ALGORITHMICS FROM EARLY YEARS

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ABSTRACT
We teach algorithmics at early stages of children development by means of various programming languages and ICT tools in order to develop their cognitive and mathematical skills. Computational thinking is not only a useful for computer scientists, but also a fundamental skill for other people. We should teach children computational skills along with reading, writing, and arithmetic.
In this article we present our three-year experience of teaching courses, during which we combine face-to-face workshops in a computer laboratory with an online teaching platform. We provide classes for various groups – ranging from courses for primary school students to courses for teachers, which we expand by elements of methodology of teaching.

KEYWORDS
Computational thinking, programming in Logo, primary school, mathematic, distance learning,

INTRODUCTION

Education at school starts with introducing basic matters in a way which is adapted to children's abilities and interests. From early years they learn how to read, write and count. Nowadays children naturally acquire some ICT skills. By using a computer, they learn how to write and draw or find useful information on the Internet. In this article, we present our approach to computer classes for young children. We also describe our experience of working on e-learning platform in order to introduce primary school students in the world of algorithmics and programming. Moreover, we would like to share some experience in organising programming competitions.

THE FIRST YEARS AT PRIMARY SCHOOL

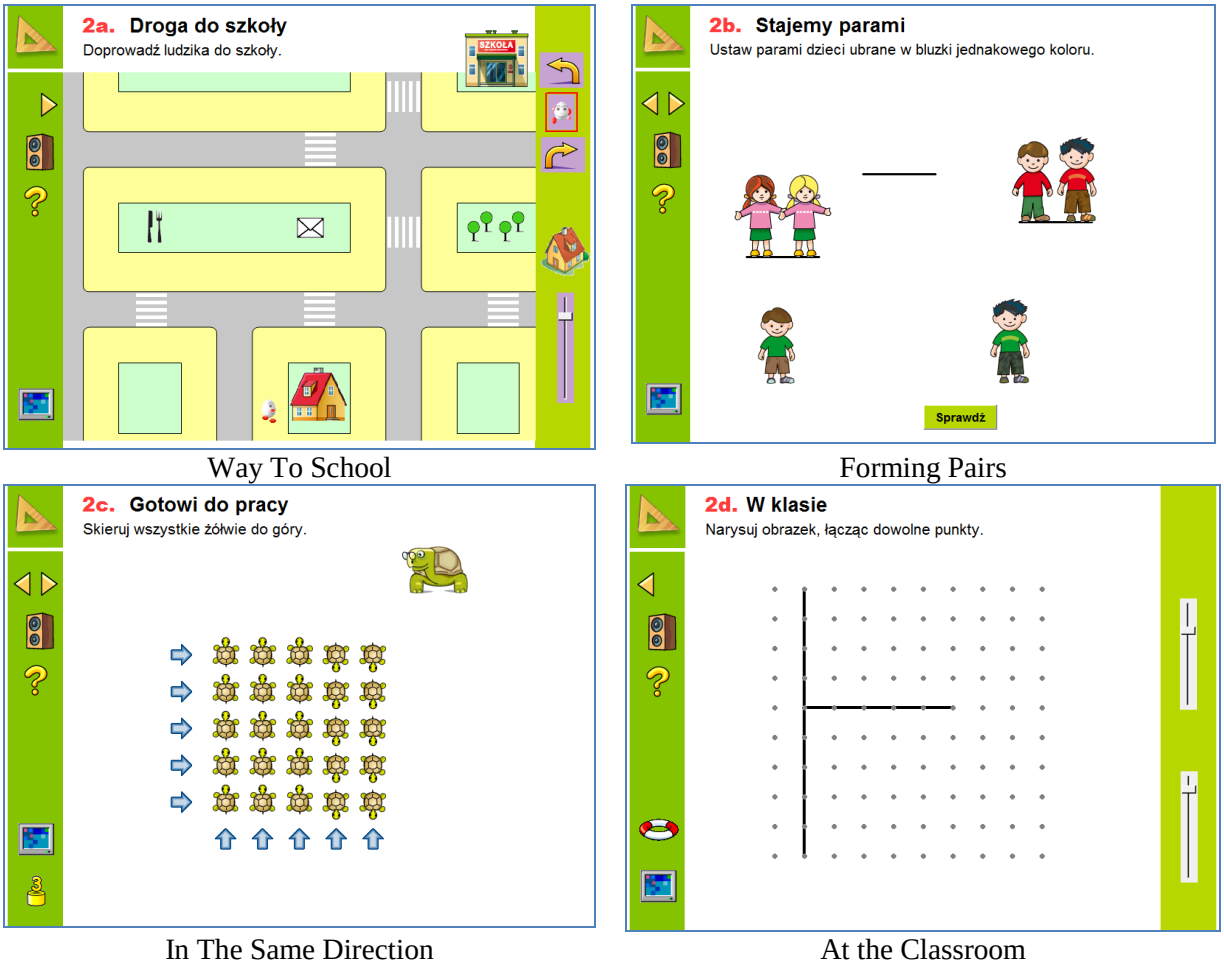
In Poland, children start school at the age of 6 or 7. For the first three years, they spend most of their time with only one teacher and the lessons are not divided into subjects. It is called integrated teaching. Thus, pupils naturally acquire literacy, maths, science and arts. In the syllabus there is a special part for computer classes. At this level of education, students create texts, pictures and animations, they try to use computer as a learning tool by playing and experimenting. "Educators must use computers as a natural part of the learning experience to gain the most of this powerful tool. This includes:

