

# Sharing Computer Science Education Ideas: Israeli-Russian Collaboration

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This article describes a unique Israeli-Russian project, in which Israeli high school computer science (CS) teachers promote curricular reform in the Russian region of Penza, based on the Israeli high school CS curriculum. The reform involves local schools, universities, the hi-tech industry and local government officials. It includes changes in courses, textbooks and other teaching materials. The Israeli teachers provided workshops to assist the Russian teachers in the assimilation of the reform. This collaboration may encourage other countries to collaborate and not necessarily re-invent the wheel; for some countries it can serve as a catalyst to assist in bringing computer science education into schools.

## 1 INTRODUCTION

Over a million people have immigrated to Israel from the Former Soviet Union (FSU) since 1989. Among them were doctors, engineers, scientists and other intellectuals who have since contributed to science and culture in Israel. Between 9,000 and 10,000 of the immigrants became teachers in the Israeli educational system, most in mathematics, in sciences including computer science, and in English. One of these teachers, when visiting the Russian region of Penza, in the autumn of 2010, was surprised to find that no significant changes had occurred in the Russian CS curriculum since he left twenty-four years earlier. Following his visit, he and one of his colleagues in Israel decided to lead a cur-

ricular reform based on the Israeli CS curriculum with which they were familiar. This reform led to a unique collaboration between the two communities. Such a collaboration, however, can be taken a step further, as other countries who seek the way of integrating computer science into schools don't have to re-invent the wheel and can benefit from the existing curriculum and supporting material. Translation is necessary in most cases, and, though challenging, it is feasible.

In the following sections, we describe in brief the Israeli and the Russian educational systems (1.1), the Israeli CS curricula (1.2), the unique project that the two Israeli teachers are leading (2), and we conclude with some reflections (3).

### 1.1 The Educational Systems in a Nutshell

#### 1.1.1 The Israeli Education System

The Israeli education system is basically centralized. The Ministry of Education sets educational policy on all levels, and then implements it with the assistance of specialized committees, work teams and professional inspectors.

Students go through nine years of mandatory education, usually divided into elementary school (grades 1-6) and mid-level school (grades 7-9). Three additional years (grades 10-12) are optional. These three years culminate in an extensive set of matriculation exams (called *Bagrut* in Hebrew). The exams are based on a core of required subjects, and several electives. Among the required subjects are Hebrew (language and literature), English, and mathematics. The sciences are electives, as is computer science. Subjects are taught in "study units," each of which represents approximately 90 hours of study. Many of the subjects can be studied on various levels; the most common are the 3-unit and 5-unit programs.

### 1.1.2 The Russian Education System

In Russia, the study program is also a general one for all students and, like in Israel, culminates in final exams. There are core subjects and several electives. Informatics, as computer science is called in Russia, is an elective, as are all the sciences. Mathematics is one of the core subjects. Currently, the method of study in Russia is undergoing reform, from the old standard to a new one. Following the old standard, informatics was studied in grades 1-3 as an elective and in grades 7-11 as a mandatory subject. According to the new standard, informatics will be mandatory in grades 8-11 in two modes: basic and advanced. This evolution will take a few years until final implementation.

CS as a career and pursue the discipline in higher education. The program is divided into five modules, for some of which there is more than one alternative.<sup>1</sup>

#### Fundamentals 1 and 2 (double-length; 180 hours):

These two units introduce the central concepts of algorithmics and implement them in a programming language.

#### Second Paradigm or Applications (90 hours):

This module has several alternatives. It introduces the student to a second programming paradigm, which is conceptually quite different from the approach adopted in the *Fundamentals* modules, such

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The current informatics curriculum was designed in the early 1990s, when schools were not very well equipped with computers. This situation has changed and now a new curriculum is in place and the teachers are motivated to implement it.

