

# Introducing Topics from Informatics into Primary School Curricula: How do teachers take it?

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**Abstract.** The process of introducing compulsory ICT education at primary school level in the Czech Republic should be completed next year. Programming and Information, two topics from the basics of computer science have been included in a new textbook. The question is whether the new chapters of the textbook are comprehensible for primary school teachers, who have undergone no training in computer science. The paper reports on a pilot verification project in which pre-service primary school teachers were trained to teach these informatics topics.

**Keywords:** primary school, informatics curricula, teacher education

## 1 ICT as a compulsory subject in the Czech Republic

The new Education Act of 2004 brought about some major changes in the school curricula in the Czech Republic. The Framework Educational Programme (FEP) define the limits of compulsory education. The orientation of education is set on key competencies and favours outcome-oriented teaching. Information and communication technologies have become one of the nine educational areas for primary and lower secondary school level [1]. The subject Information and Communication Technologies (ICT) is compulsory from primary school level. The school reform is now entering its 5th year. This means that all children leaving primary school level should now have the skills and basic competencies to work with computers and with information.

The reality, however, is far from positive and does not correspond with the expectations. Although the one-year ICT course should be taught in any one year between the 1st and the 5th grade, most schools leave the subject for the last possible grade, i.e. the 5th. The introduction of this new subject meets with a number of difficulties:

- this subject has never before been taught at primary school level, there is no tradition of or experience with teaching it;
- the concurrent transition to new ways of creating school educational programmes and at the same time the shift of responsibility for creating and realizing curricula to the teachers and the schools made the introduction of this new subject more difficult;

- primary school teachers neither have been trained nor are being trained, they lack the necessary experience, there are no lifelong education courses organized by the Ministry of Education;
- teachers do not have methodological materials, pupils do not have textbooks, there has been no research in this area;
- primary school teachers have received no training and are still not receiving any training in the area of didactics of information technologies during their undergraduate studies.

The introduction of the subject Information and Communication Technologies has been and still is uncontrolled.

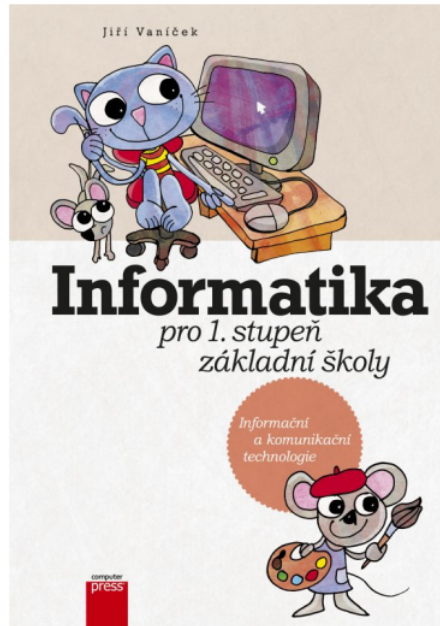
## 2 Basics of computer science in ICT curricula

Simultaneously with the process described above other changes that have an impact on the school curricula could be observed over the past few years. There is a trend of reintroducing into the teaching of work with computers not only topics of digital literacy, but also topics from the basics of computer science. Already in 2003 K-12 Curriculum Committee of The Association for Computing Machinery in the USA stated that the “goals of a K-12 computer science curriculum are to introduce the fundamental concepts of computer science to all students, beginning at the elementary school level”. [2] In the same document they also demand that “upon completion of grade 5, students should develop a simple understanding of an algorithm.”

Not only Czech statistics show a decline in the teenagers’ interest in technical subjects. For example the 2006 OECD document states “that between 1990–2005 the numbers of science and technology students have been decreasing in relative terms.” [3]. This results in increased attempts to endorse sciences in schools. The attempts to reverse the decline of interest in sciences are connected with the effort to establish computer science as a true science discipline. The initiative Computing at School defines “Computer Science as the fourth science” because it lets us “understand the natural world in a new way, and is rapidly invading other disciplines, not merely as a way to do calculations, but as a whole new way of thinking”. If we accept these arguments, then the basics of computer science may, in combination with motivation through digital technologies, develop scientific thinking in all pupils, analogous to other sciences.