- Interacting computers within the classroom environment
- Using them as a part of the everyday curriculum
- Applying their use to real problems for real purpose" (Davids & Shade, 1994)

Teachers working with primary school students should put emphasis on developing their skills, abilities and hobbies. There is a question: how to use the power of computers, for example, its multimedia features, simulation or visualisation to improve learning process. Seymour Papert provides us with one of the answers to the question with the theory of microworlds. "A microworld is a genre of computational document aimed at embedding important ideas in a form that students can readily explore. The best microworlds have an easy-to-understand set of operations that students can use to

engage tasks of value to them, and in doing so, they come to understanding powerful underlying principles." Even a small child can explore such application.

Beneath there are same examples of such projects which are designed in a constructivist way with strong thematic relation to subject rings typical of early school teaching (Jochemczyk, W. and other, 2009). In the lesson "In our school", which is taught at the beginning of the school year, students get familiar with school environment and its surroundings. There are four exercises: Way to School, Forming Pairs, In the Same Direction, At the Classroom.



Way To School | Forming Pairs

In The Same Direction | At the Classroom

Figure 1. The lesson about school

Most of software available for young children is instructional in nature, based on the paradigm of *explain*, *practise*, *and test*. We try to present another approach, known as microworlds, which is based on very different principles, such as *invention*, *play*, *and discovery*.

In the unit on programming, pupils have a microworld, where they can control the movements of a turtle. They start with simple drawings. In this microworld, they can go forward, backward, turn right, left and change the colour and width of the pen. They have to click on a button and the turtle goes on. The next step is to drag and drop Logo instructions to make a list of commands. Pupils learn how to create their own procedures. At the end of the unit, children write commands in the command line. We find this kind of lesson very important because it is children's first step in programming. They can easily learn how to solve some difficult problems. According to Papert "Once programming is seen in the proper perspective, there is nothing very surprising about the fact that this should happen. Programming a computer means nothing more than communicating to it in a language that it and the human user can both "understand." And learning languages is one of the things children do best. Every

normal child learns to talk. Why then should a child not learn to "talk" to a computer? (Papert, 1980,. p.5-6)

Unfortunately, we have noticed that many teachers do not understand the art of programming. Probably, mainly because of the fact that they teach different subjects and teaching informatics it is not a field where they fell confident. What can be done to support teachers in their professional development is an open question. We also face the problem of misunderstanding to our approach by the publishing house while preparing our materials for curriculum. They prefer simple and technical exercises that have nothing to do with constructivist idea.

While working with older students, we can offer some more complicated tasks. There are some examples of tasks for ten-to-twelve-year olds.

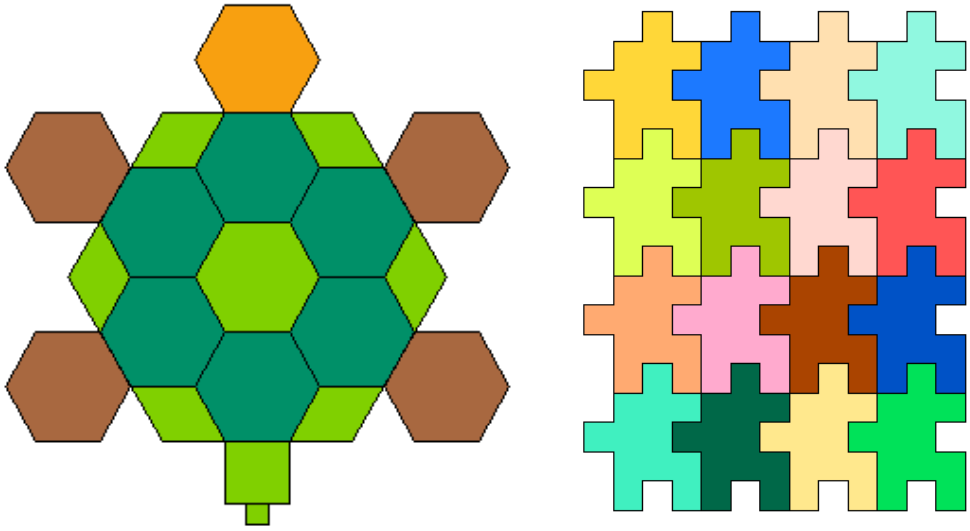


Figure 2. Some examples of tasks

By solving several tasks students build their own knowledge. They learn how to

- efficiently use the most important procedures of turtle graphic;
- find recurrent elements, apply iteration and recurrence;
- divide a problem into sub-problems, to form procedures with – and without - a parameter. (Compare Borowiecka, A. and other,2008)

They also learn how to scale a drawing and to find proportions or test procedures with parameters – for different values, with special consideration of boundary conditions.

