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Romanian National Olympiads in Informatics and Training

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Abstract. The paper discusses the Romanian experience, including two on-line forums which have helped improve the participation and quality of the informatics experience in Romania.

Key words: informatics, olympiad, training, problem.

1. Informatics Secondary Education. Background

This section presents a general view of the secondary education in Informatics in Romania.

Secondary education in informatics in Romania started in 1971, when 5 informatics high-schools were founded, one in each of Bucureşti, Iaşi, Cluj, Braşov and Timişoara. Another informatics high-school was founded afterwards in Petroşani. Until 1989, only these 6 schools provided secondary education in informatics.

After 1989, the number of informatics schools or informatics classes in ordinary schools increased rapidly, since students and parents became more and more interested in this discipline.

Over time, changes have frequently occurred, both in informatics education and in the educational system. Every minister of education tried to do a major transformation in the educational system, at different levels.

15 years ago, a student studied informatics for 8 hours/week. Today, in an ordinary mathematics-informatics class, a student studies 1 hour/week in the 9th and 10th grades (representing the age range of 15–17 years), and 4 hours/week in the 11th and 12th grades. There are only a few special (intensive) classes for 4 and 7 hours/week respectively.

This situation has an obvious negative impact on the quality of education in the field.

2. Alternative Training

In Romania, the major problem in informatics education is the lack of teachers and especially the lack of qualified and/or proficient teachers. We have had to find alternative ways to train students.

2.1. *Centre of Excellence for Young People Capable of High Performance*

In 2001, the Centre of Excellence for Young People Capable of High Performance was founded by the order of Minister of Education and Research. Gifted students were declared a national wealth, having specific educational needs.

In the whole country, 9 Regional Centers of Excellency were founded, each coordinating 5–6 counties, each having its own coordinator and developing its own training program on 6 disciplines: mathematics, informatics, chemistry, biology, physics and geography. The main idea was to gather highly-skilled students with the best teachers and to develop special activities as a response to their higher educational needs.

Is this program a success?

After 7 years, the Center of Excellence still lacks national coordination, budget or headquarters. In some counties this program has never worked (the person in charge did not organize the activities of the Center of Excellence: teachers' registration, students' registration, training programs, etc.). In some there are hesitating attempts to make it work (the activities of the Center of Excellence are organized, but not for all the 6 disciplines, training activities are scheduled too late or not every week). But in some counties this program really works, year after year. For instance, every academic year, over 1000 students in Iaşi choose to spend week-ends working at the Center of Excellence. Almost 100 teachers train students for excellence. Passion and enthusiasm make things work.

2.2. *.campion*

`http://campion.edu.ro`

In 2002 we started .campion, an online training program for performance in informatics, supported by teachers with remarkable results and brilliant students, former winners of international informatics olympiads.

The program is supported by SIVECO Romania, a leading software company, in cooperation with the Romanian Ministry of Education and Research.

Nowadays .campion is part of Siveco Virtual Excellence Center, together with Siveco Cup, the National Contest for Educational Software.

The main goal of .campion training program is to offer all students an equal chance to participate in a high level training in computer science. The specific objectives of our training are:

- to develop algorithmic thinking,
- to develop programming skills,
- to develop competitive spirit.

Students are divided into 3 training groups, according to their level/age:

- group S (Small) – beginners in computer science, the first year in programming; age should not exceed 16 years (9th grade or primary school students);
- group M (Medium) – intermediate level, one or two years experience in programming; age should not exceed 17 years (10th grade);
- group L (Large) – advanced in programming (11th and 12th grade).

The training program consists of rounds: alternating training rounds and contest rounds.

For each round, students receive 2 problems, to be solved in 10 days for a training round, and in 3 hours for a contest round.

Solutions are graded using an automatic online grading system. After grading, on the website are published:

- for each student: personal grading sheets;
- for each group: rankings for the current round and also total rankings, including all the rounds;
- for each problem: solutions, solution descriptions, grading tests.

All past problems are organized in an archive (task description, test, solutions).

Each year, the best 50–60 students, participate in an on-site final round, consisting of a single contest day. The main goal of the final round is to offer students the opportunity to know each other, to compete in a real, not virtual environment, to be awarded and acknowledged.