The question when to start teaching the basics of computer science can be answered as follows: “There is a strong analogy with the other sciences. We take it for granted that every student should learn the elementary concepts of (say) Physics at primary school and Key Stage 3, ... Exactly the same pattern should apply to Computer Science.” [4] However, the basics of computer science are not included in the official curricula documents for primary school education in the Czech Republic. E.g. algorithms are mostly included in mathematics, in ICT the documents only state that “the pupil should use algorithmic thinking in his/her interaction with a computer” [1]. The approach in the UK is very different: “the Government is now encouraging every good school to offer Computer Science as part of their curriculum, from primary

school onwards.” [4]. Topics from computer science are much more solidly anchored in Slovak primary schools as well, since “informatics at primary ... schools consists of the following five collective thematic units: 1. Information around us, 2. Communication through digital technologies, 3. Procedures, problem solving, algorithmic thinking, 4. Principles of the functioning of digital technologies, 5. The information society.” [5] Two of these topics focus on the basics of computer science.



**Fig. 1.** The cover of the new textbook Informatics for primary school

One of the important international activities promoting a higher share of computer science at primary and secondary school levels outside the school curricula is the Bebras contest (Beaver of Informatics) for primary and secondary school pupils [6]. The history of this contest dates back to 2004 and it has been held in the Czech Republic since 2008. The topicality of this contest is clearly manifested by the growing number of children and young people as well as countries participating in the contest. And this despite the fact that the contest does not focus on information technologies and user approaches. It prefers questions and topics from the basics of computer science, i.e. algorithmization, understanding information and its representations, and also mathematical and logical foundations of computer science. The problems which are compulsory for each state have not included questions about the use and role of ICT in everyday life during the last few years. The contest is gradually spreading to younger children. Slovakia opened the category for 8-year-old pupils in 2011. The Czech Republic opened the contest to primary school pupils in 2012.

### 3 Innovation in ICT teaching at primary school level

With the aim of accommodating both trends described above, namely the extension of teaching computer science to lower age groups and the emphasis on computer science topics, we wrote a textbook and a teachers' book and prepared a set of teaching materials for ICT education at primary school level (see Fig. 1). [7] This textbook includes topics not only of the basics of computer use, but also topics of propaedeutics to computer sciences connected with algorithmization and the understanding of information. The reason for dealing with these topics was to try and influence the teachers and to broaden their perspectives in the discipline. We bore in mind Rohann's assertion that "Primary school teachers, who are educated to teach a wide variety of subjects, will therefore need a thorough understanding of the subject matter of technology to know which topics to address and how to address them in their technology lessons." [8].

The textbook of Informatics for primary schools includes 8 chapters:

- 4 chapters from the area of ICT on running applications, drawing, writing and Internet (including communication)
- 2 chapters from the area of introduction to computer science (programming, information)
- an introductory chapter for very young pupils, manipulation with mouse, work on keyboard etc. (see Fig. 2)
- a concluding chapter on computer- assisted learning and on projects with the use of technologies.

