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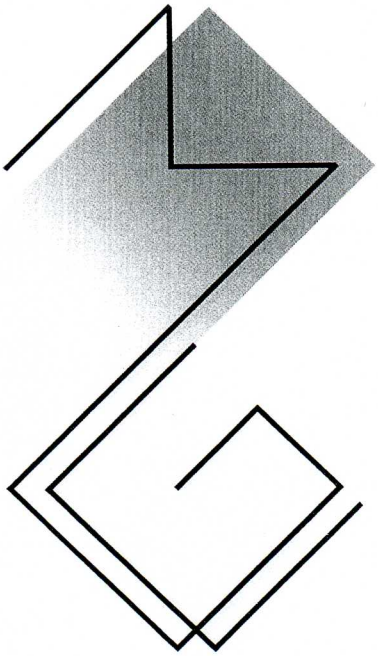

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"KANGOROO" AND "BEAVER" – THE CONTESTS FOR ALL PUPILS TO BE MORE INTERESTED IN MATHEMATICS AND INFORMATICS

Valentina Dagienė, Romualdas Kašuba

Vilnius University, LITHUANIA, valentina.dagiene@mif.vu.lt, romualdas.kasuba@mif.vu.lt

Abstract

Contests at school may attract students to be interested in mathematics and informatics. By the examples of internationals Mathematics "Kangaroo" and Informatics "Beaver" contests we present how a contest may introduce a variety of even advanced concepts in a very short time. And about that the students need no specific pre-knowledge and learn in an explorative way to solve the given contest problems. A main focus while preparing a contest should be given to the development of good tasks that also can be used by the students and teachers in their further learning and teaching activities.

Keywords: *teaching by solving, developing tasks, contest in math, contest in informatics.*

Introduction

Concepts of Mathematics and Informatics play a central role in curricula and standards at schools. However, very often the training of skills in exercising and application software is given much more room than the understanding of fundamental concepts. The reasons for that may be manifold: lack of time, missing teacher education, missing materials, pressure from industry, etc. In this paper, we are going to show how Mathematics and Informatics concepts may be introduced to schools in a student-motivated and playful way.

There are three basic ways students can interact with each other as they learn any subject. They can work individually toward a goal reading textbooks, listening to teacher or making exercises, they can work cooperatively with other students with interest in each other's learning as well as their own, and they can compete to see who can achieve the best results.

Of the three interaction patterns, competition is one the most dominant in recently society. Research indicates that a vast majority of students in the United States view school as a competitive enterprise where one tries to do better than other students. This competitive expectation is already widespread when students enter school and grows stronger as they progress through school (Johnson & R. Johnson, 1991).

Mathematics competitions or mathematical Olympiads are competitive events where participants write a mathematics test. These tests may require multiple choice or numeric answers, or a detailed written solution or proof. In the United States, usually only competitions where the participants write a full proof are called Mathematical Olympiads.

There are plenty of mathematics contests over the world: Wikipedia presented more that 20 international contest and more than 30 regional contests in mathematics. Each country runs several items of contests in mathematics as well.

Informatics (or Computer Science in some countries) is younger science; however there are also many international, regional, and national contests as well.

Mathematics Kangaroo and informatics Beaver: organizational structure

Mathematical Kangaroo is an international mathematical competition with more than 40 countries that take an active part in it. The idea of Kangaroo started in the 1980's in Australia, and its originator was Peter O'Halloran, a famous mathematician and teacher. The goal of the competition is to evoke interest in larger and larger numbers of students around the world. Because there is no qualifying contest, all that are willing can participate in the competition. The rules of the Kangaroo competition are simple: the contest takes place in every country on

the same day. The students solve the same problems translated into their native languages. The time limit is 75 minutes and the format is that of multiple-choice test.