### 1.2 The Israeli CS Curriculum

In the early 1990s, an Israeli committee chosen by the Israeli Ministry of Education developed a high school computer science (CS) curriculum which has been implemented since the mid-1990s. The main principles that guided the designers of the curriculum were the following:

- CS is a full-fledged scientific subject and should be on a par with physics, biology, and chemistry
- The “Zipper Principle”: conceptual and experimental issues should be interwoven throughout the program
- A well-equipped computer laboratory is mandatory
- To be certified to teach CS, teachers must have adequate formal CS education - at least an undergraduate degree in CS and a teaching certificate

The program emphasizes the basics of algorithmics and although it includes programming, it does so only as a means to having a computer carry out an algorithm. The background and motivation for the program, its general structure and its initial implementation are discussed in [1]. A detailed description of the curriculum itself is given in [2].

Here we very briefly describe the program. The curriculum has two tracks: one of 3-units and one of 5-units. The first is taken by students who have little interest in the discipline, while the second is usually taken by students who may seek to choose

as logic programming, functional programming and system-level programming. Other alternatives concentrate on a general application area, and teach both its principles and its practice. These may be computer graphics, information systems and Internet state-less programming.

#### Software Design (90 hours):

This module concentrates on data structures, introducing abstract data types.

#### Theory (90 hours):

This module is intended to expose the student to selected topics in theoretical CS and has a few alternatives, among them computational models.

Two tracks can be constructed from these modules: a 3-unit, 270-hour track, and a full 5-unit, 450-hour track. The material is all written in Hebrew, and has been updated from time to time, starting with implementation in a procedural language, Pascal, later switching to C, and finally to Java or C#.

One of the main concerns of the Israeli program designers was computer science teacher education. Many studies and discussions related to this issue have been published, for example [3,4,5,6]. It is important to maintain a high level of quality of CS teachers and to form a group of leading teachers. In Israel, in order to be accredited as a CS teacher by the Ministry of Education, the requirement is at least a Bachelor degree in CS and a teaching certificate. In some cases, a crash program was designed to enable in-service teachers

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<sup>1</sup> The various alternatives to the applications and the theory modules are currently under examination and possible changes under discussion.

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to gain the approval of the Ministry. This effort was led by the National Center for CS teachers in Israel (“Machshava”).

In addition to updating the high school CS curriculum, a middle school CS curriculum was designed and is now being implemented as a pilot in two hundred schools. This program begins in the seventh grade with a 60-hour course called Introduction to Computer Science based on Scratch.

## 2 THE JOINT PROJECT

### 2.1 The Project - First Steps

Zeev Fraiman (the first author of this paper) is an Israeli high school CS teacher. Before his immigration to Israel 24 years ago, he taught informatics in the Penza regional high school for gifted students. In the autumn of 2010, while visiting his family in Penza, Zeev paid a visit to his old school where he met the local informatics teacher. He also met one of his former students who had become an assistant to the regional Minister of Education (Mrs. Kopeshkina). These meetings led to a web-based Fundamentals course, which Zeev, from Israel, taught to 9th and 10th grade students in the Penza school.



The Penza delegation visit to Israel, December 2010

The Governor of Penza (Mr. V. Botchkarev) understood the unique potential of this project and suggested expanding the experiment through the provision of workshops for teachers that would help them lead curricular reform based on the Israeli curriculum. In December 2010, the Governor sent an official delegation to Israel to learn more about the Israeli education system and the CS curriculum in particular. Among the members of the delegation were regional officials, representatives of academia, a school principal, and the local teacher who had worked on the experimental project with Zeev. Thanks to the successful visit, the project gradually began to expand.

Four months after the delegation’s visit, Zeev and Evgeny (another Israeli high school CS teacher who emigrated from Russia to Israel twenty-one years ago) conducted a five-day workshop for fifty Russian experienced informatics teachers, many from rural



Evgeny and Zeev with Mr. Botchkarev, the governor of Penza’s region

schools in the Penza region. Most of these teachers had an academic background in areas other than CS or informatics; only 10% of the participants had a formal academic degree in CS. The workshop was based on the Israeli *Fundamentals* units and included a final examination, similar to the Israeli *Bagrut* exam, at the end. Thanks to the success of the first workshop, it was agreed to expand the project through additional workshops, and to prepare teaching materials in Russian.