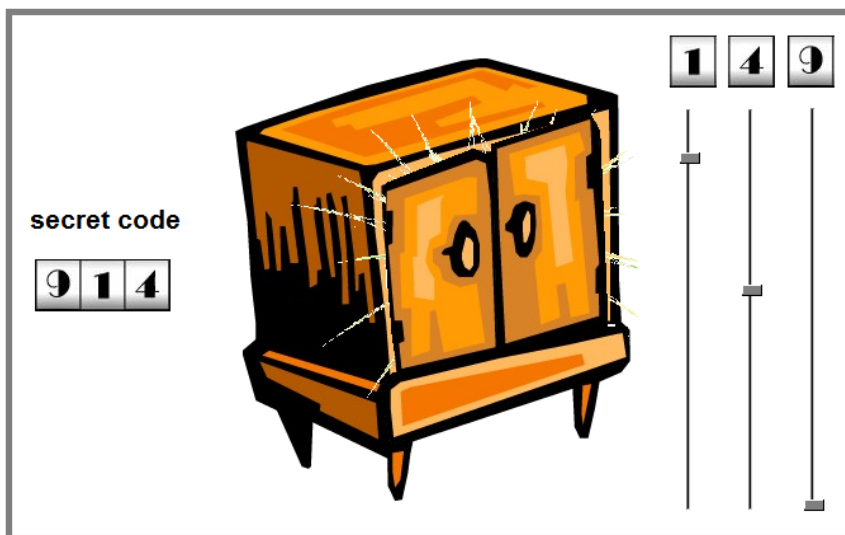
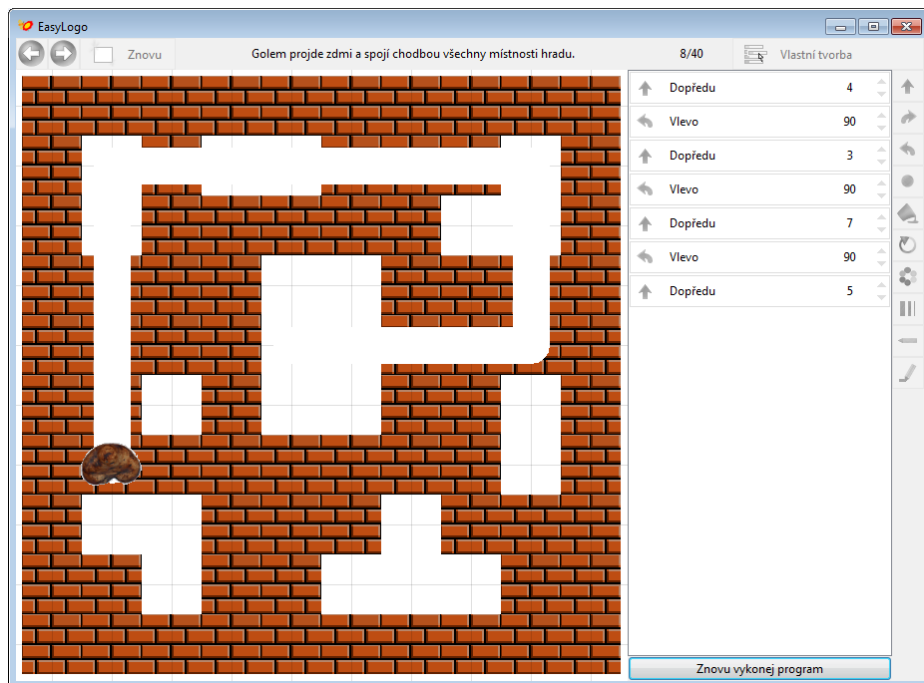


Fig. 2. "Set the input code to the treasure by dragging the sliders", the activity for beginners.

Let us now introduce the two "computer science" chapters in more detail. The chapter on programming uses the application EasyLogo, whose author is Ľubomír Salanci [9],

a simple microworld based on Logo, in which the user controls a figure that, analogously to the “logo-like turtle”, moves and draws. Apart from giving direct control the application offers a system of creating programmes as a sequence of commands with integer parameters, a loop of a known number of repetitions, a simple application of procedures.



**Fig. 3.** Programming activity for beginners in EasyLogo, creating tunnel in castle walls to join all chambers using turtle drawing commands

The main advantage of this environment is a set of programming exercises for the pupil, implemented into the environment of the application. Each task has a goal and tools for reaching it, which makes it possible to guide the pupil methodologically from simpler to more difficult algorithmic problems. The pupils may work at their own pace and the computer gives them full feedback. They learn new concepts in accordance with the constructivist paradigm, in creation, manipulation, in activities appropriate for their personality, temperament and age. The teacher is in the role of manager, an assistant rather than the person assigning the problems or explaining the subject matter. The closed learning environment of these tasks gives the teacher a feeling of security, and this, according to Slovak teachers, is much appreciated.

