COMPUTER SCIENCE PERFORMANCE - RESOURCES, PARADIGMS, IMPACT

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Summary. The article identifies the ways in which the Olympiads and competitions influence the quality of computer science education. Two terms are defined: *Olympic* and *performance*. The differences and analogies between "competition" and "class" problems, "competition" evaluation versus "class" evaluation are indicated. Also, the auxiliary tools of the training program for the programming competitions are analyzed, such as: online performance training platforms (.camp, infoarena etc.). Two paradigms of performance training are analyzed: the segregated model, the integrated model. The article also deals with software creativity contests in which students present a complex application, developed over time. Such contests do not exclude algorithms, because any program involves the implementation of an algorithm.

Key words: Olympic students, performance, evaluation, competition, solving competition problems, paradigms of performance training.

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Rezumat. În articol sunt identificate modurile prin care olimpiadele şi concursurile influenţează calitatea învăţământului la informatică. Se definesc doi termeni: *olimpic* şi *performanţă*. Sunt indicate diferenţele şi analogiile dintre problemele ”de concurs” şi probleme ”de clasă”, evaluare ”de concurs” versus evaluare ”de clasă”. De asemenea, sunt analizate instrumentele auxiliare ale programului de pregătire pentru concursurile de programare cum ar fi: platformele online de pregătire de performanţă (.campion, infoarena etc.). Se analizează două paradigme ale pregătirii de performanţă: modelul segregat, modelul integrat. Sunt tratate în articol şi concursurile de creativitate software în care elevii prezintă o aplicaţie complexă, dezvoltată în timp. Astfel de concursuri nu exclud algoritmica, deoarece orice program presupune implementarea unui algoritm.

Cuvinte cheie: studenţi olimpici, performanţă, evaluare, competiţie, rezolvarea problemelor de competitivitate, paradigme ale învăţământului de performanţă.

Introduction

Many times I have heard, in various contexts, the following statement: ”*The results of the students at the Olympic educational competitions are irrelevant, they are not a measure of the quality of an educational system. Only 0% of the students are Olympic*”. In what follows I will try to identify ways in which the Olympic competitions and ordinary competitions influence the quality of Computer Science education.

First of all, I will define two terms, which will appear during this process: *Olympic* and *performance:*

- Olympic is a pupil who participates in the Olympic competitions and school competitions, according to his choice, preparing to standards corresponding to the competition. In other words, I do not define the *Olympic* by the results obtained in competitions, but by his educational career and his attitude. He chooses to be competitive (not the teachers / parents), he is motivated to study a certain field to performance standards.

- Through Computer Science performance I understand the ability of a pupil to build algorithmic solutions to new problems and to implement them efficiently using appropriate technologies. Again, it should be noted that I do not measure performance by the number of diplomas obtained in competitions, but by creativity, innovation and (here's what differentiates Computer Science from other fields!) the ability to transpose the solution into a functional and efficient programme.

"Competition" issues versus "Class" issues

The first aspect that I want to highlight is that the Olympic and school competitions are the prerequisites for the formation of high performance computer scientists. Not just because it offers the competitive framework (to be an Olympian you must participate!), but because it offers relevant educational resources for a performance training. The problems created by the scientific commissions of the competitions represent the best tool for the formation of Olympians. These differ from the problems currently used in the classroom for introducing new concepts. First of all, the formulation is different, a competition problem will always be formulated in a context (real or imaginary). The pupil must analyze the context of the problem, identify the relevant elements and develop the algorithmic model for the given problem. Extremely important skills for a computer scientist! In the course of a career, a computer scientist will never meet a client who will say: "I have a vector with n elements, sort it!". The client will come with a story, he has cows, each cow has its own personality, which he will describe in detail, etc. From a complex story, the computer scientist must extract the relevant data for the client's application and then algorithmically model the reality. Solving competition problems forms such skills.

Problems formulated in the following way are frequently used in the classroom:

1. Give a vector with n elements, order it in ascending order.

2. Give a vector with n elements, order it descending.

3. Give a vector with n elements, sort the first k elements in ascending order and the last n-k elements in descending order.

4. etc.

It can be seen that the problem is "out of context" and the work tasks are repetitive. Competition problems, besides the context, have another feature: they are not repetitive. Each problem is a new problem (of course, on different levels of difficulty and complexity). A pupil working on competition problems will not apply mechanically,

repetitively an assimilated algorithm, but will create new, innovative algorithmic solutions.

