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Israel: The Regional Competition and Teacher Involvement

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Abstract. During the last year, the Israeli ministry of education increased its support to the Israeli IOI project. The primary goals of the increased support were to expose the project to a wider audience of high school students and to expand the team selection and training process. The team selection process involves several stages. The two early stages are: students' early preparation and a regional competition. We present here several questions of the regional competition, which require only numeric answers without algorithms or explanations. We then display the results of a survey, conducted among our high-school teachers, of their attitudes and involvement in the project's early stages. The results shed light on the teachers' views of the project's regional competition, task characteristics, school selection, student preparation, and more.

Key words: regional competition, teachers attitudes.

1. Introduction

The International Olympiad in Informatics (IOI) is the primary computer science (CS) competition for young (secondary school) students. In Israel, until 2010, the IOI project was composed of four stages: a self-study stage towards the national competition, a national competition, an advanced training and team-selection stage, and the national team's preparation for the IOI. A detailed description appears in the Israeli IOI website (`www.tau.ac.il/~cstasks`; Hebrew) and in our previous paper (Zur *et al.*, 2010). For the past two years, an increased support by the ministry of education (`http://www.csit.org.il/`; Hebrew) enabled us to expand the project's four stages, and add a fifth stage. This stage consists of a regional competition, which precedes the national competition. This stage is aimed for a large audience, including students with very limited programming experience. The better students of this stage are invited to the national competition. In our previous, 2011 paper (Zur *et al.*, 2011), we described our initial experience with the new regional competition and its successive national competition, and provided some statistics regarding the students' backgrounds, motivation,

achievements and points of view. In this paper, we further elaborate on the regional competition and our teachers' attitudes and involvement. In Section 2 we elaborate on our recent regional competition, and in Section 3 we display the outcome of a questionnaire posed to our high-school teachers.

2. The Regional Competition Tasks

In the past year, the regional competition was held in November. It took place simultaneously in 140 high schools. Participation in the exam was voluntary, and approximately 1800 students, with orientation towards CS and math, participated in the exam. The exam was harder than that of the previous year. Only a few students obtained a grade higher than 90.

As one primary goal was to expose the project to an audience as wide as possible, we posed algorithmic tasks for which the required answers were not an algorithm, but rather the outcome of an algorithmic computation. This is in line with the approach presented by Burton (2010) and Kubica and Radoszewski (2010). This approach offers the opportunity of reaching students who are less acquainted, or even unacquainted with programming. The exam tasks focused on mathematical and algorithmic characteristics, on which one had to capitalize her computation.

The regional exam included five tasks. Task 1 required parallel computations of shortest paths on a grid with obstacles. Task 2 involved arithmetic operations and backward reasoning. Task 3 involved the processing of a list, element by element, with some bookkeeping. This task is based on the task "Mean Sequence" of the 17th Olympiad in Informatics (`http://olympiads.win.tue.nl/ioi/ioi2005/`) held in Poland in 2005. Task 4 required recursion and dynamic programming; and Task 5 was based on computing a greatest common divisor.

We display below two of the five tasks. The first one – Task 2 – was the easiest for the students and the second task – Task 3 – was the hardest.

Task 2 of the regional exam

Given the two operators $+1$ and $\times 2$, which you may use repeatedly; compute the *minimal* number of operator invocations required to reach each of the two integers 417 and 794 from the integer 10.

For example, for reaching 21 from 10, two invocations suffice: $\times 2$ and then $+1$. For reaching 24, three invocations are required: $+1$, $+1$ and then $\times 2$.

Hint: The units-digit of the multiplication of the two answers (to 417 and 794) appears in one of the answers.

The objective of this task was to examine whether students turn to backward reasoning (as the suitable computation is that of starting from any of the given integers and computing backwards towards the integer 10). The hint was provided in order to assist

students in verifying their calculation results. We found in our previous study (of 2011) that the vast majority of the students do not err in their calculations, when the solution scheme is clear to them. The hint helps decreasing the likelihood of calculation error even further.

Out of the 1767 students, 1331 (75%) provided the correct answer for the integer 417, and 1090 (62%) provided the correct answer for the integer 794. A total of 1041 (59%) provided the correct answer for both integers. We may notice a difference between the two calculations (for 417 and 794). The calculation required for 794 is longer. We believe that the clearer one's view of the solution the lower the likelihood of error, particularly as the required computation "gets" longer.

Task 3 of the regional exam

The following increasing sequence, S, of 10 elements is as follows:

50 96 146 194 250 320 350 374 396 420

We would like to calculate the *number* of non-decreasing sequences of 11 positive integers such that each of the sequences keeps the following characterstic: the average of the 1^{st} and the 2^{nd} elements is the 1^{st} element of S, the average of the 2^{nd} and the 3^{rd} element is the 2^{nd} element of S, ... the average of the 10^{th} and the 11^{th} elements is the 10^{th} element of S.

