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Kids Programming Marathon: A Step toward Better Engagement with Computer Science Education

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Abstract. Due to the importance of spreading computer science education among young people, we present in this paper our work in preparing and organizing a computer science competition for children from 8 to 15 years old, named Kids programming marathon, the marathon goes in three phases and targets all kids in the country, tasks of the marathon are divided into three different types, each type is intended to support different skills for children, we show our motivation and goals of the marathon, we present the process of the marathon in details and show the materials of the competition, how it was chosen and how it is used in the tasks, we show some statistics, and finally discuss the impact of the marathon on the society, and our view for the future of this competition.

Keywords: computer science education, competition, young people, programming marathon.

1. Introduction

As the World Development Report for 2019 (*World Development Report 2019: The Changing Nature of Work*, 2019) stated that: ”The nature of work is not only changing – it’s changing rapidly. We don’t know what jobs children in primary school today will compete for, because many of those jobs don’t exist yet. The great challenge is to equip them with the skills they’ll need no matter what future jobs look like – skills such as problem-solving and critical thinking, as well as interpersonal skills like empathy and collaboration, and the most effective way to acquire these skills is to start training at early ages.”

We live in a world that is rapidly evolving, with technology tightly intertwined in life, in school and at work. Learning computer science (CS) helps people better understand our technology-enabled world. It positions students for high-demand jobs and provides them with skills that are broadly applicable – illuminating new approaches to problem-solving, critical thinking and creativity.

Technology can be a powerful force for social and economic inclusion and for addressing the many challenges facing our communities. By empowering children at early ages, we're investing in building stronger and more resilient communities.

Due to the importance of early learning of analysis and logical thinking skills for children (*2018 State of Computer Science Education*, 2018) and the role of competitions in introducing computer science in more interactive way, couples of years ago we worked with the Syrian Virtual University, the organizational team of the SCPC – the Syrian Collegiate Programming contest and other scientific partners to launch the kids programming marathon (KPM), an annual programming competition for children and adolescents in many regions and cities in Syria.

The Kids Programming Marathon is considered as an updated version of a similar competition that was part of the Syrian Olympiad in Informatics (SOI) (ALNAHHAS & ALAZAB, 2015; Idlbi, 2009) which was held ten years ago, and was halted in 2012, when the national Olympiad was restricted to secondary school students, due to the war conditions in Syria.

Compared to other competitions related to computer science and programming which are held either locally or internationally (Scratch Olympiad, IOI, Bebras) our training materials cover many aspects like logical problems, visual programming, and textual programming, in a more useful mix in introducing Computer Science concepts at early ages. Visual programming serves as a brief introduction to programming aspects like loops, conditions and variables in more interactive way and without Syntax restrictions. On the other hand, textual programming serves a more professional way in programming that is compatible to problems in the IOI. Logic questions are needed to introduce computer science concepts in a very familiar way like problems in Bebras competition. Integrating these three aspects brings more learning benefits to contestants than just focusing on one aspect.

This paper demonstrates our main objectives and motivation in section 2, in addition to the materials in section 3, statistics we worked on are presented in section 4, and the scientific and administrative improvements we made to our previous work in SOI, section 5 discuss the future of the event and its impact, and we conclude the paper in section 6.

2. Background and Motivation

In recent years, computing has grown in our daily lives. It is no longer confined to commercial or industrial applications, but extends to all aspects of our activities in life, in school and at work. As computing becomes more important, children at schools became more interested in learning how to create new technologies other than just using word processing or spreadsheets.

Computer science education or "CSE" is a very large subject. It blends all the "STEM" subjects of science, technology, engineering and math, and also includes design. It's important for students to learn these skills because computer science is everywhere.

By increasing access to CS for all youth as early as possible, we help them prepare for the jobs of today and tomorrow. This education gives them the opportunity to become the world's next innovators.

To accomplish this fluency, we need to deal more seriously with the syllabus of computer science, and its important aspects of learning writing in addition to reading, in the language of the computer: learning programming and the accompanying learning of the basic logical and mathematical concepts contained within its practices.

Competitions are one of the most important ways to encourage young people to discover new fields. They have been widely used to introduce children to various fields of science, including computer science that has algorithmic nature, in which the emphasis is on testing problem solving skills and logical analysis through an entertaining and rich experience in which the contestant learns programming the computer to serve its interest. Therefore, we are working on organizing a programming marathon for children and adolescents, to raise the general scientific level and enhance the skills of analysis and creative thinking among all.