This is .campion from a student's point of view. Between 1000 and 1500 students register every year. About 500 consistently participate. The feedback we collect every year indicates that 30%-75% of the training for the best students (participating to the Final Round) is provided by .campion. All Romanian IOI (International Olympiad in Informatics), CEOI (Central-European Olympiad in Informatics), BOI (Balkan Olympiad in Informatics), and JBOI (Junior Balkan Olympiad in Informatics) medalists are .campion finalists.

In 2005 and 2006 we began international cooperation, between Balkan countries, providing an English version of .campion. The cooperation was excellent with Bulgaria and Moldova, but from a general point of view, international .campion was not considered a success, and we lost support for this initiative.

What does .campion represent from a teacher's point of view?

First of all, of course, it represents a resource for self-conducted students' training or for the teacher-conducted training. But, for us, the National Committee, .campion represents a practical way to train teachers. As we previously emphasized, teachers are the critical resource.

We select teachers from all over the country (according to the results of their students) and propose they cooperation in a .campion training program. Most of them agree and send problems according to some technical specifications. Afterwards, we analyze the problem, the solutions, the grading tests, and the checkers. We suggest improvements, we correct errors, and we constantly communicate by e-mail with the teacher proposing the problem. Definitely, a successful cooperation in .campion leads to a successful cooperation with the committee preparing the national olympiads in informatics and the national informatics team training.

2.3. *infoarena*

`http://infoarena.ro`

Together we learn better! This statement, written on the Infoarena website, describes in a simple, yet precise way, Infoarena.

Infoarena is a training website made by students for students. On this website, students organize programming contests, publish educational materials, and exchange ideas. A problem archive is available on the website, including Infoarena contests problems, but also problems from different stages of the National Olympiad in Informatics. Online grading is available for Infoarena contests, and also for the archive problems. The Infoarena team has implemented a rating system, reflecting the performances of Infoarena users. Ten to twenty students are supporting the Infoarena website, but a lot of volunteers are helping them, adding to the Infoarena archive problems used in various national and regional contests. Infoarena is a dynamic program, continuously improving. A remarkable educational community, Infoarena yearly attracts students eager to learn and also willing to help others to learn.

3. Romanian Olympiads in Informatics: 30 Years of Experience

This section presents a general view of the Romanian Olympiads in Informatics. Comparing the beginning and the current state of the olympiads might give us a real perception of the changes that happened over 30 years.

3.1. *The First Olympiad in Informatics*

In 1978 the first Olympiad in Informatics was organized. A few facts from the first olympiad are that there were about 60 participants who had to write both a handwritten and computer contest. Their choice of languages for the computer portion was Fortran, Cobol and ASSIRIS.

The general procedure of the contest was: students wrote programs on a special sheet of paper called a “programming form”;

- the programming form was given to the operators, who punched the cards;
- the program written on the punched cards was run on the computer (IBM 360 compatible) twice; after the first run the errors made by the operators were corrected;
- the listing obtained after the second run was handed to the National Committee; the National Committee unfolded the listing (usually in a long hall) and corrected it “by hand”.

Sample task

Consider a sequence of `n` ($1 \leqslant$ `n` $\leqslant 100$) positive integers less than or equal to `50`. For each distinct integer in the sequence determine the number of appearances in the sequence. Draw an horizontal histogram to represent the number of appearances of each distinct integer, using a corresponding number of `*s`.

3.2. *Informatics Olympiads after 30 Years*

Nowadays the National Olympiad in Informatics has three stages and two divisions. The first division is for gymnasium students (5th to 8th grade), while the second division is for high-school students (9th to 12th grade).

For each division 3 stages are organized: a local, regional and national stage.

The local stage is organized in each town, using contest problems proposed by local teachers. The best students qualify for the regional stage. Actually, the selection is not very tough, the local stage being a good practice competition. A regional stage is organized in each county, using contest problems created by the National Committee. According to the results of this contest, each county selects a team to participate in the National Olympiad. The number of members in the team is between 3 and 11, and is established according to the results obtained at the National Olympiad in the past years by the teams of the county.

The National Olympiad in Informatics gathers about 300 high-school students and about 160 gymnasium students. The contest is held over two consecutive days and consists of 3 problems for each contest day. After a day break, half of the students may participate in another 2 contests, having the purpose to select the national informatics teams (10 students in the Junior Team, 24 students for the Senior Team).