The Israeli teachers designed a 100-hour course (4 hours/week), also based on the Israeli *Fundamentals* units, with small changes (the Israeli course is based on 180 hours) called *Reduced Fundamentals*. The material developed included a text book in Russian (similar to the Israeli *Fundamentals* textbook), an assignment booklet, also in Russian, including six hundred assignments, twenty Israeli *Bagrut* exams, and PowerPoint presentations. In addition, a website in Russian was opened for teachers and students participating in the project.

Seven rural schools began to teach the *Reduced Fundamentals* course (using regional free hours). In parallel, the students studied the regular Russian informatics curriculum and will take the Russian informatics test in the 11th grade. In September 2011, the project expanded to thirty schools. All taught the *Reduced Fundamentals* course using materials that were developed for the project.

### 2.2 Expansion of the Project

The success so far encouraged expanding the collaboration. In this section, we outline the expansion in details, step by step, for the readers who are interested in the development of this project to get an idea of the efforts and time line needed. At the end of the section we summarize the outline in Table 1.

In December 2011, the Israeli teachers conducted a second workshop. The participants were divided into two groups: graduates of the first workshop and new teachers. Both groups learned the *Reduced Fundamentals* course as well as pedagogical topics such as the difficulties with which students have to cope and how to address them, and the typical misconceptions. Several representatives of the Penza Pedagogical University also participated in the workshop.

Between December 2011 and the autumn of 2012, four more workshops were conducted by the Israeli teachers, and, as will be elaborated below, a three-level program came into shape.

In the spring of 2012, the Israeli teachers conducted a third workshop for sixty teachers that included advanced “*Fundamentals*” topics and additional pedagogical issues, such as preparation of lesson plans and a final exam. At the same time, a fourth workshop was organized for thirty university professors and twenty students of mathematics and informatics at the Belinsky Pedagogy Institute (now part of PSU). This workshop was devoted to the Scratch programming environment and its advantages as a tool for creating methodological materials in many areas. Thanks to the success of this workshop, the PSU decided to include the environment in their regular CS program (see also the three-level program in section 2.3 below).

In the spring of 2012, the Pedagogical University of Penza merged with Penza State University (PSU) and is now the Belinsky Pedagogy Institute within PSU. The Institute plans to use the first stage of the three-level program and to add a mandatory programming course for their first year students since most have no programming background. Today their first programming course (Java and C#) is taught in the third year of their studies

As part of this initiative, the Israeli teachers taught *Reduced Fundamentals* to 10th grade students in three local schools. They also taught *Scratch* based on the Israeli curriculum for 8th and 9th grade students. Their lessons were open to the public and many teachers from other schools as well as local officials observed them. At this stage, the local Education Ministry decided to adopt the text book and the assignment booklet and they were approved for teaching in the entire Penza region.

In the summer of 2012, Zeev conducted a two-day workshop for over thirty new teachers who decided to join the project. The workshop was partially devoted to the approved materials and partially to *Building Android Applications*, as training for teachers who had decided to teach this course as an experiment. In the autumn of 2012, the sixth workshop was conducted for teachers from forty new schools that decided to join the project.

In March 2013, the Israeli teachers conducted two seminars and three additional workshops:

- a one-day seminar at the Technological University of Penza (PTU) for the university teachers and students, focusing on comparisons between the Israeli and Russian curricula;
- a two-day seminar at Penza State University (PSU) for thirty students and their tutors, focusing on programming projects preparation and *Scratch* applications;
- a one-day workshop at the United College for twenty-six college teachers, focusing on the Scratch environment and the Israeli curriculum;
- a two-day workshop for fifteen teachers, focusing on the *Building Android Applications* course; and
- a three-day pedagogical workshop for forty teachers, focusing on the *Reduced Fundamentals* course and some advanced topics.