Since many years in "Kangaroo" there were five main levels of participation: Minor (in Lithuania, grades 3 and 4), Benjamin (grades 5 and 6), Cadet (grades 7 and 8), Junior (grades 9 and 10) and Student (grades 11 and 12). In recent years in Lithuania the additional Nipper level (grades 1 and 2) was successfully adjoined to the whole event. The competition is held annually (not earlier than) on the third Thursday of March. According to the organizers, the key competence tested by the Kangaroo is logical combination, not just pure knowledge of formulas. Because of the rising popularity of the Mathematical Kangaroo in many participating countries, it currently became the most participated scholar math competition: over 5,000,000 students from 47 countries participated in 2009.

From the point of view of history the "Kangaroo" Contest originated in Australia and later on was adopted in France in 1991. Then it quickly enjoyed wide and increasing popularity among students in many countries. The contest's main purpose is to inspire mathematical thinking and to teach first of all simply how to enjoy math problem solving.

The competition is executed as a 75-minute multiply choice test, consisting in the 4 main categories of 30 questions (at Minor grade, 24 questions only), equally divided among the categories of 3-point-, 4-point- and 5-point-questions. 5 solutions are given, exactly one of them being correct. One is given the respective points for choosing the correct answer, 0 points for not answering and a quarter of the respective points are taken off for choosing a wrong answer. Each participant is given 30 base points at the beginning (except Nipper and Minor, where correspondingly 18 and 24 question are proposed), so that the minimum number of points at the end is always at least 0. The maximum number of points in the main categories is 150.

In Lithuania the Lithuanian version of Kangaroo content started in 1999 (in Polish and Russian schools in Lithuania the competition was known before), mainly due to considerable efforts of Prof. J. J. Mačys, who, year by year, is preparing and publishing all issues of Lithuanian version (problems with solutions together with multilevel comments, vide [7]) and the Ministry of Education and Science of Lithuania, constantly supporting the whole event and from the side of which its main specialist Mrs. M. Skakauskienė during all that period was permanently involved.

Taking things strictly, the start of the "Beaver" contest on informatics (and computer fluency) in Lithuania in 2004 brought also the realization to the idea, wish and long-term desire of the first author of that publication to develop corresponding contest in informatics. Now this content enjoys the dynamic growth and meanwhile is being spread through 15 countries.

The name "beaver" – in Lithuanian origin "bebras" – itself is associated with the hard-working, intelligent, goal seeking and lively animal. The main goal of the "Bebras"/"Beaver" contest is first of all to motivate pupils to be more interested in informatics topics and to promote thinking, which is algorithmic, logical and based on informatics.

The main principles of the "Beaver" are borrowed from the "Kangaroo". Moreover, there is a very similar game "Lwionko" (lion cub) in the Ukraine and Poland in physics, and in Belarus and Russia schoolchildren participate even in a few games in different educational disciplines.

The Bebras contest is an Informatics contest for all secondary school students that is performed at school at computers and offer 18 to 24 problems to be solved by the students within 45 to 55 minutes. There are different task sets for the age groups Benjamin (grade 5–8), Junior (grade 9–10) and Senior (grade 11–12), in some countries are two age groups for the youngest: Benjamin and Cadet. Teachers who may also integrate the contest into teaching activities are usually also supervising the contestants.

The general goals of the Bebras contest are: (1) give the students motivating impulses to be interested in informatics; (2) show the variety of informatics topics and concepts; (3) show that solving informatics problems is interesting and challenging; (4) bring learning challenges; (5) support a positive attitude to informatics and computer fluency.

In the past few years, the number of the Bebras participants has been remarkably growing. In 2009, the Bebras contests took place in 11 countries, with about 150 000 participants total (Bebras, 2010). Most participants, 82 799, came from Germany, and about 40% of German participants were girls. Estonia had the strongest relative participation with 3 482 contestants. The Bebras mover country Lithuania participated with 10 358. Seven further countries are going to run the Bebras competitions in November 2010 (Bulgaria, Egypt, Finland, Israel, Romania, Slovenia, and Switzerland).

Workshops for developing the Bebras tasks are being organized each spring. The main goals of the workshops are to develop a set of tasks for the coming contest, to discuss them and come to an agreement among the countries with different curricula and traditions of teaching computer science in general education.