We created 40 problems for the environment EasyLogo (see Fig. 3, 4), some of which are based on the Slovak version of the application. Using the turtle graphics pupils draw pictures, move figures, solve problems, read and correct already written programmes. The chapter on programming is complemented by activities in which

pupils create commands for their classmates to carry out some task and by algorithmic questions with multiple-choice answers.

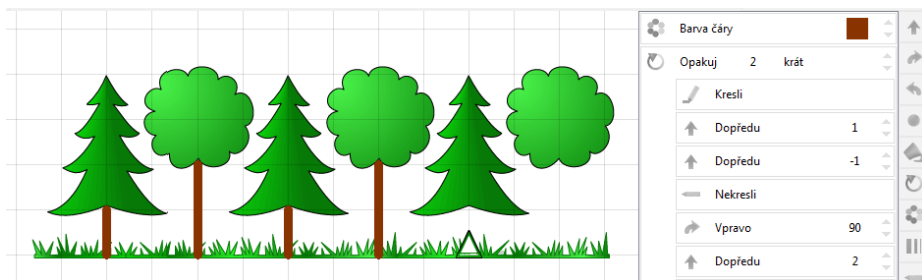


Fig. 4. Advanced programming activity in EasyLogo, drawing tree trunks using a loop

The chapter on information deals with information from the point of view of its content (what do the things around us tell us), representation (signals, symbols) and types of digital media (text, audio, video). The chapter also focuses on representation of information in the form of lists, tables and graphs. Apart from user competencies (e.g. writing into a table, formatting the list, creating graphs from tables) pupils train competencies to understand these structures. They learn to distinguish between a numbered and an unnumbered list, to choose the format of a table for recording specific data, to choose the suitable type of list, to read information from graphs and to make a graph “manually” (see Fig. 5). When reading a graph, pupils are taught to pay attention to the graph’s information value. Pupils then make use of tables, charts and graphs with simple data processing in their own research (measuring, questionnaires, surveys). The chapter has been supplemented by web application Grafy online (Graphs online) [10] for simple conversion of data from a table or chart into a graph, and software activities in which a pupil creates graphs from tables “manually”.

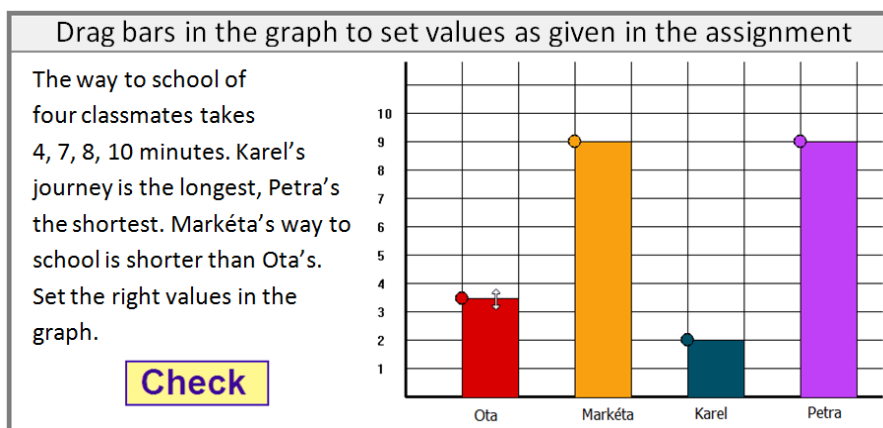


Fig. 5. A learning activity in which the pupil “manually” sets the values on the graph with the mouse to make them correspond with the text on the left (translated).

## **4 Verification among pre-service teachers**

Simultaneously with the process of writing the new textbook we started piloting the course Didactics of Information Technologies for pre-service primary school teachers at the Faculty of Education, University of South Bohemia. The one semester course consisted of a one-lesson lecture and a one-lesson lab-course a week. In the lectures the students were introduced to the different topics as described in the textbook, in the seminars they worked with the materials described in the paragraphs above.