2.1. *Main Objectives*

- Support teaching of computer science at schools, raise the general scientific level and enhance the skills of analysis and creative thinking for all children.
- Support the community and provide useful content in the field of programming and informatics and the development of fluency in dealing with information technology.
- Encouraging outstanding students in the IT field.
- Support the youth ability to come up with solutions to problems that are facing their societies, which is considered as economically – disadvantaged after a long war.
- Programming training will serve as a learning model, demonstrating how computer science education with informal learning settings can support the development of technological fluency.
- enabling youth people to design and create projects that are meaningful to them and their communities(Hubwieser, Armoni, & Giannakos, 2015).
- Training and preparation at early ages which is significantly reflected on the performance of teams participating in the Informatics Scientific Olympiad later.

2.2. *Participation and Problems' Categories*

The Kids Programming Marathon includes two competitions:

- The junior competition (8–11 years).
- The senior competition (12–15 years).

The two competitions aim to test the optimal performance of solving several questions divided into three categories:

- A problem formulated as a game, required to be solved using the graphical programming language Scratch, which offers an enjoyable start and easy to identify the concepts of programming.
- Computational and Logical thinking Problems.
- C ++ scripting problems, taking into account the complexity for each age group.

2.3. *Structure and Stages*

The Kids Programming Marathon plan consists of three phases:

- **Phase 1:** The first qualification test based on logical tests for all applicants, logical questions will be in the form of multiple-choice for all categories. All kids in the country are eligible to participate in this phase, kids should solve 20 to 30 questions with equal marks for each using a special system on computer. Participants should apply in special contest centers prepared for the competition, one in each province or area, so students are assigned a nearest geographical center to his residence area. Registration is held online some weeks before the competition. The goal of this phase is to filter the participants to find who are suitable for the contents and the objectives of the marathon, so all kids with 40% and higher of full mark are qualified to the next phase. An optional training program is offered to the qualified students with the help of Syrian virtual university centers and other sponsoring organizations and institutes.
- **Phase 2:** The second qualification test, based on tasks that cover logical and programming tests for all candidates from the first phase. Contest are also conducted using a special computer system and is held in special centers where each participant is assigned to the nearest center. The competition consists of Five multiple-choice logic tasks -which are corrected automatically-, one or two scratch tasks and two textual programming simple tasks, both Scratch and textual programming problems are corrected manually by the scientific committee (details in materials section). Qualification of this phase is based on choosing fixed number of students with higher total marks. The winners constitute the participants of the marathon finals.
- **Phase 3:** The final competition for all the candidates from the second phase, the contest is held in a single center in the capital where all participants from all other cities should gather. The contest is held using the special computer system where logical tasks are corrected automatically and programming tasks are corrected manually as will be described in the materials section of this paper, tasks are distributed amongst three types of the marathon, with about ten logical tasks, two scratch tasks for first age division and one for the second division. First division tasks consist of simple output-only tasks whereas second division students should solve two tasks using C++ programming language. The top three students of each division are the winners of the competition.

3. Materials

The goal of the marathon is to stimulate creativity, logical thinking and problem-solving capabilities of children and adolescents, so the material should be chosen carefully to achieve these goals. we decided that the tasks should be in different types, each type should be related to a target that leads to one of the general goals, besides the mixture of tasks should be consistent and should contribute to the general aim of the marathon.

Three main types of tasks are used with different mark distribution for each division of participants as will be discussed later.

- The first type is **Logical Thinking Tasks** that aims at capturing the creativity and innovation skills of the participants.
- The second type is **Scratch Tasks**, where Scratch is a well-known programming tool for young people that helps interactively program games, stories and animations (Resnick, Kafai, & Maeda, 2005).

The aim of these tasks is to teach kids problem solving skills without the need of teaching them advanced syntax of textual programming languages.

- Third type of tasks is **Textual Programming Tasks** that target advanced problem-solving skills including solution analysis, synthesis and testing.

3.1. *Logical Thinking Tasks*

These tasks are used mainly in the early phase of the marathon, whereas a different form is used in the proceeding phases, the advantage of this type of tasks is that it does not need any prior training, it is very useful to test logical thinking and deduction abilities of children. In the first stage a very simple form of this tasks is used, this form is similar to the one used in IQ tests, but it should be tolerated to be easily understood by young people, the target of using such tasks is to measure the logical and mental capabilities of kids, the following is a sample question of this type:

> To prepare a pie we need 3 apples and two oranges, if we have 10 apples and 10 oranges, how many pies can we prepare?
> A: 1
> B: 3
> C: 6
> D: 10

Tasks of this form can be mathematical, logical or linguistic; which allows to measure different aspects of child skills.