Sample task for selection of Junior National Informatics Team

Consider two groups, each of them containing `n` digits ($1 \leqslant n \leqslant 9$). In any group, digits may appear more than once. Using all the digits of the first group we build a positive integer (`n1`). Similarly, using all the digits of the second group, we build another positive integer (`n2`).

Determine `n1` and `n2` so that the difference `n1-n2` is greater than or equal to `0` and minimal. In case there is more than one solution, choose the solution with minimal `n1`.

Sample task for selection of National Informatics Team

Zaharel draws `N` points on a plane ($N \leqslant 100000$). Being a peculiar person, he also chooses `M` points on the X-axis ($M \leqslant 200000$). All the coordinates of the points are less than 10^9. Then, he asks himself for each of the `M` points which of the `N` points is closest (situated at minimum distance). The distance between two points (x_1, y_1) and (x_2, y_2) is considered $(x_1 - x_2)^2 + (y_1 - y_2)^2$.

Determine for each of the `M` points the closest of the `N` points.

3.3. *Training Camps*

Two training camps are organized for the national teams. Training consists of theoretical courses and also problem solving sessions. During the training camps students have selections contests (3 for each camp), in order to select the teams for IOI, BOI, CEOI and JBOI.

4. Task Definition and Development

The task definition and development process is a crucial part in the organization of any contest, whether regional, national or international, because the contest results (and winners) are established based on the sum of scores obtained for each task in the contest task set. Since the purpose of a contest is to rank the competitors accurately according to their abilities, several aspects are considered when developing tasks for a particular contest (like the difficulty level of the tasks, the age group of the competitors, the contest duration and others). These aspects are considered from two perspectives, during two stages of the task definition and development process. During the first stage, each member of the contest committee develops one or more tasks individually and then he/she submits them to the other members, as candidate tasks for the contest task set. During the second stage, several tasks are chosen from the set of candidate tasks and these tasks will form the contest task set. We will describe the structure of the contest committee, the contest and task types and the syllabus for each contest type. Afterwards, we will discuss aspects of both stages of the task definition and development process. Finally, we will present some grading related aspects.

4.1. *The Contest Committee*

The members of the contest committee belong to one of the following categories:

- remarkable high-school professors, teaching informatics both in classes and within Centers of Excellence;
- university professors and teaching assistants, working in the domain of mathematics and computer science;
- former medalists of international olympiads in informatics and former members of the Romanian national informatics team, who are currently bachelor, master or PhD students.

The responsibility of each member of the contest committee is to create at least one contest task (candidate task) and to participate in the process of selecting the candidate tasks which will form the contest task set.

4.2. *Syllabus, Contest Types and Age Groups*

In Romania there are local, regional and national olympiads, for seven age groups:

- gymnasium pupils – four age groups (5th, 6th, 7th and 8th grade);
- high-school pupils – three age groups (9th grade, 10th grade, 11th–12th grades).

The pupils belonging to the seven age groups vary significantly in terms of their algorithmic and programming skills and knowledge. For this reason, in order for the contest results to be meaningful, the difficulty levels of the tasks must be suitable for the type of contest (local, regional, or national) and the age group of the competitors. For each age group, there is a loosely defined syllabus. The syllabus for the 11th–12th grades is the most inclusive and includes of the following general topics: greedy algorithms, divide and conquer techniques, dynamic programming, graph algorithms, data structures, combinatorics, computational geometry, string algorithms and game theory. For the other age groups, some of these topics are excluded from the syllabus. For instance, graph algorithms are not included in the 10th grade syllabus and dynamic programming algorithms are not included in the 9th grade syllabus. Furthermore, each topic contains basic and advanced techniques. The advanced techniques can be considered only for the larger age groups (11th–12th grades). Officially, the syllabus is defined loosely, i.e. the topics and their contents are broadly defined. Unofficially, however, the syllabus is quite detailed; these details are filled by the experience, knowledge and common sense of the contest committee members. We should mention that the detailed syllabus for the informatics olympiads is far more advanced than the topics the pupils are taught at school. Thus, a lot of emphasis is put on the individual supplementary training of each competitor (alone and under the guidance of a teacher) and on the participation in the alternative training programs (.campion, Infoarena and others).

