* components – benjamins and cadets had slightly different variants, easier and more difficult; third one fits into *programming* and

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2 i.e. not only of *computer wizards*

3 note that each contestant had 40 minutes to solve all 15 tasks of his/her category

was assigned only to cadets. In 3.3, we will study the differences among the pro-gramming tasks at the level of cognitive skills, which students had to apply while solving them. We will also show the results of different age and gender groups.

Park the Car Benjamin task B9, Cadet task C9	**Programming**	authored by M Tomcsanyiova

Path of the car from its position to the parking place can be described by the following commands: *forward* – car will move to the next turn or to the parking place, *right* – car will turn right by 90 degrees, without moving forward, *left* – car will turn left by 90 degrees, without moving forward.

Which **sequence of commands** describes the path of our car to its parking place?

a) *forward left forward left forward left forward right forward*
b) *forward left forward right forward left forward left forward*
c) *forward left forward right forward left forward right forward*
d) *left forward right forward left forward right forward*
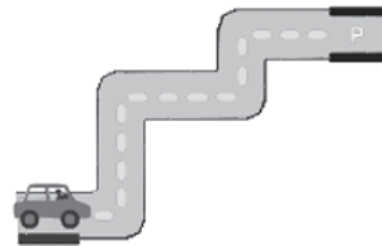
| **Necklace** Benjamin task B15 (easier version), Cadet task C14 (more difficult version)	**Programming + Data Handling**	authored by D. Bezakova

Beaver girls are dressy; they create new necklaces for every party using a special *necklace machine*. They only have to set a pattern, which the machine then repeats while threading the necklace. Which pattern will produce this necklace?
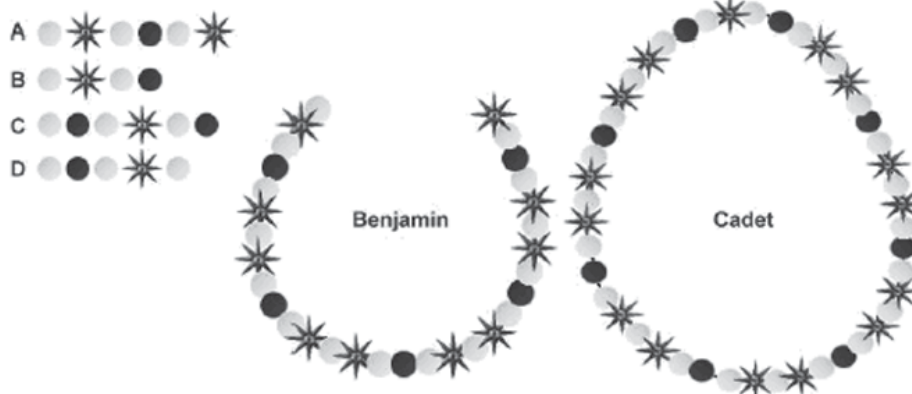
| **Algorithmic Drawing** Cadet task C15	**Programming**	from Logo literature

We can learn a beaver algorithm, which creates various drawings on the squared paper: Let us choose three numbers between 1 and 9; for example 3, 1 and 6.

- **Step 1**. Draw a line of the length set by the first number (that is, 3 squares on the paper) and turn right by 90°.
- **Step 2**: Draw a line of the length set by the second number (that is, 1 square on the paper) and turn right by 90°.
- **Step 3**. Draw a line of the length set by the third number (that is, 6 squares on the paper) and turn right by 90°.
- **Step 4**: Repeat steps 1 to 3 three more times.
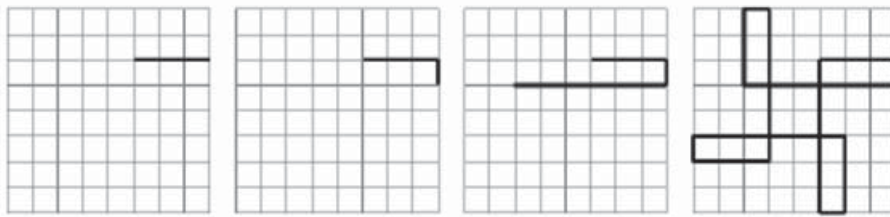
Which trio of numbers will create the drawing to the right?