For example, if S was composed of four elements: 4 7 10 12 the answer would have been 3, as each of the following sequences keeps the required characteristic:

4 4 10 10 14
2 6 8 12 12
3 5 9 11 13

1. What is the number of non-decreasing sequences for the given sequence S?
2. Can the number 350 in S be changed such that the answer to (1) will increase? If so, what number should it be changed-to in order to get a maximal answer for (1)?
3. Can the number 320 in S be changed such that the answer to (1) will increase? If so, what number should it be changed-to in order to obtain a maximal answer for (1)?

The objective of this task was to examine whether students demonstrate both inductive progression and abstraction. The inductive progression should be carefully employed upon advancing "through" the given sequence S. Abstraction should be expressed by conducting repeated projections of a (shrinking) range of (consecutive) values, during the inductive progression. A student who gains sufficient insight into the task should answer properly not only part 1 of the task, but also parts 2 and 3.

Out of the 1767 students, 238 (13%) answered part 1 correctly; 38 (2%) answered part 2 correctly; 52 (3%) answered part 3 correctly; and 20 (1%) answered all three parts

correctly. As with the previous task, we believe that the better insight one gained into the task, the lower the likelihood was for her to err. The low achievements in this task assisted us in an initial "pin-pointing" of the top students.

3. Teachers' Attitudes and Involvement

The teachers' involvement in the regional competition was vital for the project's success. The regional exam was held in the schools, and the teachers participated in their schools' local arrangements. They identified the talented students, notified them about the exam, and (some) advised them on how to prepare. The exam questionnaire was posted in the internet at a time that was announced a-priori. The teachers downloaded the questionnaire and posed it to the students. The exam lasted two hours.

As the exam answers involved only several integers, the teachers were asked to copy their student solutions to a spreadsheet and submit it to us. We graded the exam (automatically, with a short computer program) and posted the list of the top 15%, whom we invited to the national competition. We also posted the exam solution.

Due to the vital role of the teachers in the regional exam, we were interested in examining their views. Thus, we conducted a preliminary study among the CS teachers whose students participated in the regional competition, in an attempt to learn about their backgrounds, attitudes, involvement and perceptions of the Olympiad project.

We posed a 14-question questionnaire. The questionnaire was sent by e-mail to 122 CS teachers, and was answered by 45 of them (37%). The following gives some information about the teachers who answered the questionnaire:

- 85% were experienced teachers who teach CS for more than 7 years.
- 85% of the teachers were heads of the CS program in their schools.
- 20% of the teachers have been involved in the project for more than 7 years. 49% of the teachers have been sending students to the Olympiad project for 2-6 years. The rest (31%) were new to the Olympiad project, this being their first year of participation.

We present below the questions from the questionnaire along with a summary of the teachers' answers.

The type of questions posed in the regional and national competitions are different from the type of questions which students encounter in their CS studies. Do you find this type of questions interesting?

- The vast majority of the teachers (86%) claimed that they find such questions very interesting. Some teachers said that the questions stimulate thinking and creativity.
- Some teachers said that they use these questions to motivate talented students, and others said that they borrow ideas from these questions and use them in the classroom.

Do you think that the Olympiad project encourages students to select CS in high school?

- Most of the teachers said that the Olympiad project primarily interests talented students, and therefore does not affect most of the students' decisions whether to choose CS studies in high school.
- Contrary to that, some teachers said that the Olympiad project encourages the CS students and adds interest to the subject.

Are you satisfied with the way the regional and the national competitions are organized?

- Most of the teachers (62%) were satisfied with the format of the competitions. Some teachers mentioned that the fact that the regional competition takes place in the schools makes it easier logistically for the teachers, and it is also better for the students because of the location familiarity. They also mentioned that the regional competition is a good preparation for the national competition. In addition, some teachers said that because the regional competition takes place in the schools, it reaches a wider audience.
- 22% of the teachers thought that the format can be improved. Some suggestions were: to allocate time for the preparation of the students towards the competitions; to let students take the regional exam individually at their convenience; to organize the competitions earlier in the year so as to allow more time for the IOI team preparation.
- 16% of the teachers had no comments regarding the format of the competitions.

Are you familiar with the Israeli Olympiad website?

Almost all of the teachers (91%) said that they are familiar with the website. They said that they referred students to the website, and that they presented the students with sample questions from previous competitions (found in the website). Some teachers said that they borrowed ideas for questions they posed in their regular CS classes.

Do you prepare the students to the regional competition?

- 40% of the teachers said that they did not prepare the students for the regional competition because they do not have enough time. Yet, they did encourage the students to enter the website. One teacher said that she would like to have answers to the sample questions in the website in order to help her prepare the students.
- 40% of the teachers said that they did prepare the students to the regional competition. They conducted special lessons dedicated to sample questions. Some teachers let the students work individually on these problems in class. Others handed out sample questions with their solutions.