Furthermore, competition issues contain restrictions on the volume of data and restrictions on available memory and runtime. Again, it is very important for a computer scientist, because the pupil must analyze the complexity of the algorithms he builds, both in terms of runtime and memory space and decide which algorithm is more efficient.

By solving problems such as those commonly formulated in the classroom, the pupil demonstrates that he has acquired a certain algorithm and can apply it. Specifically, we can achieve objectives from the first 3 levels of Bloom's taxonomy (knowledge, understanding, application). Solving competition problems, the pupil will form competences that correspond to all the 6 taxonomic levels [1].

"Competition" evaluation versus "Class" evaluation

evaluation
synthesis
analysis
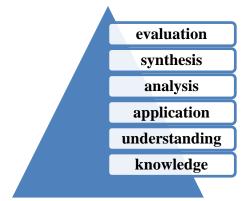application
understanding
knowledge

Figure 1. Bloom's taxonomy

The assessment that we will call "class assessment" is consistent with that of the pupils facing the baccalaureate exam. The competences to which this type of assessment aims rarely exceed the first 3 taxonomic levels. The pupil evaluates expressions, applies an algorithm step by step on a specified data set, identifies data sets on which the algorithm provides a specified result, implements a given algorithm, completes or writes small code sequences that target elementary data processing / data structures. data or write a function / programme for such processing. The evaluation scale is formulated so that each constituent of the code is scored. Even if the pupil's programme does not solve even the given problem, only by disparate elements of the programme, scored according to the scale, the pupil can obtain 6-7 points out of 10.

I did not intend here to make an analysis of this way of evaluation, but only to put it in the mirror with the evaluation at the Computer Science competitions. In competitions, the pupil not only builds an algorithm, but also implements it in a programming language. The pupil's programme is run on a variable number of test data sets, and the results provided by the programme are verified with an automatic evaluation system, more precisely by a programme written by the author of the problem for this purpose.

Thus, the first condition of the pupil's programme to receive points is that the programme should be functional, the number of points received being proportional to the efficiency of the programme. The evaluation in this case mainly concerns competences from the top of Bloom's taxonomy. The pupil builds different algorithmic solutions, analyzes them from the point of view of complexity, chooses the optimal solution, and then implements this solution. In order that the programme may work, the algorithmic

solution must be logically correct, produce correct results on at least some types of test data, and be properly implemented. Let's remember an old, but completely true, saying: "a programme that almost works is like a plane that is almost flying." This is the starting point in the competitive evaluation and in this way we practically build a working style: the pupil knows that he does not receive points for "code breaks", that a program must be completed in its entirety, that it must be checked on tests with a varied and graded structure, that it must be optimized in accordance with the restrictions of the problem. This style of programming, which is learned step by step, problem by problem, will become a philosophy of life

Regardless of the system, the evaluation is the mechanism by which we regulate the good functioning of the system. The performance standards that we use for the evaluation will be crucial for the quality of education, because both pupils and teachers build their educational approach in relation to these standards.

Online performance training platforms

Over time, various platforms have been developed for preparing pupils' performance in Computer Science, which mainly contain problems with automatic evaluation of pupils solutions, but also other resources, such as specialized articles, educational software, etc. Such platforms exist in all the countries with a tradition in Computer Science, but I will mention the 3 most important ones existing in Romania:

1. The .**campion** educational archive (campion.edu.ro/arhiva) - initiated by Prof. Emanuela Cerchez and Prof. Marinel Şerban, was launched as an auxiliary tool of the .campion performance training programme (2002-2012); the archive contains over 1500 problems with online evaluation, articles and educational software;

2. **Infoarena (**infoarena.ro) - project started by a group of enthusiastic students (Cristian Strat, Silviu Gănceanu, Mircea Paşoi and Leonard Crestez), who promote excellence in programming by organizing high level competitions and writing educational articles;

3. **Pbinfo** (pbinfo.ro) - a platform created by Prof. Silviu Candale, which contains numerous problems with online assessment, structured on the topics of the school syllabus, with difficulty level adapted to the class hours, but also competition problems.

The resources created by the scientific commissions of the school competitions and the olympic competitions represent a significant part of the educational content of these platforms.