(a) 4, 1, 1
(b) 1, 4, 4
(c) 1, 3, 1
(d) 3, 1, 3
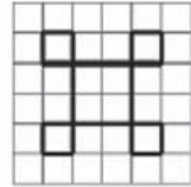
3 Analysing Final Scores of Contestants

In this section, we will analyze the data, which we obtained before and during the event. From the registration, we already knew each student's gender, age and school. During the contest, we recorded which tasks were solved by each student and which of four given alternatives they indicated as correct.

3.1 Numbers of Contestants and their Total Scores

In the recent year 9 317 students took part in the contest in Slovakia, out of them 6 260 in categories Benjamin and Cadet. Figure 1 shows total numbers of boys and girls in these categories, together with the distributions of their total scores. Horizontal axis represents all possible scores (between 0 and 80); vertical axis represents numbers of boys and girls who got corresponding score.

- We consider the total scores excellent – 58% of contestants got more than 50 points; 40% got more than 60 points; 13% got more than 70 points. This proves that the main goal of the event was accomplished – to provide attractive opportunity to develop informatics education to a wide group of students.

- Attendance of the girls in these two categories significantly exceeded our expectations. We find it a priority and challenge to keep such attendance also in the following years of the contest.

- Other gratifying observations are average scores – in categories and by gender: average score of benjamin boys was **48.54 points** and benjamin girls **47.38 points**. In our opinion these results disprove the misconception that *informatics is a boyish subject*. (Later in this paper, we will examine what is the difference in boys and girls results in different types of tasks.)
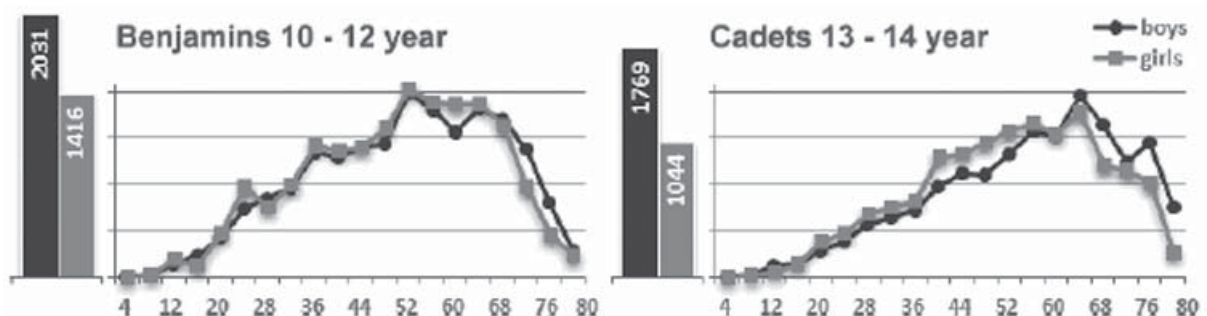

Figure 1 – Numbers of contestants in two categories and the distributions of their total scores

- Average score of cadet boys was **51.55 points**, average score of cadet girls was **51.53 points**. These results are rewarding in two senses – by the values themselves and because of minimal difference between boys and girls. Figure 1 shows significantly higher number of cadet boys than girls.

3.2 Scores in Particular Components

We were curious about the performance of students in four components of informatics education. Figures 2 and 3 illustrate how we decided to divide total number of points (i.e. 80) among four components and what were the average gains in them (left-hand side of Figure 1) – separately for two categories and two genders. Note that in both categories we intentionally overbalanced programming: in Benjamin tasks 32% of points could be gained in that component; in Cadet tasks it was even more – 39%.