Would you like to receive help with the preparation of the students towards the regional competition?

- Most of the teachers (74%) said that they do want help with the preparation of the students. The teachers offered many suggestions, the main ones include: to conduct teacher training workshops; to provide additional learning materials and guidance for the teachers; to conduct local or regional training sessions for the talented students; to provide a discussion group in the website; and to add additional classroom

hours dedicated to the Olympiad project. One teacher suggested locating young talented students (8th graders) in math by posting weekly questions in the website, thus exposing them to algorithmics.

- The rest of the teachers said that they do not need help with the preparation. Most of them doubted students' spare time. Some said that it is enough for the students to self-study from answers to the sample questions. One teacher claimed that our evaluation may be conducted without prior preparation.

Do you collaborate with the math teacher in your school in the process of selecting and preparing talented students to the regional competition?

- Most of the teachers (75%) said that they do not collaborate with math teachers in their school. Some of the teachers said that they were unaware of this possibility and they will collaborate with the math teachers next year. Others said that there is no need to collaborate because they are familiar with all the talented students in their school. A few teachers claimed that the math teachers are not interested in collaboration because their students are too busy with their studies, and they have their own Olympiad project.
- The rest of the teachers claimed that they do collaborate with the math teachers in the process of selecting and preparing talented students.

Does the principle of the school support the Olympiad project and does he encourage the students' participation?

Most of the teachers (78%) said that the principle of the school supported the Olympiad project and encouraged the students' participation. They said that the principles viewed the Olympiad project as a worthy project for developing talented students. The principles helped with the logistics and the organization.

Did talented non CS students participate in the regional competition?

Only 18% of the teachers said that non CS students participated in the regional competition. The non CS students heard about the competition from friends, from science and math teachers and through a letter they sent to the students. The rest of the teachers (82%) said that non CS students did not participate in the competition.

Were you surprised with the number of students from your school that passed the regional competition (and invited to the next stage)?

38% of the teachers reported that no student in their school passed the regional competition. 48% of the teachers reported that 1 or 2 students passed the regional competition. 14% of the teachers reported that 4 to 14 students passed the exam. Most of the teachers (65%) were not surprised with the results of their students. The teachers that were surprised said they expected that more of their students would pass the exam, as they are very talented.

Is this the first time that your students encountered the type of questions which appeared in the regional competition?

The vast majority of the teachers (85%) said that the students encountered this type of questions for the first time. The other teachers claimed that they used such questions in their classrooms, or their students were familiar with such questions from previous years.

Describe the students' reactions about the questions in the regional competition.

- All students felt that the questions were challenging. Some students enjoyed the challenge and others felt that the questions were too difficult.
- Some of the positive remarks included: the questions were not standard questions; they were math and not CS oriented; the students enjoyed and expressed interest in the questions because they were stimulating and did not require coding; the questions were difficult, challenging and interesting; after the exam the students continued discussing the questions and their answers.
- Other, more frustrated remarks were: the questions were exhausting, hard to understand and there was not enough time to solve them; the questions were very difficult, they required non standard thinking; only a small number of students showed interest in the questions; the questions had many possible solutions, it was hard to find an algorithm; we did not have the required math background; some students continued despite the difficulty and others gave up; even the bright students were frustrated.

After the regional competition, did you solve the questions with your students?

Most of the teachers (86%) did not solve the questions with their students. The main reasons mentioned were: lack of time, lack of interest on behalf of the students, and difficulties in gathering the students together.

How did you cope with the students' questions during the regional competition?

Most of the teachers said that they did not answer questions because they did not feel involved with the professional aspects of the competition.

4. Conclusion

Our main conclusions from the study described in the previous section are:

- Most of the teachers claimed that they find the questions very interesting. In addition, they borrow ideas from the questions to their classrooms.
- Almost all of the teachers said that they are familiar with the website and that they refer students to the website.
- Preparation for the regional competition should not take place during school hours because teachers claim that they are very busy preparing the students for the CS matriculation exams and therefore do not have spare time to dedicate to the Olympiad project.
- The Olympiad project team should be involved in the preparation towards the regional (and the national) competitions because the teachers claim that they do not have the professional qualifications required in order to prepare the students for the competitions. The teachers suggested to conduct workshops both for teachers and students and to increase the utilization of the website with training materials and weekly questions and discussions.
- We should find ways to reach younger talented students prior to the time in which they start studying CS in secondary school. This will let us teach these students

for a longer period of time, and better prepare them for the Olympiad project. In addition, this would encourage students to choose CS studies in high school.
- We should encourage the CS teachers to collaborate with the math teachers, in order to locate talented math students for the CS Olympiad project.
- Most students felt that the questions were difficult, and some of them gave up. Perhaps we may include some easier (short?) questions in the regional exam in order to motivate a broader audience.

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