We were interested in the following questions: how can computer science be made more familiar to pre-service teachers, who have no training in the field and how do they grasp topics in this discipline? Other questions were whether the tasks and problems prepared for the new textbook were comprehensible, whether students would grasp both the assignment and the informatics background.

Feedback from the students was gained by the method of participant observation, by analysis of students' work and by interviewing some of the students after the course was completed. The group participating in the research consisted of 42 students in the 6th semester of a long-cycle Master study programme for primary school teachers, 2 men and 40 women, at an average age of 22 with no prior teaching experience. The students had already been tested in information literacy (corresponding roughly to the level ECDL-START) and had finished the course Technology in Education, in which they had worked with audio, video and interactive board.

The teaching in the course was very practical. In the lab-course the students were presented with the more difficult problems from the textbook, in other words with problems of the level their future pupils would be expected to master. The lectures were devoted to the different topics from the textbook. The students, who were in the position of their prospective pupils, were presented with the teaching methods used in the textbook. In most cases the various methodological approaches were documented or illustrated on problems and activities from the textbook, in some cases on activities the students had the chance of trying out in the role of pupils and getting hands-on experience. The students' task at the end of the semester was to create their own set of problems and activities for teaching one of the presented topics.

## **5 Findings**

### **5.1 General attitude**

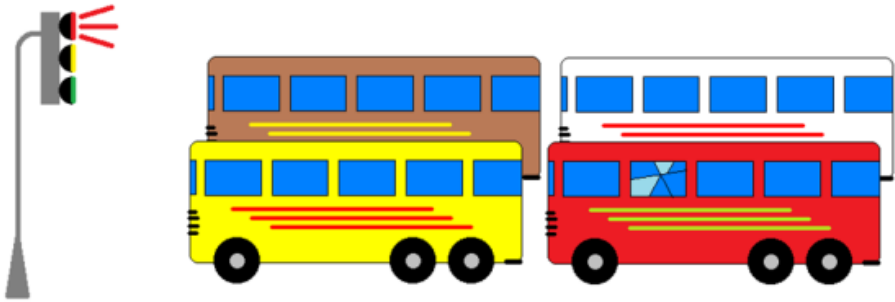
The students grew markedly more interested when they found out that this had become a compulsory subject in school curricula that they would have to teach as well.

In general, the students can be said to have regarded the presented teaching methods as beneficial, they were drawn into the playful, practical applications and problems from real life. In these cases everything seemed more comprehensible to them than in theoretical passages. As soon as the lecture brought some theoretical topic, the students tended to learn it off by heart with the aim of reproducing it, not of using it.

## 5.2 Programming

The students had no problem with the term programming, there was no apparent fear of programming. When solving programming problems the students perceived their activity as real programming. This particular group of students thus did not confirm the general prejudice against the term programming.

It can be said that roughly one half of the students were evidently enjoying their work in the environment EasyLogo. We could witness emotional reactions to the user-friendly environment and to situations when the students managed to solve some more difficult problem. In the final testing all the students were able to solve more difficult algorithmic problems using a loop (e.g. make a programme in which the turtle would finish drawing all tree trunks – see Fig. 4).



**Fig. 6.** Problems with spatial orientation in the problem assignment – is the bus with a broken window to the left or in front of the white bus?

