Information Technology Contests – Introduction to Computer Science in an Attractive Way

Valentina DAGIENĖ

Institute of Mathematics and Informatics
Akademijos 4, 08663 Vilnius, Lithuania
e-mail: dagiene@ktl.mii.lt

Abstract. Computers, information and communication technology (ICT) are more and more involved in the education process. Students should learn to use information technologies (IT) in a suitable, effective way, and when learning any subject they should be capable to implement computer facilities and thus develop their learning methods. Competitions are an excellent tool to achieve these goals. Competitions play an important role as a source of inspiration and innovation – youngsters are attracted by competitions, they get easier involved in such an activity, more willingly discuss and become more active. IT contests may be a key to the potential of new knowledge and an attractive way of binding up technology and education.

Interest in competitions essentially depends on problems. Really, choosing and developing interesting tasks (problems) is one of the most important issues bringing students into competitions. Attraction, invention, tricks, surprise should be desirable features of each problem presented to competitors. The problems have to be carefully selected, taking into account the different aspects of each problem. IT competitions should encourage students to think about computer science and to understand what it can be.

Introduction to computers, learning by using ICT are the actions aimed at solution and analysis of particular problems. Before starting IT competitions, tasks must be planned very carefully and based on some theoretical analysis. The main attention is paid to develop some criteria for creating as well as selecting tasks.

The history of the Lithuanian IT competition named "Beaver" started on October 21, 2004. Approximately 3500 students from about 150 comprehensive schools were involved in it. Afterwards, the workshop of participants from several foreign countries was held and building of a framework of the international "Beaver" competition was started. The paper deals with theoretical and practical issues of developing new kinds of competition in IT in Lithuania, called "Beaver".

Key words: information and communication technology, problem solving, computer science, competition, learning by doing.

1. Introduction

Today, we are more open and more eager to learn about information technologies, quickly adopt and utilize them in order to enrich our lives. New knowledge and competences are continuously required. However, innovation is not something that falls from the sky like the rain, – it has to be planted.

Information technology, management science marketing, etc. – all these areas of human activities offer employment and fair pay for those who are skilled in analytical thinking and problem solving.

Competition makes the teaching of various subjects more attractive (Katz, 1992; Dagiene, 1993; Schofield, 1995). When students start learning basic concepts of computer science, they may find very soon a place where they are able to demonstrate their skills, their projects, share their interests and to compare themselves with others. This wish might be one of the reasons why a lot of students, soon after they have started learning IT, choose one of the areas where they are able to demonstrate their work immediately, e.g., creation of web sites, computer graphics (Papert, 1980).

For those students, one of the most powerful means which endorses their motivation is competition. The students meet there their peers from all over the country and from other countries, make friends and also waiting for the next competition ready to show their abilities which have improved since the last competition.

When designing curricula for the teaching of computer science or IT, one should consider the attractiveness of teaching methods and students' motivation (Dagiene 1997; Grigas 1993). Some aspects should be taken into account: 1) practical activities are more interesting and attractive than theoretical studies for school students; 2) elements of competition stimulate the learning process.

2. Framework of Contests

The idea of a competition in IT for all school students in Lithuania started a few years ago. It was named by "Beaver" after the hard-working, intelligent, goal seeking, and lively animal.

The main principles of the "Beaver" are borrowed from the international mathematical contest "Kangaroo", which is popular in many European countries and all over the world (International ..., 2005). For example, the Lithuanian tournament involves about 60 000 participants annually with more than 2/3 of schools taking part in it. The goal of the competition is to evoke interest in mathematics of more and more students around the world. The IT competition "Beaver" has been created in order to inspire students in computer science.

Understanding and handling the fundamentals of computer science is more important than knowledge of some technical details. Of course, there is a need to learn the basic computer managing technique very well, but computers have to be understood at many levels, namely, as a multipurpose tool and not only as a collection of buttons and instructions; as a development of ideas not a finished work; and as an explanation of the concepts.

The first contest of "Beaver" was launched on October 21, 2004 for all students in Lithuania. As many as 3470 pupils from 146 schools have participated in it.

The second contest proceeded on October 19–21, 2005. It was decided to choose one day for each level: October 19 for 5–9 classes, October 20 for 9–10, and October 21 for 11–12 classes. About 6000 students from 300 comprehensive schools have participated this year.

2.1. *Goals*

The main goals of the "Beaver" are to promote interest in IT and informatics for all school students, to motivate students to learn and master IT. The competition should help to engage children to take an interest in computers and IT application from the very beginning at school. The IT competition should encourage children to use modern technologies in their learning activities more intensively and creatively. It should bring all school students together and encourage them to brainstorming and sharing their experiences.