Attractiveness of Kangaroo and Beaver tasks

The quality of tasks is crucial for the success of all task-based competitions. Usually competitions have several goals and the tasks have to fulfil a wide variety of criteria. The tasks must reflect the goals of the competition and should be adequate for the applicants. Seeking to motivate students to learn more deeply science issues competitions are one of the best ways to capture their attention [3]. In educational competitions, tasks should attract students and drive them to learn and explore as well to develop skills in the particular area [6]. Children are attracted by competitions and get easier involved in discussions and become more active.

The main common features of both contests naturally are the elegant form and lively nature of proposed tasks.

The most powerful means, which stimulate students' motivation to show interest in science, are competitions or contests. The feeling of belonging to some group of common interest is important.

Interest in contests essentially depends on tasks. Attraction, invention, tricks, surprise should be desirable features of each task presented to competitors. The problems have to be selected carefully, taking into account the different aspects of each task, i.e. what educational power it contains and how to interpret its attractiveness to pupils (whether it stimulates the motivation of learning).

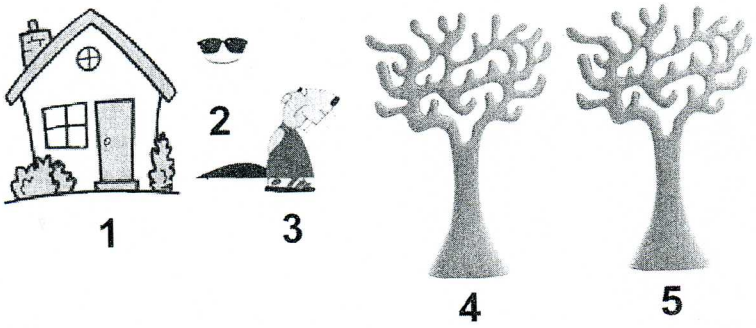
Tasks should be based on some concepts.

In contests it is very important to choose interesting and learning motivating tasks (problems). Therefore, one should try to present tasks from various fields of science and life, with a lot of real data and engaging situation. The selection of tasks for a contest is very important: they must cover as many sub-areas as possible. Moreover, the tasks have to be selected carefully, with regard to different aspects of each task (i.e., what educational power it has) and interpretation of its attractiveness to pupils (whether it stimulates the motivation of learning).

Examples of Tasks ("Bebras"/"Beaver")

Mandatory Benjamin Task: Stamping (created by Lithuania)

Beaver has five stamps and they are numbered from 1 to 5:



He stamped a nice picture:

In which order did beaver use the stamps?

A) 5 - 2 - 4 - 3 - 1
B) 5 - 3 - 4 - 2 - 1
C) 5 - 2 - 3 - 4 - 1
D) 5 - 4 - 2 - 3 - 1

While solving this task even the younger children learn a lot about concepts of programming: coding of basic actions as commands (1 to 5), sequencing of commands and even reverse engineering! Although there is not a concrete algorithm part of this task this task can be classified as algorithmic thinking task. As shown in figure 2, this mandatory task was an easy to solve task for the Benjamin age group.

Sample task: Friends (created by Estonia, "Bebras"/"Beaver")

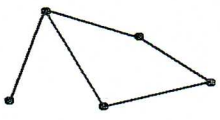
We know that

- Michael's friends are John, Peter and Tom
- John's friends are Michael and Anne
- Anne's friend is John
- Peter's friends are Michael and Tom
- Tom's friends are Michael and Peter

We represent people as points and we draw a line between two people if we know that they are friends with each other.

Which of the given figures can be obtained this way?

a. 

b. 

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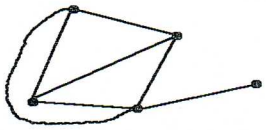
d. 

This was in the Bebras 2009 contest a mandatory task for elder Benjamins. It is a task of type structures that allows learning experiences in representing relations by graphs. So the concept of a graph is learned while solving this task.

Example task 2 ("Bebras"/"Beaver"): Islands in a Lake.

Now we give an example of a possibly perfect interactive task:

Beaver discovered a number of islands in a lake and decided to build bridges to connect them. While building bridges Beaver follows the rules: the bridges must be built keeping the directions East-West and North-South and shouldn't overlap each other.