### 2.3 The three-level program

After a discussion by the Israeli teachers and all the Penza parties, a decision was made to design a three-level program for grades 7-10 (shown also on Table 2):

- In the 7th and 8th grades, students will take the *CS basics with Scratch* course with emphasis on algorithmics. This course is based on the new Israeli curriculum for the 7th grade and is



Zeev and Evgeny with rural school teachers after a lecture on the Israeli education system

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TABLE 1 – THE JOINT PROJECT’S DEVELOPMENT

<b>Autumn 2010</b>	Zeev visited Penza and subsequently taught a web-based <i>Fundamentals</i> course.
<b>December 2010</b>	An official Penza delegation came to Israel.
<b>April 2011 1st workshop</b>	Based on the Israeli <i>Fundamentals</i> units, a 5-day workshop was offered to 50 Penza experienced informatics teachers.
<b>Spring 2011 – December 2011</b>	The <i>Reduced Fundamentals</i> course was developed including new Russian materials. The project (teaching the <i>Reduced Fundamentals</i> course) expanded to 30 schools.
<b>December 2011 2nd workshop</b>	A 2nd workshop was offered that included the <i>Reduced Fundamentals</i> course and pedagogical topics. It was offered to graduates of the first workshop, new teachers, and representatives of PSU (Penza State University).  The three-level program came into shape.
<b>Spring 2012 3rd workshop</b>	The 3rd workshop on advanced <i>Fundamentals</i> topics and pedagogical issues was offered to 60 teachers.
<b>Spring 2012 4th workshop</b>	The 4th workshop on the <i>Scratch</i> programming environment was offered to 30 professors and 20 students from PSU.
<b>Spring 2012 Open lessons</b>	Open lessons in 3 local schools were offered: the <i>Reduced Fundamentals</i> course (10th grade), <i>CS basics with Scratch</i> (8-9 grades).
<b>Summer 2012 5th workshop</b>	The 5th workshop (2-days) with new materials and the Building Android Applications course was offered to 30 new teachers.
<b>Autumn 2012 6th workshop</b>	The 6th workshop (2-days) covering the <i>Reduced Fundamentals</i> course and <i>Building Android Applications</i> course was offered to representatives from 40 new schools.
<b>March 2013 Two seminars &amp; three workshops</b>	One-day seminar at PTU (comparisons between the Israeli and Russian curricula); 2-day seminar at PSU (programming projects and <i>Scratch</i> ); 1-day workshop at the United College ( <i>Scratch</i> and the Israeli curriculum); a 2-day workshop for 15 teachers ( <i>Building Android Applications</i> ); and a 3-day pedagogical workshop for 40 teachers ( <i>Reduced Fundamentals</i> ).

grounded in three years of experience of the Israeli teachers who taught the course in Israeli schools.

- In the 9th grade, students will take the *Reduced Fundamentals* course in Java. This course is based on the Israeli curriculum (the *Fundamentals* units) but unlike the Israeli program, it takes a procedural approach rather than an object-oriented one.
- In the 10th grade, students will take the *Building Android Applications* course. This course is based on the *Planning and Programming Mobile Phone Systems* unit of the Israeli curriculum (one of the alternatives of the extended curriculum in Software Engineering) and will have a practical/applied flavor. The initiative for this course came from the local Penza hi-tech industry and the Governor, and the intention is to prepare students for the local work force.

TABLE 2 – THE THREE-LEVEL PROGRAM

Grades	Topic	Connection to the Israeli curriculum
7-8	<i>CS basics with Scratch</i> With emphasis on algorithmics	Based on the new Israeli curriculum for the 7th grade
9	<i>Reduced Fundamentals</i> (Java)	Based on the Israeli curriculum (the “ <i>Fundamentals</i> ” units)
10	<i>Building Android Applications</i> with a practical/applied flavor	Based on the <i>Planning and Programming Mobile Phone Systems</i> unit of the Israeli curriculum

2.4 The Current Stage of the Collaboration and Future Plans

The following represent activities related to the collaboration.