As IT becomes a commonly used tool of education, this playful contest could ensure that boys and girls will equally benefit from it. We hope that "Beaver" encourages students to learn the skills that will be needed in the labour market in future.

Cognitive, social, cultural and cross-cultural aspects are very important while using technology – the competition will put a strong emphasis on culture and language.

The "Beaver" competition can help the educational community to clear up school students who can use IT in the most creative and profound way, and to promote students' ability to derive pleasure and satisfaction through intellectual life.

There are three mentoring schemes: the Junior (aimed at primary pupils), Senior (for the basic level) and Advanced (for the secondary level). The competition is designed for all school students.

2.2. *Assessment*

The history of "Beaver" began on September 25, 2004, when the experimental trial, in which 779 school students participated, was held. Its aim was to check selected technologies of the contest and to evaluate the level of complexity of the problems presented. After a month, on October 21, the first Lithuanian "Beaver" contest took place.

Various evaluation schemes and different methods were analysed and discussed. A conclusion was drawn that there should be two main criteria: 1) evaluation has to be clear, easily understandable and facile to memorize, 2) evaluation has to prompt thinking, but not guessing answers. Hereunder the evaluation scheme was worked out.

During the contest, each participant has 45 minutes to solve 18 problems of various levels of complexity: 6 problems for 3 points, 6 – for 4 points, and 6 – for 5 points. A correct answer adds as many points as indicated at the problem, an incorrect one – minus 25% of the indicated points, unanswered problems – 0 points. To avoid negative results, each participant must start with the amount of points equal to the total number of the problems. By the way, the competition was a subject of individual participation, just like International Olympiads in Informatics (IOI Regulations, 2002), but the schools were rewarded for their active involvement.

Each group was given two hours to perform the tasks, collect the results, and send them to the organizers. Preliminary results were calculated and announced the next day.

2.3. *Technology*

The PDF technology was selected for the contest, taking into account that PDF is the universal file format that preserves fonts, images, graphics, and layout of any source

document, regardless of the application or platform used to create it. It was also clear that schools possessed different kinds of equipment and different level of IT knowledge.

The local organizer had to download from the official "Beaver" site (www.bebras.lt) the software (Acrobat Reader CE with some extra programs for testing computers and collecting results) and the PDF registration form (its aim was to collect the basic information on the participants: contacts, OS, number of students and computers involved). Filled in forms had to be uploaded to the server of the National Examination Center, which organized the collection and preliminary processing of the results. A week before the contest, local organizers could download the packages of problems for each group.

On the day of the contest, at the fixed time known in advance, the "Beaver" site reveals the passwords for opening of the problems. The contest starts when the first problem is opened and ends when the participant pushes the "Exit" button, or the time allowed for solution expires. The program forms a coded answer file. The local organizer must collect these files (via local network or manually) and to upload them to the server of the Center. When the answers are collected, the program investigates them, calculates the results, sorts them according to schools, regions, age groups, etc.

3. Theoretical Reasoning of IT Competitions

Framing of the competition was long-lasting exploratory work, accomplished before projecting a Young Programmers School, National Olympiads in Informatics (Dagiene, 2004), National Logo Competitions, etc. The competition is a particular form of teaching and learning, which should influence the implementation standards of ICT and curricula between different countries.

When developing the project of the competition we focused on two main aspects: 1) what is taught in different countries, what the main content is, and what kinds of main skills are to be provided for students, 2) what content should be included in the competition in order to familiarize pupils with computer science.

There are fundamental researches referring to the ICT implementation at schools and informatics teaching, their data were applied in (OECD, 2001; Pelgrum, 1993; Williams, 2003). Three main branches could be emphasised: 1) computer integration when teaching various subjects; it is especially obvious in primary schools, 2) teaching of ICT as an applied subject (or computer literacy), 3) slightly deeper teaching, trying to clarify what the computer science is (usually providing the basics of programming).

The most difficult task is to find the answer to what content has to be implemented at school in order to present computer science to pupils. Most countries have frameworks for IT curricula; there are common international agreements (Anderson, 2002; Longsdale, 2004). There is, however, a lack of confidence whether the education in the domain of IT implementation is taking the right direction, i.e., whether the focus on technology tricks does not overwhelm the deeper perception.

"Beaver" contests will not obviously solve more fundamental issues of the IT curricula development; nevertheless it would be desirable that these competitions bring enthusiastic education specialists from all over the world to provide proposals on what should be taught and what kind of knowledge is required by a youngster of certain age.