The local and regional olympiads are qualifying contests for the national olympiad in informatics, which is the most important informatics contest in Romania. This fact is acknowledged, among other things, by granting to the prize winners free admission to universities with a computer science department. Winning a prize in the national olympiad in informatics is challenging, as there are only three prizes awarded per age group (or 5, in case the total number of competitors is large enough). Based on the results at the national olympiad and another selection contest, a small number of competitors are chosen to be part of the national informatics team. The pupils who are part of the national informatics team take part in several subsequent selection contests, from which participants at the international informatics competitions are selected. The seniors are selected for participating in IOI, CEOI, BOI and Tuymaada International Olympiad. The juniors are selected for participating in the Junior Balkan Olympiad in Informatics (JBOI). It is worth mentioning that the JBOI and the junior informatics team are quite new (the JBOI started in 2007 and the junior informatics team was established in 2008) and that they represent an important means for stimulating the interest of secondary school pupils in informatics. The syllabus for the seniors is a superset of the one for the 11th–12th grades' national olympiad, including more advanced concepts for each topic. In general, it is well aligned with the one proposed in [1], but also contains several more advanced techniques such as hashing, max flow algorithms, bipartite matching, interval trees, and AVL trees. The curricula for the junior level is only loosely defined and is now under active development.

The Informatics contests are characterized by several parameters. Two of them have already been mentioned: the geographic scope (local, regional, or national) and the age group. The number of rounds, duration per round and number of tasks in a contest round are some other important factors. The local and regional contests consist of only one round with two tasks and their duration is usually 3 hours. The national olympiad consists of two rounds, held in two consecutive days. Each round lasts for about 4-5 hours and consists of three tasks. The contests selecting the junior and senior national informatics teams have the same format as the national olympiad (two rounds, 3 tasks and 4-5 hours per round). The pupils participating in the IOI, CEOI and BOI are selected based on 6 other contest rounds, having the same format. Overall, an IOI candidate has to solve 30 tasks, starting with the national olympiad and finishing with the last selection contest. Every task is awarded the same number of points (100).

Other types of contests are online contests, with variable duration, different number of tasks per round and different grading styles (IOI style or ACM ICPC style), like those hosted by .campion [2] and infoarena [3].

4.3. *Task Types*

Just like in the IOI, the contest tasks are of three types: batch, reactive and output-only. The batch tasks are the most common and they are the ones the competitors are most accustomed to. Batch tasks are also the easiest to prepare and test. Reactive tasks require special support from the evaluation system. In Romania, an evaluation system capable of supporting batch, reactive and output-only tasks is used. Output-only tasks are generally not appreciated by the competitors and they have rarely made the pupils' skills and knowledge stand out. For this reason, only one or two of them are used in the IOI selection contests. All the tasks are algorithmic in nature and must be implemented in a programming language, like C/C++ or Pascal.

4.4. *Creating a Contest Task*

During the first stage of the task development process, the authors compose and prepare their tasks. The first thing to be considered is the syllabus, which depends on the contest type (local, regional, national, or international) and age group (school grade). Based on the syllabus and the task author's experience and preferences, a task idea is developed. The most important part of the task at this point are: **the algorithm** required for solving it (the reference solution), an estimation of **the difficulty level** of the task and an estimation of the **duration** a competitor who is above average would require for finding and implementing the algorithm. The difficulty level is expressed as the percentage of the total number of competitors who should have the necessary knowledge for developing the required algorithmic techniques and who should be able to find them and implement them in a programming language in a reasonable time (typically ranging from a quarter to half of the contest duration).

After the task idea and solution are defined, alternative solutions are searched for, both equally efficient and less efficient than the reference solution. Occasionally, the reference solution may not be the most efficient one for the task, particularly in the case of contests for younger age groups or when the most efficient solution is either very difficult to find or too complicated to implement. After finding all (or most) of the alternative solutions, the author decides the number of points each solution should be awarded, based on its efficiency in terms of time and memory. The next steps consist of developing a clear problem statement, implementing all the solutions and creating several test cases. Each test case is assigned a number of points (the sum of the points of all the test cases should be 100). The most common situation is represented by 10 or 20 equally weighted test cases. At this point, time and memory limits are set, based on the behavior of the reference solution. The test cases and their associated points are chosen in such a way that each solution receives the desired number of points. The author may also choose to award partial scores for some of the test cases. The duration estimation can also be updated, based on the unforeseen problems he/she encountered while implementing the reference solution.