Help Beaver to build as many bridges as possible. Use the mouse to connect pairs of islands.

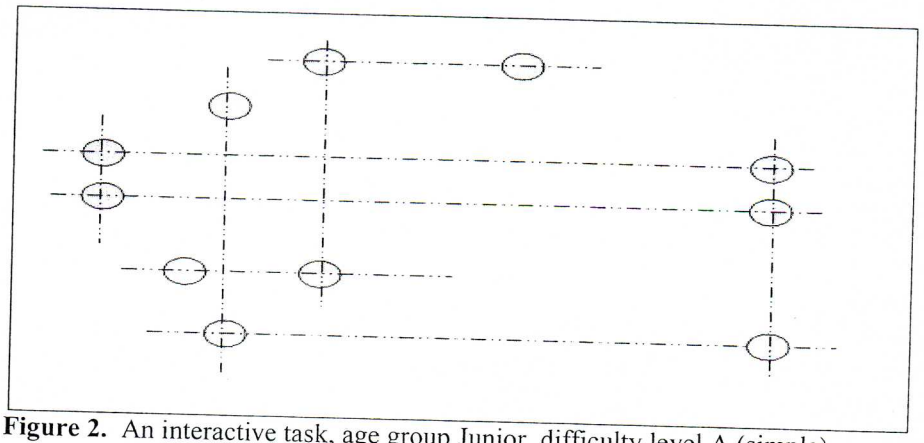


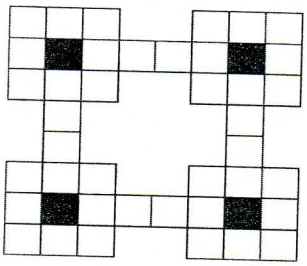
Figure 2. An interactive task, age group Junior, difficulty level A (simple).

It is an algorithmic thinking (ALG) task, since a solution strategy incorporates strategies to find all different ways of building bridges. The possibility of interactively building bridges that are counted automatically and that can also be reset allows a sort of game-based learning.

Domino stones (Kangaroo competition, proposed by Lithuania)

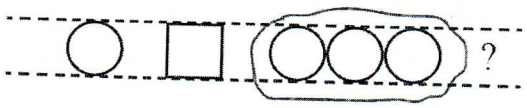
(2003 B19, J2, S9, compare also M24). The composite board shown in the picture consists of 44 fields 1 x 1. How many possibilities are there to cover all 40 white fields with 20 rectangular stones 1 x 2? (The board cannot be turned. Two possibilities are different if t at least one stone lies in another way.)

Answers: A 8 B 16 C 32 D 64 E 100



Lining up. Kangaroo task, proposed by Lithuania (2003: B14, C4, J8, S3).

The area of the wooden square equals *a*. The areas of each wooden circle equals *b*. Three circles are lined up as shown in the picture.



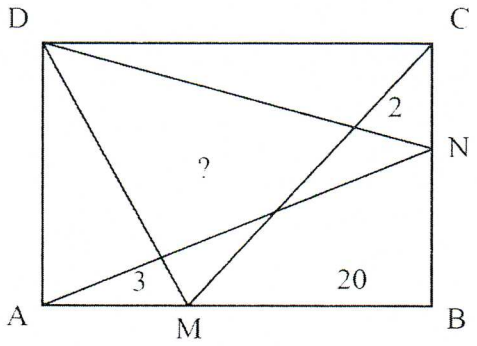
If we tie together three circles with a thread as short as possible, without mowing them, what is the area inside the thread?

Answers: A $3b$ B $2a + b$ C $3a$ D 64 E $a + b$

Defining unknown areas Kangaroo competition (2006: S25).

Point M and N are given on the sides AB and BC of the rectangle ABCD. Then the rectangle is divided into several parts as shown in the picture. The areas of 3 parts are also given in the picture. Find the area of the quadrilateral marked with "?".

Answers: A(20) B(21) C(25) D(26) E (not enough information is given).



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