4. Attractive Tasks – the Keystone of Contests

Problem solving is an individual's capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious (Dagiene, 1993; Reed, 1998). Interest in competitions essentially depends on problems. Attraction, invention, tricks, surprise should be desirable features of each problem presented to competitors.

During the preparation of the methodology of teaching algorithms for the Young Programmer's School by Correspondence (this school has already been existing for twenty five years), we have raised the principle that it is of high importance to choose and classify the compilation of problems that would actualize the purposes of teaching algorithms and pedagogics.

The problems have to be selected carefully, with regard to different aspects of each problem (i.e., what educational power it has) and interpretation of its attractiveness to students (whether it stimulates the motivation of learning).

Two large groups of problems were distinguished:

1) reading problems (for analysis);
2) writing or developing problems (interactive tasks in the "Beaver" case).

Some tasks especially connected with programming and algorithms are similar to the solution of mathematical problems. However the solutions of traditional mathematical problems are usually short and written in a single way; that is why it is not necessary to analyse here how the solutions should be written.

The constructions of computer languages are rather longer than the mathematical ones and have a great variety of expression means. Therefore, it is not easy for a student to develop an algorithm. One of the most comfortable and effective ways of learning algorithms is to learn to read and analyse algorithms prepared by others.

The main principle in the presentation of algorithm reading problems is to avoid the passive reading. Therefore, it should be demanded to accomplish a certain exercise during the reading.

Since the "Beaver" competition is dedicated to all students and a majority of them didn't attend the programming course, it is impossible to provide the fragments of applications for reading. The universal method has been picked out – several powerful commands with simple syntax have been selected (for example, based on the Logo language) and their description provided.

Thus students not need to be familiar with a programming language. Algorithms are presented on verbal, graphical, or Logo-based (with explanation of commands) notation.

The problems can be of different types: starting from the most common issues of IT and their applications in every day life to specific integrated problems related to history, languages, arts, and, of course, mathematics. In our IT contests, some problems were related to the usage of various most common programs, others – to hardware and software, some of them were connected with the Lithuanian culture and language. About half of the tasks were devoted to introducing algorithms and understanding IT more deeply.

According to our experience, we have proposed the following task groups for competition:

- logical,
- software essential,
- hardware elements,
- algorithms-related,
- Logo-based,
- combinatorial,
- computing history,
- social, cultural, ethical issues.

The spectrum of IT tasks should be reflected and widened. That is the main challenge for international "Beaver" enthusiasts.

Also, it is very important to choose the problems so that the participants of the competition could have as equal starting points as possible, irrespective of the operating system or computer programs used by them.

One feature of the set of problems has shown that they were rather well-balanced. There was not single problem unsolved by someone, but also there was not a single problem that would be solved by all the participants.

5. Conclusions and Discussions

IT competitions may be the key to the potential of new knowledge and an attractive way of binding up technology and education. We understand that if "Beaver" remains a local contest, its perspectives will be rather poor. The Lithuanian "Beaver" Organizing Committee invites everyone interested in this initiative to think about our idea, to consider the local situation and to contact us.

We are open for all kinds of proposals and ideas for collaboration and hope to find friends and partners in all countries. Integration of IT into the teaching process is our target, and we have to try to achieve it together.

We are ready to share our experience, technology, and future plans with everyone who is interested. We expect that it will foster your own competitions similar to the "Beaver" or encourage you to join us. We are sure that a well-organized competition with interesting, playful, exciting problems, and attractive awards will invite children of all countries to use IT reasoning and to explore the understanding of reality, achievements, and failures of IT.

Annex: Some Examples

Example 1. To compose the ornamental design shown below, from two ordinary shapes, Silvia has used the rotation and copying commands of graphics editor. What were those two initial shapes? The size of all shapes of the same type is the same.
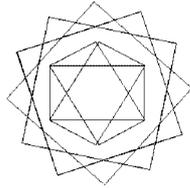
A	Square and rectangle
B	Square and rhomb
C	Triangle and square
D	Triangle and rectangle

Example 2. Using Logo, a simple programming language, Julia has drawn a rectangular spiral with the aid of the following commands:

forward 10 – the turtle moves forward drawing a line of 10 steps (dots) long;
left 90 – the turtle turns left making an angle of 90 degrees.
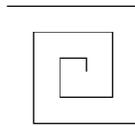
Which of the following numbers expresses the length of the whole spiral in dots?

A   550
B   170
C   300
D   250

Example 3. Which automatic sequence is used to fill the column given in the figure?