In the second and third phases of the marathon a different form of logical tasks are used, which are Bebras-like tasks, in which a story with brief description is provided, and a multiple-choice question is to be answered, children should analyze the content and find the suitable answer, this kind of questions are more suitable for second division where children are older, but we find that they can be used for younger children as they

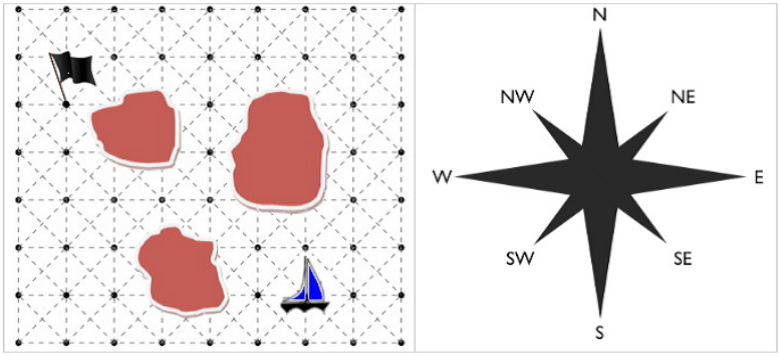

Fig. 1. Sample of used Bebras task in the marathon, the task is about finding a shortest path between the boat and the flag.

accepted and many of them managed to solve them in the last year. The aim of this form of tasks is to measure the analytic thinking of the kids along with the ability to comprehend and perceive the content to get the correct answer. Fig. 1 shows an image of a Bebras task that is used in the last year final stage of the marathon, a convenient story is provided to refer to the task of finding the best path.

In our first experiment which was a part of SOI in 2007, we used a different content for this type of tasks, they were about logical circuits, number theory and logic, but we find later that these subjects are no more suitable as they does not reflect skills but just knowledge, besides they are now more popular and are taught at school. Whereas the new model of IQ style and Bebras-like tasks are more convenient as it is shown by our new experiment.

Tasks of this type are in multiple-choice form and are always automatically corrected by special contest computer system designed for the marathon.

3.2. *Scratch Tasks*

Scratch is a well-known visual programming language for young people; it uses the principle of interactive programming to help users make games and animations. Tasks of this type is intended to be with algorithmic background in the marathon. So, we use this type of tasks to measure and teach problem solving skills to children. That means we are investing the programming part of Scratch rather than animation and movement parts.

To illustrate this idea, we show a sample task that has been used in the marathon before; Fig. 2 shows a sample image of Scratch task, in this task the child should program the movement of the characters as given in the task statement, he should process the interaction between the items and design the movement algorithms accordingly. We try to format the task in an approach where children should not rely on static knowledge of Scratch environment, instead the key point of the task needs to be designed according to the problem-solving abilities, that can be defined by using the appropriate item in the

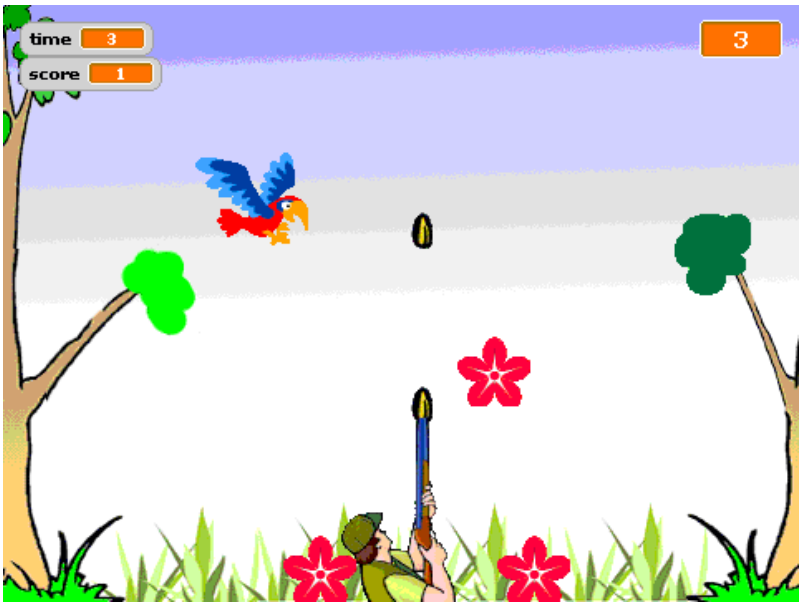

Fig. 2. Sample of Scratch task, a game where the child should develop a suitable logic for it.