- In the Benjamin category, relatively low scores gained in the component of digital literacy surprised us. Most probably, these topics are not properly integrated into informatics curriculum and/or into teaching processes.
- We were pleased to get relatively symmetrical gains distributions for program-ming in both categories. Initially, we expected the average gains to be lower.
- In Benjamin category, we observe significant difference between number of top 20% of boys and girls in the problem solving component. In all lower percen-tiles
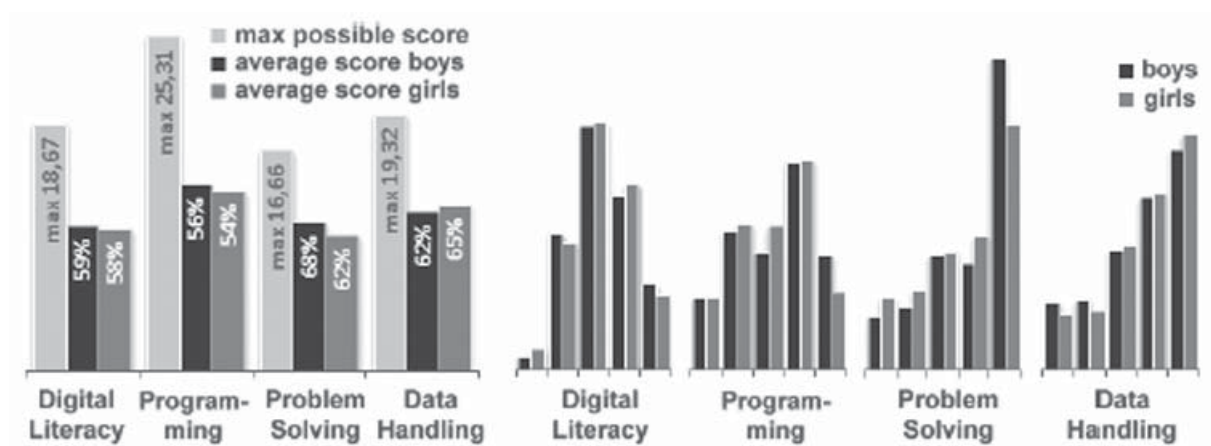

Figure 2 – Benjamin maximum and average scores for boys and girls. On the right, there are distributions of gains coming from four components. Horizontal axis shows five intervals of possible gains (0-20%, 20-40%, 60-80% and 80-100%)
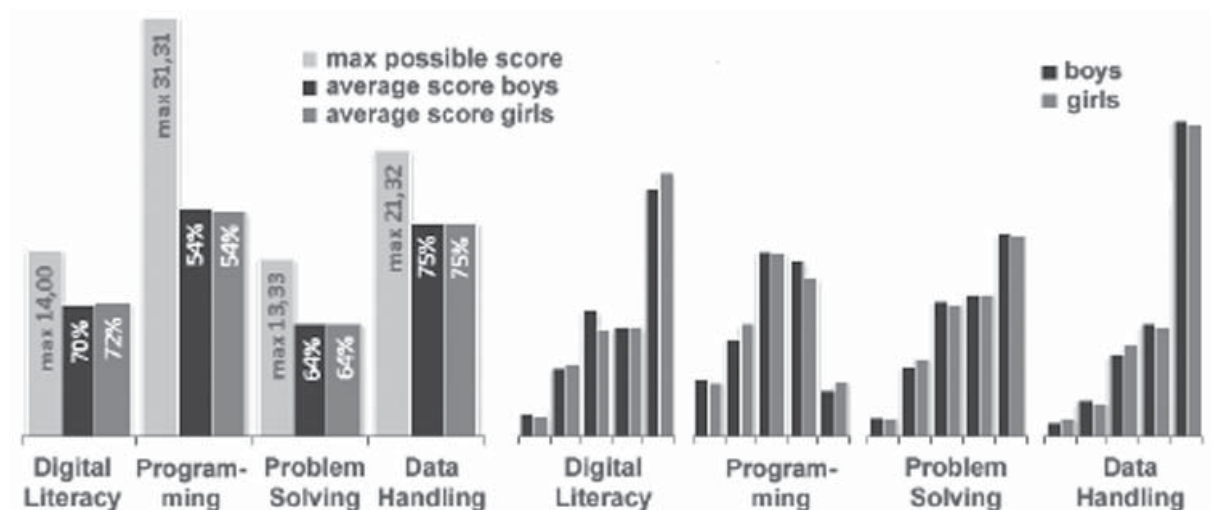

Figure 3 – Cadet maximum and average scores for boys and girls. On the right, there are distributions of gains achieved in four components

the average gains of girls are slightly higher than of boys.