	A		
1	2005-02-04	A	Sequence of dates in 15-day spacing
2	2005-02-19		
3	2005-03-06	B	Arithmetic progression with the difference 0.5
4	2005-03-21		
5	2005-04-05	C	Geometrical progression with the denominator 2
6	2005-04-20		
7	2005-05-05	D	There is no automatically created sequence
8	2005-05-20		
9	2005-06-04		

Example 4. A graph is a figure consisting of **points** (named vertices) and **segments** connecting each pair (called edges). The sequence of segments, which connects any two vertexes of the graph, is called a **path**. If the path consists of all the edges of the graph repeated only once, it is called the Eulerian path. The Eulerian path, which starts and ends at the very same vertex, is called the Eulerian cycle. Which one of the given graphs contains the Eulerian cycle?

a   b   c
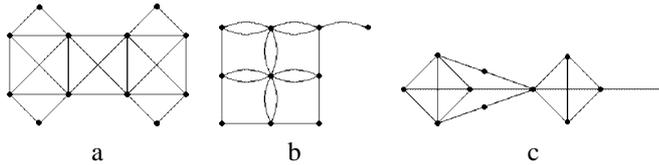
A   a
B   b
C   c
D   It is impossible to draw the Eulerian path.

Example 5. Sometimes all of us like to play different computer games. Probably you have also tried to lift a minefield of "MS Minesweeper". Let us remember the rules of the game:

A number that appears on the square when you click it indicates how many mines are in the eight squares that surround the numbered one. A red flag in the square indicates a mine.

Which fragment of the game consists of the wrongly signed red flags?
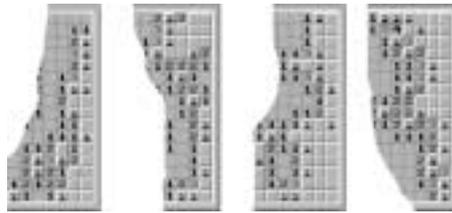
Example 6. Logo, a simple programming language, may perform the following commands:

`forward` n – the turtle moves forward drawing a line of n steps long;

`right` α – the turtle turns right making an angle of α degrees;

`repeat 5 [forward 30 right 30]` – the turtle moves forward drawing a line of 30 steps long and turns right making an angle of 30 degrees; these actions are repeated five times.

The turtle always looks up from the beginning.

Which of the mentioned sequences may result in the following figure?
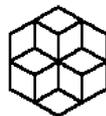
A   `repeat 3 [repeat 6 [forward 20 right 60] right 120]`
B   `repeat 6 [repeat 6 [forward 20 right 60] right 60]`

```
C     repeat 4 [repeat 6 [forward 20 right 60] right 90]
D     repeat 6 [repeat 3 [forward 20 right 120] right 60]
```

Example 7 *(interactive task).* The following cells contain names. Use an empty extra cell and arrange those names in alphabetic order with the minimum number of operations.

First click the name and afterwards click the empty cell. If you made a mistake you may delete the result and solve the problem once again.

David
John
Peter
Jonas
Ivan
Tom
Marta
Jean
Stanislaw
Anna
Silvia

References

Anderson, J., and T. Weert (2002). *Information and Communication Technology in Education: A Curriculum for Schools and Programme of Teacher Development*. UNESCO.

Dagiene, V., and G. Grigas (1993). Development of problem solving skills and creativity through distance teaching of programming. In G. Davies and B. Samways (Eds.), *Teleteaching: IFIP Transactions* (A-29). Elsevier Pub. pp. 179–182.

Dagiene, V., and J. Skūpiene (2004). Learning by competitions: Olympiads in Informatics as a tool for training high grade skills in programming. In T. Boyle, P. Oriogun, A. Pakstas (Eds.), *2nd International Conference Information Technology: Research and Education*. London. pp. 79–83.

Dagiene, V. (1997). Learning via electronic mail: What and how? In *Education for the 21st Century*, 2–4 December, Cape Town. pp. 1–10.

Grigas, G. (1993). An experiment of computer programming practice by e-mail. *Interpersonal Computing and Technology*, **1**(2), 1–10.

IOI Regulations (2002). `http://olympiads.win.tue.nl/ioi/rules/index.html`

Katz, L.G., and S.C. Chard (1992). *Engaging Children's Minds: the Project Approach*. Norwood N J, Ablex.

Longsdale, M., and D. McCurry (2004). *Literacy in the New Millennium*. Adelaide, Australian Council for Educational Research, NCVER.

OECD (2001). Schooling for tomorrow. Learning to change: ICT in schools. Education and skills. OECD publications, Paris, OECD Center for Educational Research and Innovation.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. New York, Basic Books.