- To date, sixty schools have joined the project and taught the *Reduced Fundamentals* course to 9th and 10th grade students. At least two thirds are rural schools; the rest are in larger cities in the Penza region. Next year, two hundred schools are expected to participate in the project.
- Last year, one hundred fifty students who completed the *Reduced Fundamentals* course took a final exam that was written by the Israeli teachers, based on the Israeli *Bagrut* examination. The exams were graded by the local teachers who reported good results, with difficulties mainly in reading comprehension. Students in ten other schools are continuing with the *Reduced Fundamentals* course, and will complete their first cycle by the end of this year.
- Some of the schools began the first stage of the three-level program (*CS basics with Scratch*) as an enrichment program. The Penza region intends to add this as a compulsory course next year for the 9th and 10th grades, in the hope that this will encourage students to focus on scientific subjects (including CS) in high school.
- Students in the Penza regional school for gifted students completed the *Reduced Fundamentals* course and are now taking the *Building Android Applications* course in the format of weekly web-based lessons given by the first author. Several other schools have already begun the third stage of the three-level program as an extra-curricular enrichment topic. All the local teachers receive support and guidance from the Israeli teachers via the Internet.
- Most of the Penza teachers who took the workshops (nine workshops with over three hundred teachers so far) are teach-

ing along the lines of the program. Those teachers who taught the *Reduced Fundamentals* course last year are continuing with a second cycle of students. The project and the three-level program will be presented to the Russian Ministry of Education as a model for other regions.

- In the spring of 2012, the Pedagogical University of Penza merged with Penza State University (PSU) and is now the Belinsky Pedagogy Institute within PSU. The Institute plans to use the first stage of the three-level program and to add a mandatory programming course for their first year students since most have no programming background. At this time, the students take their first programming course (Java and C#) in the third year of their studies.
- The Penza United College plans to start teaching according to the three-level program next year.
- The regional education office of Penza has started to work on a regional curricula, based on the three-level program: *CS basics with Scratch* (grade 8), *Reduced Fundamentals* (grade 9), object-oriented programming principles (grade 10), and *Building Android Applications* (grade 11). They also adopted the Israeli model for in-service teachers' courses led by local leading teachers.



Zeev with 6th grade students from a rural school that decided to study Java on their own

### 3 AFTER THOUGHTS

Teachers are the cornerstone of every pedagogical change or educational reform. The success of the assimilation of changes in the school system strongly relies on the teachers who promote it. The project we have described is a vivid example. We see teachers, Israeli and Russian alike, in a joint effort to promote a reform in the CS curriculum of the Penza region in Russia. The project also shows that the well-established Israeli curriculum can be adopted in other countries, thus avoiding the need to start with a blank slate. The project has been encouraged by the Israeli Ministry of Education, by

Russian decision makers, schools and universities, and by teachers who wanted to take part in this interesting initiative. More than twenty media items (on TV, in daily newspapers and in the teachers' professional journal) have been devoted to the project in Russia.

The project serves as a study case for collaborative work with other countries, not only in CS but also in mathematics and the sciences (physics, biology and chemistry). In these fields, a well-established Israeli curriculum exists as well as a body of expert experienced teachers (some of whom are also immigrants from the former Soviet Union). This model of collaboration may also serve for other countries (European and the US), where well established study programs exist for the sciences, and can be shared with third world countries which seek to promote the study of sciences. In the area of computer science, the situation world-wide is a bit different. In many countries a well-established CS curriculum does not yet exist, policy makers are not yet convinced that CS is a subject that high school students should be exposed to, and CS teacher training programs are not yet integrated in higher education institutions. For these countries the project can serve as a catalyst to bring computer science education into the school system, perhaps by collaborating with each other or with other countries. **IR**

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