• Cadets – both boys and girls – scored very well in both digital literacy and data handling components.

3.3 Scores in the Programming Component

Let us analyze in more detail all tasks directed (completely or partly) at program-ming. In Benjamin category there were 5 such tasks (labelled as B9, B11, B13, B14 and B15). In Cadet category there were 6 of them (labelled as C6, C9, C12, C13, C14 and C15[4]). Figure 4 shows how students scored in them.

Significant variances in results, especially low achievements in some of the tasks inspire us to classify what kind of cognitive skills must be applied by students when solving these programming tasks:

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4 B9 is identical to C9, B14 is identical to C13 and C14 is more difficult version of B15

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understand given language (a set of atomic commands),	B9, C9, C12
understand given language (a set of atomic commands and one or more control structures),	B13
understand description of process(es), progress, method(s), rule(s) of behaviour or generative rule(s),	B11, B14, B15, C6, C13, C14, C15
interpret given program,	B9, B13, C9, C12
apply given generative rule(s) or method(s) to an initial state, input value or situation,	B11, B15, C6, C14, C15
deduce possible result, final state or final product,	B9, B13, C6, C9, C15
match several descriptions with several behaviours,	B14, C13
compare different situations or solutions by certain criterion.	B11, C12
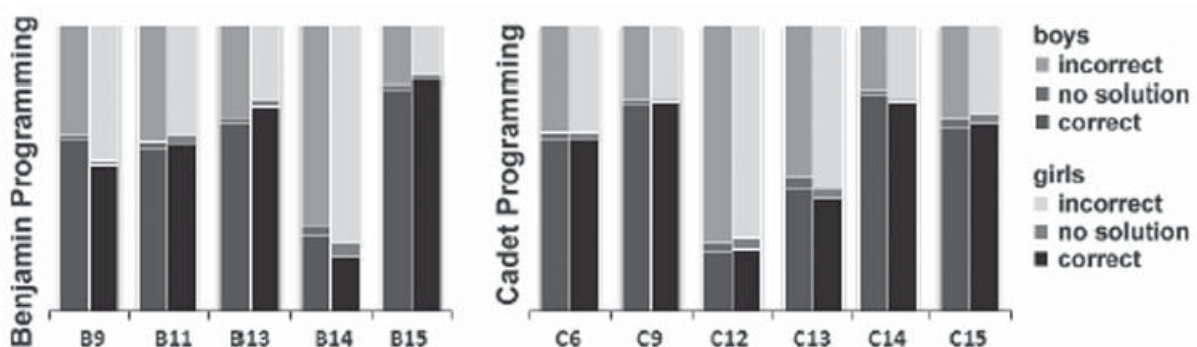
Figure 4 – How successful were boys and girls when solving the programming tasks

We assume that the most problematic (and leading to incorrect solutions) were in particular **understanding** descriptions of processes and behaviours, **matching** descriptions of processes with real behaviours and **comparing** several solutions by certain criteria. When preparing next year's tasks and when analyzing them we will concentrate on studying this hypothesis (among others).

When analyzing programming tasks of the recent year we drew on the fact that some of them were (nearly) identical for all benjamins and cadets. Figure 5 shows the dependency of the number of correct and incorrect solutions (separately for boys and girls) on students age for tasks B9+C9 and B15+C14 (see section 2.3). Left chart affirms natural and expected growth of correct solutions with age, and also that girls scored less than boys.

Right chart validates that (a) for cadets task C14 was harder variant of B15, and also shows (b) that girls scored excellently. We believe that observation (b) relates to the topic of task B15+C14 – Necklace (without any big risk we can classify it a *girlish task*) and proves that programming tasks with thoroughly elaborated topics and wordings guarantee the increase of interest and achievements of the girls.

4 Findings Obtained by An On-line Survey

Immediately after the contest we contacted teachers of all benjamins and cadets involved. For the number of 6260 students of these two categories, there were 210 teachers registered as their instructors. Out of them 50 teachers from 50 schools answered our survey. They together represent 1515 contestants, that are 24,2% of all benjamins and cadets. Thus, we have obtained quality summary of the forms and contents of the informatics subject in the lower secondary education, about its scope and preferences, about the attitudes to the Bebras contest, to its tasks and four components of informatics education. The survey also revealed how teachers are using the Bebras web site in the classes, how they integrate it into the subject and whether it supports them to in reach their pedagogical goals.