Pelgrum, W.J., and T. Plomp (1993). The worldwide use of computers: a description of main trends. *Computers in Education*, **20**(4), 323–332.

Reed, W.M., and J.K. Burton (1998). *Educational Computing and Problem Solving*. New York, The Haworth Press, Inc.

Schofield, J. (1995). *Computers and Classroom Culture*. Cambridge University Press, Cambridge, Massachusetts.

International Mathematical Contest "Kengūra" (2005). `http://www.kengura.lt` (in Lithuanian).

Williams, K. (2003). Literacy and computer literacy: analyzing the NRC's being fluent with information technology. *The Journal of Literacy and Technology*, **3**.

V. Dagienė graduated from Vilnius University, Lithuania, in 1978, and received the PhD in physical science, informatics from the Vytautas Magnus University, Lithuania, in 1993. In 2005, she passed the habilius procedure in social sciences (educology) from the Vytautas Magnus University. She has been working as a head of Informatics Methodology Department at the Institute of Mathematics and Informatics and also as a professor at Vilnius University. V. Dagienė is an author of more than 50 textbooks in the field of informatics and programming for high schools. Her main research focus is teaching informatics and information technologies in high school. She is also engaged in programming languages, algorithms, learning Logo, problem solving, distance education, localization of software. She takes care of informatics teaching in primary, basic, and secondary schools, she has initiated and supervised the preparation of curricula of informatics and information technologies. Besides she works in various expert groups and work groups of the Ministry of Education and Science in Lithuania and abroad.

Informacinių technologijų varžybos – patrauklus būdas supažindinti su kompiuterija

Valentina DAGIENĖ

Kompiuteriai, informacinės technologijos labai traukia jaunimą. Tačiau norima, kad mokiniai ne tik žaistų, bet ir naudotų kompiuterius mokymuisi, savo veikloje, o mokydamiesi suprastų, kas ir kaip daroma. Varžybos – vienas patraukliausių būdų, skatinančių mokytis. Straipsnyje aptariami varžybų privalumai ir būdai tam pasiekti.

Prieš keletą metų pradėtas formuoti informacinių technologijų konkursas „Bebras". Šio konkurso tikslai: a) skatinti mokinius intensyviau naudotis informacinėmis technologijomis mokymosi procese, b) patraukti jaunesniojo amžiaus vaikus domėtis informacinėmis technologijomis, kompiuteriais ir jų taikymu, c) parodyti moksleiviams informacinių technologijų teikiamus privalumus mokantis įvairių dalykų, d) išaiškinti gebančius kūrybiškai ir greitai naudotis informacinių technologijų priemonėmis ir įgytomis žiniomis moksleivius.

Lietuvos mokyklose jau daugelį metų gyvuoja „Kengūros" konkursas – sprendžiamos matematinės užduotys, galvosūkiai, lavinama mąstysena ir vaizduotė. „Kengūra" atkeliavo iš Australijos, o prancūzų dėka išpopuliarėjo ir dabar šie konkursai vyksta beveik 40 šalių. Norima, kad informacinių technologijų konkursas „Bebras" peržengtų Lietuvos sienas, išplistų pasaulyje, paskatintų ne tik mūsiškius, bet ir kitų šalių vaikus naudotis kompiuteriu mąstant, suvokti modernių technologijų teikiamas galimybes ir įvertinti jų trūkumus.

Informacinių technologijų konkurso „Bebras" istorija prasidėjo 2004 metų spalio 21 dieną, – šalyje buvo suorganizuotas konkursas ir jame dalyvavo 3470 moksleivių iš 146 mokyklų. Konkurso dalyviai trimis srautais po 45 minutes sprendė 18 įvairaus sudėtingumo užduočių. Konkurso užduotys labai įvairios: nuo bendrų, loginį mąstymą lavinančių galvosūkių iki su konkrečia kompiuterio aparatine ar programine įranga susijusių užduočių. Įdomu tai, kad neatsirado nė vieno mokinio, kuris teisingai išspręstų visas pateiktas užduotis, taip pat nebuvo nė vienos užduoties, kurios niekas nesugebėtų išspręsti. Konkurso užduotys, nugalėtojai bei visų dalyvių rezultatai paskelbti konkurso svetainėje www.bebras.lt.

Varžybose ypatingą svarbą užima užduotys (uždaviniai). Nuo jų įdomumo priklauso visų varžybų sėkmė ir populiarumas. Straipsnyje pagrindinis dėmesys skiriamas uždavinių tipams aptarti, pabaigoje pateikiama keletas pavyzdžių.