Paradigms of performance training

I think we can conclude that educational resources exist. How do we use them? I will put in antithesis two paradigms of performance training.

1. The s*egregated* model: we identify the pupils capable of performance and carry out their training separately from the rest of the class.

Advantages: the way of preparation being customized for a very small number of pupils, good results can be obtained in short time in competitions.

Disadvantages: The pupils involved are isolated from the rest of the students in the class, a fact which generates a disadvantage both at the class level (the level of preparation of the class is not positively influenced, sometimes even on the contrary) and for the selected pupils (even if the level of their preparation grows at a more alert rate, this is done to the detriment of the development of their social, communication and collaboration skills).

2. The *integrated* model: the teacher does not select the pupils capable of performance, but works with the whole class pursuing educational objectives of high taxonomic level.

For this purpose, the use of competition problems and of the automatic evaluation of problem solutions is strictly necessary. Each problem solved, each problem proposed to be solved must be selected so as to bring a cognitive benefit to the pupils, to challenge them in discovering a solution. The automatic assessment will provide the pupil with an immediate feedback on his solution. He will be able to use this feed-back and will resume solving the problem whenever necessary, until he reaches the maximum score. The initial dramas generated by multiple evaluations of 0 points will turn into frenetic joy when, after identifying the errors and correcting them, the pupil will get 100 points. And every 100 points earned will still be a motivation to continue, to progress.

The pupils capable of performance are not selected by the teacher, but will naturally self-select. The evolution of each student will be natural, according to their own potential, the pupils will not be subjected to doping. Most of the pupils in the class will choose to participate in the olympic competition (because it will consider the competition stimulating and motivating). Of course, from one competition stage to another, the number of participants will be reduced, so that at the national stage the number of participants will naturally be small. But behind each national olympic pupil, there are, in a pyramid, numerous pupils with whom he "ran" together. And, surprisingly, even if they participated in the same competitions, with more or less success, no antagonistic feelings appear, in the classroom there is created emulation, collaboration, constructive communication between people with common passions

Advantages: In the long run, most pupils in the class will progress, achieving, at different levels, high-level educational goals. In this context, the results of the pupilss at the competitions are a relevant indicator of the quality of the education in the school.

Disadvantages: If at the beginning the teacher can work with all the pupils of the class, during their evolution it will be different and the teacher will have to individualize the learning process, using tasks from the area of the next development of each pupil / group of pupils. This becomes all the more difficult as the number of pupils in the class is higher. Even so, the progress is slower because the teacher has to make sure that all the pupils achieve the teaching goals (of course, at different levels of performance).

Software creativity contests

Although until now I have referred strictly to algorithmic competitions, I do not

want to exclude the contests in which the pupils present a complex application developed over a long period of time. In these competitions, the emphasis is placed mainly on the technologies used, on the software engineering, on the functionality of the product related to its stated purpose and not least the utility and originality of the application. Obviously, the algorithm is not excluded, any programme involves the implementation of an algorithm. These applications are usually developed in a team and develop communication and management skills of teamwork (adapting to different roles and responsibilities, productive collaboration with others, empathetic behavior, respecting other points of view) that few algorithmic competitions target. The pupils study new technologies, suitable for the implementation of the application, thus becoming independent in the learning process, able to adapt to the new things (very important ability in such a dynamic field). Starting from the purpose of the application, the pupils have to identify the problems that they have to solve, to find solutions, to plan the project stages, to constantly evaluate the project execution stage The complexity of the application requires the development of the project management, time management skills, self-assessment, as well as skills for public presentation of the final product.

Identifying, formulating and solving problems; responsibility and ability to adapt; communication skills; creativity and intellectual curiosity; critical thinking and systemic thinking; collaboration and interpersonal skills; demonstrating teamwork and leadership skills; self-training; social responsibility: all the essential competences for a person who will live in the 21st century are formed during the development of such an application. The participation in such competitions is therefore essential for becoming successful in the field of Computer Science [2].

Conclusion

This article reflects the didactic experience accumulated in 30 years of activity in the school, 18 years of activity at the Iaşi Center of Excellence and 23 years of participation in scientific commissions in competitions and school olympic competitions. In all these years, we have used the olympic and the school competitions as a tool for achieving the performance in Computer Science. Each year, other olympic pupils demonstrate that the method works, through their results in school, but especially in after-school life. As Aristotle said, excellence is a custom.

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