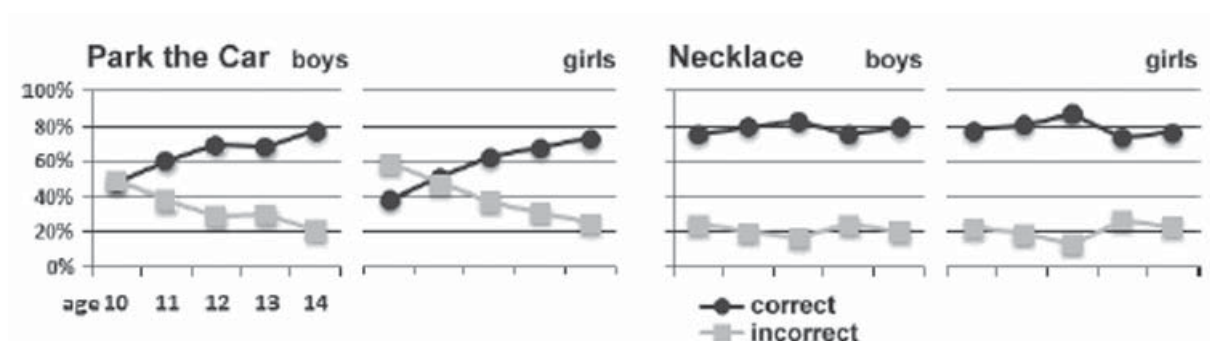For the purpose of this paper, following findings from the survey are relevant:

Figure 5 – Distributions of solutions of common programming tasks by age and gender
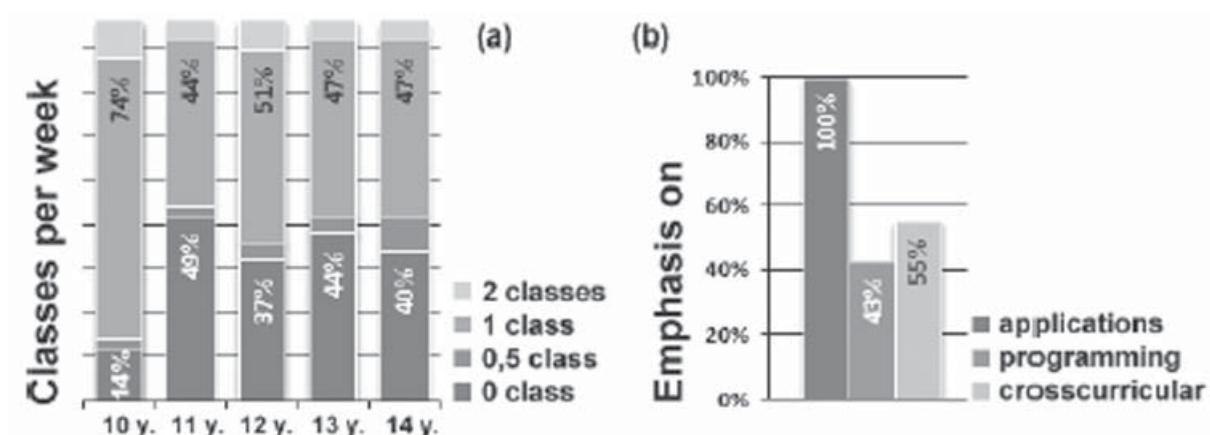

Figure 6 – Extent and specialization of informatics as a subject

- The most usual model of the number of classes of informatics is 1 per week in every grade of the lower secondary education; see Figure 6(a). Each lower secondary school has informatics at least in one grade. However, there are schools with no informatics classes in several grades – 14% of 10 year old stu-dents have no informatics, 49% of 11 year old students have no informatics etc.

- In their informatics classes 100% of schools give attention (not exclusively) to working with application software (text and graphics editors, spreadsheet etc.); 43% give attention to programming; 55% to making ICT accessible to other subjects and cross curricular projects, see Figure 6(b).