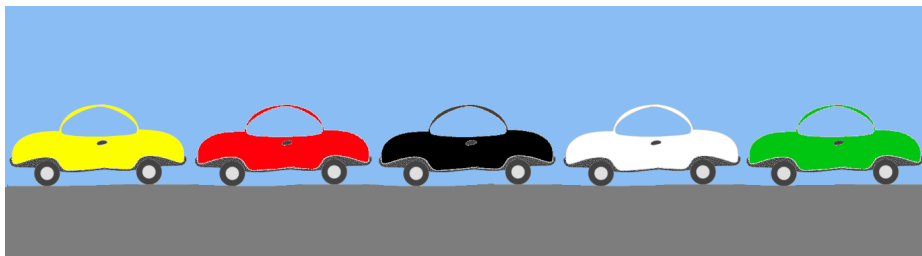
The students were not very enthusiastic about using the loop, the structure of the command Repeat in case there were more commands included. It was an additional condition that the length of the programme must not exceed 15 lines in order to fit the programme into the window of the application that forced the students to use the command Repeat. The same applied to embedded procedures which were used only if the assignment clearly stated that it was compulsory to use pre-prepared subprocedures.

## 5.3 Problem of spatial orientation

The students' problems with spatial orientation – what is in the front, what is on the left etc – were striking. For example, the task which was originally formulated as “buses parked in a garage” (see Fig. 6) that were to be coloured according to the instruction based on their position was too difficult for some of the students who were not even able to determine whether (e.g.) the red bus was in front of the yellow bus or to the left of it. This experience made us reformulate the problem in the textbook to moving buses and to add traffic lights. The direction in which the bus is going defines the direction “in front” and “behind” more clearly.



A similar situation could be observed with a problem in which the students were to determine in a picture of a line of cars (that seemed exactly the same at the front and at the back) which car was driving in front of the black car (see Fig. 7). Some students insisted that “in front” is always on the right. This probably comes from the position of words in a written text. No arguments could persuade them that the cars could also be heading to the left. It seems that these problems are of a geometrical nature and have no connection to informatics. However, these unexpected problems may disqualify many problems from real life when aiming at ordering and classification.



**Fig. 7.** A “problem” for students: which car is in front of the black one?

#### **5.4 Work with information, graphs**

When creating graphs with the help of the application Grafy online, some students had problems when trying to enter the data correctly into the table from which the graph was generated. This appears to be user competence but is based on the understanding of a table as a data structure. The students entered the data into the wrong column designed for description of the items, and when this generated a wrong graph they were at a loss how to correct it.

#### **5.5 Interdisciplinarity, creativity**

In general, the students preferred problem-solving tasks, even in programming, to tasks in which they were required to create something new. The students’ own project work was not very imaginative and was often a mere variation to problems solved in the seminars.

The students did not differentiate between informatics and other school subjects. The problems posed by the students often involved knowledge from other disciplines. For example in word processing more attention was paid to grammar mistakes than to typographic errors, in drawing more attention was paid to the right use of drawing tools from the artistic rather than the ICT point of view. The students did not convince us that they would be able to create teaching objects for use in their teaching of informatics.

## 6 Conclusion

We tried to answer the question how to train didactically pre-service primary school teachers with no former training in informatics. Twyford and Järvinen claim that “In a qualitative study the ‘hands-on’ approach was again advocated for primary school pupils, but the researchers added that pupils’ understanding of technology can be best achieved when the presented problems are authentic” [11]. Our experience supports this claim. The useful approach seems to be to introduce pre-service primary school teachers to the basics of informatics by including topics and problems close to their pupils, in other words by including manipulative, practical problems accompanied by explanatory commentaries showing the relation between the problem and informatics.

Our sample of pre-service primary school teachers did not have troubles with algorithmic problems if they could understand the problems as controlling the movement of objects. Analogically, they easily and naturally accept the topic of understanding information and its representations if the particular problem seems generally beneficial to their pupils’ education. It can be concluded that they perceive the informatics part of education much more in the context of education as a whole than in the context of computer science.

If we want primary school teachers to include the basics of computer science in their curriculum of ICT correctly, they will have to have methodological guidance, either from teachers’ textbooks or from in-service seminars. In the offered course pre-service teachers paid more attention to attractiveness, playfulness, manipulative nature, usefulness of the activities than to disciplinary purity and correctness. These findings make us believe that additional training of primary school teachers in computer science would bring no significant effects in the direction of improving their teaching.

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