At any moment during this stage, the author may collaborate with other members of the contest committee. The collaboration usually consists of writing alternative solutions, improving the task statement and, rarely, developing test cases.

This stage of creating tasks may start several months, although usually less than a month, before the contest date and finish several days (one or more) before the contest. The stage usually consists of several iterations, in which the problem statement, algorithm implementations and the test cases are gradually developed and improved. Small parts of the problem statement are changed particularly often, in order to help the competitors understand the task requirements clearly, as well as to avoid potential typing mistakes.

4.5. *Selecting the Contest Task Set*

We consider that the set of contest tasks must have all of the following properties:

- it must contain tasks of different levels of difficulty (from easy to difficult);
- the range of algorithmic topics covered by the tasks must be broad (i.e. multiple tasks should not be solvable by similar techniques);
- all the tasks should be solvable within the allotted contest time, by above average competitors – this does not mean that we expect this situation to actually occur, because there are many other factors involved;
- the tasks should make a good distinction between highly skilled, average skilled and poorly skilled competitors.

A few days (or, rarely, even weeks) before the contest date, after the tasks have been developed (at least partially) and submitted as candidate tasks, the process of selecting the contest tasks begins. The tasks are classified based on their level of difficulty, the types of required algorithmic techniques (greedy, dynamic programming and others) and the estimated time for solving them. A balanced set of radically different tasks is selected, which has all the properties mentioned before. The tasks are chosen democratically, based on the votes of the contest committee members. Each member votes the tasks he/she thinks should be part of the contest task set. The period between the classification of tasks and the casting of votes is reserved for discussions among the contest committee members. By expressing their opinions before the vote, all perspective on the tasks can be shared. It often happens that issues which were otherwise disregarded come up during this discussion phase. The discussion phase usually helps the opinions of the committee members to converge to a large degree. This way, after the votes are cast, it is often the case that more than half of the chosen tasks are voted in favour by more than 75% of the members. Another issue which is taken into consideration is the number of rounds of the contest. In this situation, votes are cast for selecting problems for each round. However, the task set is final only for the next round to come with changes being allowed for the future contest rounds.

4.6. *Grading the Tasks*

The tasks are graded automatically using an evaluation system which supports batch, reactive and output-only tasks. For the batch tasks, a grading program and the test cases are all that is required. The grading program checks the solution and outputs the score for each test case to standard output, using a well defined format, in order to properly interact with the rest of the evaluation system. When the solution is unique, and no partial score is awarded for a test case, a default grading program may be used. Setting up reactive tasks requires a number of test cases and two programs: the grading program and a program which interacts with the contestant's solution. Once the grading process is started, it can be stopped and resumed at any time. The evaluation system generates individual score sheets for each contestant.

5. Results

Romania participates in the International Olympiad in Informatics, Balkan Olympiad in Informatics, Central-European Olympiad in Informatics (the last two competitions being initiated by Romania), Tuymaada International Olympiad and in Junior Balkan Olympiad in Informatics (a new competition, initiated in 2007 by Serbia).

Romania has been participating at the IOI since 1990, winning a total of 67 medals (19 Gold, 32 Silver and 16 Bronze [4]).

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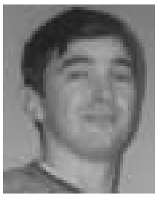

M.-I. Andreica is a teaching assistant at the Polytechnic University of Bucharest (PUB), in Romania. He is currently pursuing his PhD degree in computer science, on the topic of communication in distributed systems. His research has been recognized as valuable by being awarded a prestigious IBM PhD fellowship. Mugurel has been a member of the Scientific Committee of the National Olympiad in Informatics since 2002 and has also contributed each year to the selection process of the Romanian IOI team. Furthermore, since 2005, he has been the coach of the student teams competing for PUB in the ACM ICPC regional contests. Other training activities include his participation in the .campion national project as a contest task author and his active involvement in the organization of preparation contests on several training web sites. As former IOI and ACM ICPC World Finals medalist, Mugurel has a significant amount of experience regarding programming contests and he makes use of this experience within his teaching and training activities, as well as in order to compose meaningful and interesting contest tasks. It is also worth mentioning that his experience as a former participant in informatics contests and olympiads has also had a great beneficial impact upon his research activity.