- Attitudes of students (according to their teachers) to four components of the tasks are presented in Figure 7(a). Digital literacy and problem solving compo-nents scored the most positive reactions. 67% score for programming component is lower, yet satisfying for us. Negative attitude to programming was expressed by 29% of students.

- We were pleased to learn that 37% of teachers would make use of the Bebras web site and the tasks published there directly in Informatics classes as a means of teaching/ learning, see Figure 7(b).

- The survey proved what we had worried about – there are many misconceptions about the **role of programming in general education** among teachers. They of-ten apology marginal role of programming in

their pedagogy by saying that *only small number of their students will become professional programmers*.

- In general the reactions of students to the contest were predominantly or highly positive, both teachers and students appreciated that the contest was **an occasion to succeed for many of them**, not only for *prime computer wizards*.

- The contest inspired the teachers themselves to plan their own further develop-ment in areas such as programming (43%), educational robotics (43%), web design (57%), or didactics of informatics (61%).

5 Final Observations and Conclusions

- Alternative strategies to support primary goals of informatics education are justified and attractive for students and teachers who incline to integrate them in their classes and consider them to be effective and productive.

- If we want a contest to contribute to the development of digital literacy of students (and their teachers), it must be attractive and employ all possible digital forms. Thus, it is valid to set it up as an on-line event.

- We consider programming inseparable component of informatics. However, its role is often wrongly understood and improperly implemented in teaching/learn-ing processes. This is wrong, because competencies developed by programming are important and legitimate constituents
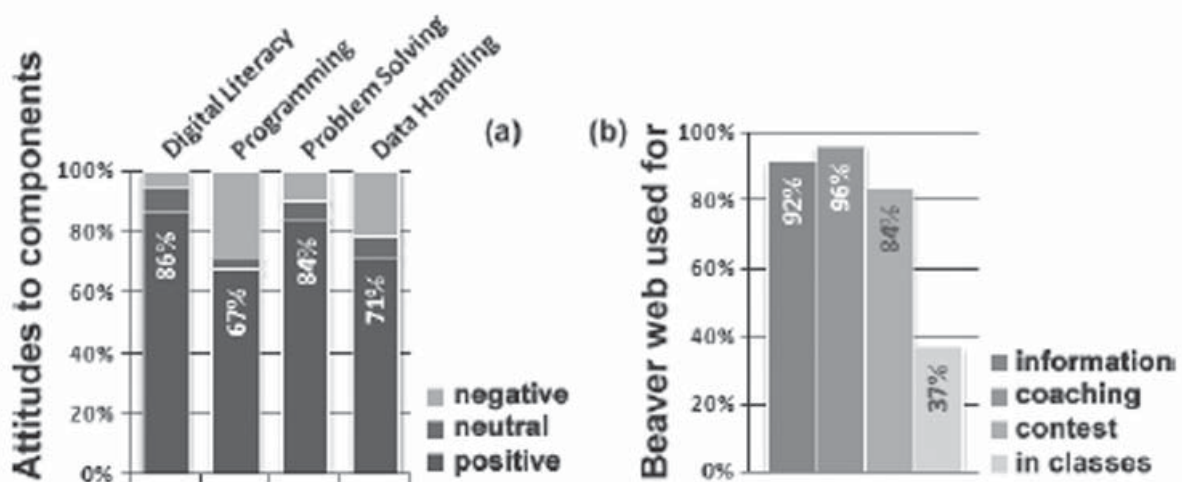

Figure 7 – Attitudes to different types os tasks. How will teachers employ the Beaver web

of modern (digital) literacy. More attention should be devoted to this area – in educational research and in deve-loping new approaches and strategies as well.

• At the age of benjamins and cadets there are no significant differences between boys and girls in their interest in modern informatics education, neither is there any significant difference in their achievements in the field – including pro-gramming. It is extremely important – and possible – to seek proper motivation and tasks to be attractive for girls.

• Informatics – including programming – can be structured and implemented in a way which develops modern constructionist education.

We are pleased to note that interests of students in programming – and their real achievements in such tasks – in lower secondary education is gratifyingly high. It is vital to thoroughly support it in boys and girls by various strategies. Bebras contest with properly set tasks is such strategy.

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