correct context, rather than just memorizing and understanding the use of each tool, this way the creativity of the children is measured correctly, besides; we design the task to have a trick that needs mathematical or algorithmic solution. Experiments held from 2007 to 2011 showed that this type of tasks was very attractive for children and helped distinguishing creative ones despite the poor Scratch tools at that time. As Scratch now contains the concepts of lists and function it is now more suitable to design more creative tasks that are better to distinguish kids with high problem-solving abilities, results of the last two years competitions revealed that this type of tasks are more favorable among younger children, older children in the second division tends to prefer textual programming tasks as will be discussed later.

Scratch tasks are corrected manually by scientific committee members, the task is divided into subtasks, each subtask is assigned a portion of the total mark, where this portion is given if the subtask is totally achieved with no partial marks.

3.3. *Textual Programming Languages Related Tasks*

We believe that even if visual programming can measure creativity and problem-solving skills, there is still a necessity to include this type of tasks even for the younger children of the first division. There are many forms of tasks in this type, depending on the phase and the division,

For first division it is very difficult for kids to compose a working program, yet they can understand the syntax and comprehend the different items of programming

language, therefore the best task form for them is to find the output of a given program, this task allows us to measure kids knowledge in the language syntax but it is tough to capture problem-solving skills by this method for children younger than 12 years old. This type of tasks that rely on finding the output is corrected manually; each part of the output is given a portion of the total mark of the task, and is given if the output is correct.

By the other hand, textual programming tasks including ones where a complex algorithm is needed proved to be very attractive and suites adolescents in the second division, they preferred it over visual programming tasks and tend to find it more challenging.

Tasks are prepared in a way that suites ages between 12 and 15, very sophisticated algorithms are avoided and some tasks is designed to measure programming skills rather than algorithmic experience of the competitors. Tasks are corrected manually, because part of the marks is allocated for code analysis, the task is first evaluated in a way similar to IOI style where output should be correct with specific time and memory limits, but if the task fails to generate correct output the code is examined manually and part of the mark is given if code reflects correct algorithm.

The most distinctive part of the marathon is the mixture of the above three different types of tasks, the tasks complement each other and integrates together to fulfill the target of the marathon by encouraging all different skills of kids as well as discovering creative and distinguished ones, the mark ratio of each type is chosen according to the age division and with accordance to the goals, for the first division, Scratch tasks cover 65% of the competition mark, 20% for logical tasks and 15% for textual programming, leaving a wide range for visual programming and keeping the advantage of including logic and textual programming. For the second division 35% of competition mark is for Scratch, 20% for logic and 45% for textual programming, these ratios are chosen as we notice that adolescents in this age prefer textual programming to visual ones.

4. Statistics

The old competition held from 2007 to 2011 proved to be very impressive, about 70% of the Syrian medalists in IOI from 2012 to 2018 were winners of that competition.

As the mark distribution among task types is elaborated in the last section, along with the correction and mark assignment scheme, Table 1 shows the average results of the first division for the last year, there was 5 logical tasks with marks distributed equally, two scratch tasks with equal marks and four textual programming tasks in a type discussed in the material section.

Table 1
Average marks for first division

Logical tasks	Scratch	Textual Programming	Total average
50.65%	33.8%	36.84%	37.63%

Total number of participants in the last phase was 75, we can notice that the logical tasks get high average whereas other types are around the total average, which reflects the need for this type of tasks in this age division. Textual programming tasks are pointless as the type of tasks for this division is not creative as mention earlier in the material section.

Table 2 shows the average results of the second division, there were four logical tasks, one scratch task and two textual programming tasks, with marks distribution mentioned in the previous section.

It is clear that logic tasks have a very high average, this is due to the fact that all students in the last phase of the competition are high skilled, It is normal that programming average is low, it is still difficult for children to compose a full working program with textual programming languages, actually, the average is very promising as the evaluation of the tasks is similar to the IOI style with multiple test cases with small part of the mark allocated for code analysis as mentioned earlier.

An important point to notice is the gender distribution of the participant, Fig. 3 shows this distribution. There are many points to consider in this statistic, firstly the number of females is relatively high compared to average female participants in computer science competitions, this is due to the involvement level of family members for young aged children. The most important point to notice is that the ratio of female participants decreases in the second division, and taking into account that the number of female participants in the national Olympiad for secondary school students is very low, this indicates that the key factor of increasing females involvement in computer science competitions is to encourage them to participate as they are younger starting from the age of 8 and provide more motivation and encouragement for them to go on. To achieve this, we grant special awards to female participants in the marathon to motivate them to stay in the track and to attract more females to participate in the future.

Table 2
Average marks for second division

Logical tasks	Scratch	Textual Programming	Total average
80.17%	41.63%	21.55%	41.31%

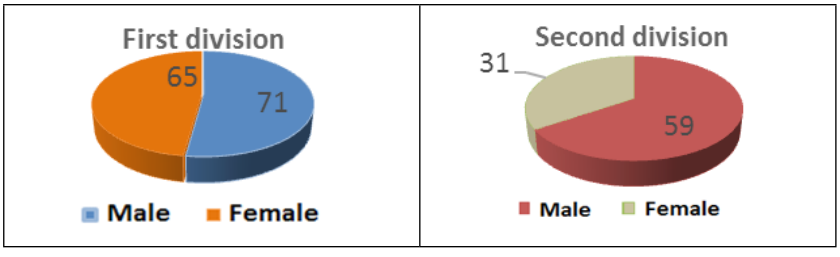

Fig. 3. Gender distribution of participants in KPM finals 2018.

5. Discussion

After two years of conducting the updated version of the marathon, it showed very important effects, the society accepted the event and adopted it very quickly, many parents were enthusiastic to send their children to this competition, as there is much more interest in computer science education in the general opinion. It is reflected this year by a very large number of participants in this year version of the marathon which is still in the first phase as this paper is prepared (about 300% increase from the last year). So, we think that the marathon is approaching its goals. We are planning to improve it and skip any problems, so we can get a pioneer experiment that can be cloned in other developing counties. We are planning to target most children in the country by cooperating with specialized organizations such as Distinction and Creativity Agency which is responsible for organizing the national informatics Olympiad, we also prepare to integrate this competition with Bebras as we are preparing to join the community shortly, the undergoing proposal is to find a plan to enroll the winners of Bebras in the marathon, to narrow and focus the efforts to train students that are really interested and have suitable talents.

The material is revised as well, we are considering using Python as a programming language instead of C++, as it seems to be more convenient for young people, and proved efficiency in many other competitions such as (ANDERLE, 2018).

We are very pleased for the wide community acceptance of the event, many institutions are willing to support the organization and scientific affairs of the marathon including Syrian virtual university, ministry of education, Distinction and creativity agency and Syrian computer society.

We think KPM starts affecting the society to push toward CSE: Many educational institutes started to organize courses to support computer science, parents are convinced to send their children to CS courses. Besides, the marathon revealed the lack of CSE in school syllabus, so that many organizations such as DCA and SCS are considering support of this type of education more seriously.

The event is promising and constitute an important factor in both improving the computer science education awareness, and support other computer science competitions that targets older people such as Informatics Olympiad and ICPC.

6. Conclusion

In this paper we presented the Kids Programming Marathon, an annual computer science competition for children aged between 8 and 15 years. We showed the motivation and goals of it, where the marathon aims at preparing new generation for the future as many jobs will be linked to computer science, the detailed information of the KPM is presented, the different phases the participants go into. We elaborated the materials used in this competition which is a combination of various types of tasks, where logical tasks enhance problem solving skills by improving the ability to connect facts logically to achieve the right solution, while solving the programming problems enhance the skills of dividing

the required task into several simpler ones and the innovation in creating appropriate solutions that meet the required target, which reflect directly on the final implementation of the program either visually with Scratch or textual with C++. We discussed some aspects of the event and showed our viewpoint for the future of it, the marathon had a positive impact on the society in the last two years, we mentioned that many organizations where inspired by the idea, many institutes started to prepare CS courses for young people and many others are considering preparing programs to fill the gap of CS in school syllabus, the kids programming marathon is a promising competition that should be supported in order to promote computer science education and for better future of our children.

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