There is also mathematical knowledge which is needed to solve the problems

- square and its diagonal;
- proportions;
- regular polygons like triangle, square, hexagon;
- angles – right angle, straight angle, angle of 360 degree, partition into equal parts.

In general, working with microworlds can help to introduce "Powerful Ideas in Mind-Size Bites"(The title of chapter 6 of "Mindstorms: Children, Computers, And Powerful Ideas" 1980, p. 135) Children are able to think about very serious problems in relatively simple way. They can think about issues such as: What can humans do better than computers? Or what can computers do better than humans?

Logo and Imagine are designed for the educational use and have many mechanisms to create multimedia projects. It is a good instrument to create open exercises, stimulate thinking and make one's

own creative activity. For that reason we encourage teachers and students work and play in this environment. That is why we organise distance learning courses.

DISTANCE LEARNING

Due to the fact that programming is a quite difficult skill, one can ask how to organise distance learning courses to help students in taking up this challenge. Martin Dougiamas in article "Social Constructionism as a Referent" wrote: "Most importantly, such learning is best when you are expressing and presenting posts, projects, assignments, constructions etc for others to see. In this situation your personal stakes are a lot higher, and a lot of self-checking and reflection takes place that increases learning. Seymour Papert (the inventor of logo) famously described the process of constructing something for others to see as a very powerful learning experience, and really this sort of thinking goes right back to Socrates and beyond." Active learning as a form of asking questions more than preparing lectures is know from ancient times. For centuries, a great afford was done to put in practise such ideas in different forms like learning by doing, role playing, interdisciplinary projects. In the 21 century social learning become more popular with usage of different tools. One on them is e-learning Moodle platform. The role of ICT is irreplaceable, it helps delivering of learning activities and publishing of resources, supports a social constructionist framework education and above all it enables collaboration and communication.

Bearing in our mind the 21 century learning principles, we focus on organisation of distance learning courses. The youngest target group are primary school children. The workshops for them entitled "Programming in Logo Environment" have been organised since 2005, that means, this year we have the 5th edition. Each time about 60 children from different schools in Mazovia district took part in our workshops. Usually a course consists of 4 hours face-to-face activities and 56 hours of distance learning on the Moodle platform.

The objectives of our project are to study programming in Logo and getting familiar with the Imagine environment. Moreover, while taking part, students improve their computer communication skills and they learn how to gain new knowledge through the Internet-based courses. The students proved that they did not have problems connected with virtual communicating and they were also ready to make a great effort to acquire new abilities.

The first meeting is organised in order to know each other and to integrate the group. This allows us to take up the challenge to learn programming. Moreover, students also solve some algorithmics problems.

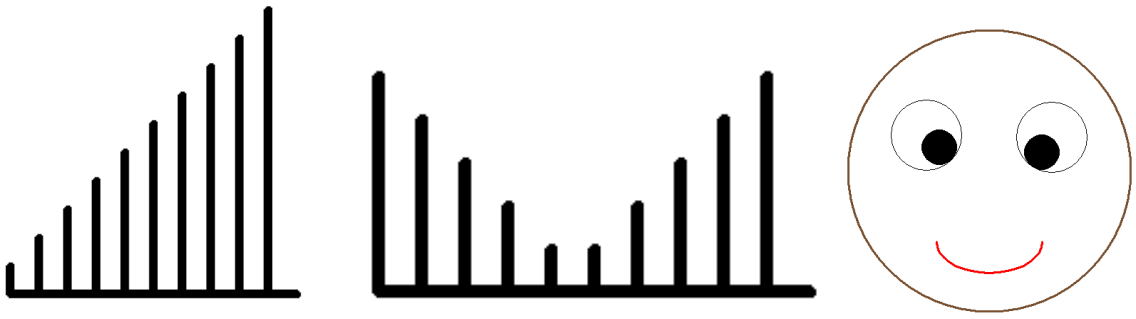


Figure 3. Some algorithmics problems

For subsequent six weeks every student works on the e-learning platform. The course material is divided into three parts according to logical rules and the level of difficulty. The first part is dedicated to remind primitive logo functions and simple examples of using iteration. In the second part we improve ability to apply repeat instruction introducing more difficult problems and recursion. We also

deal with different tasks including fulfilling, using random functions and drawing pictures in various sizes. Third part is concentrated on analysing and testing.

The students actively participated in various activities. For example there was a forum called “Think and Describe”. The question was how the turtle can draw certain pictures. The students have to describe various solutions.

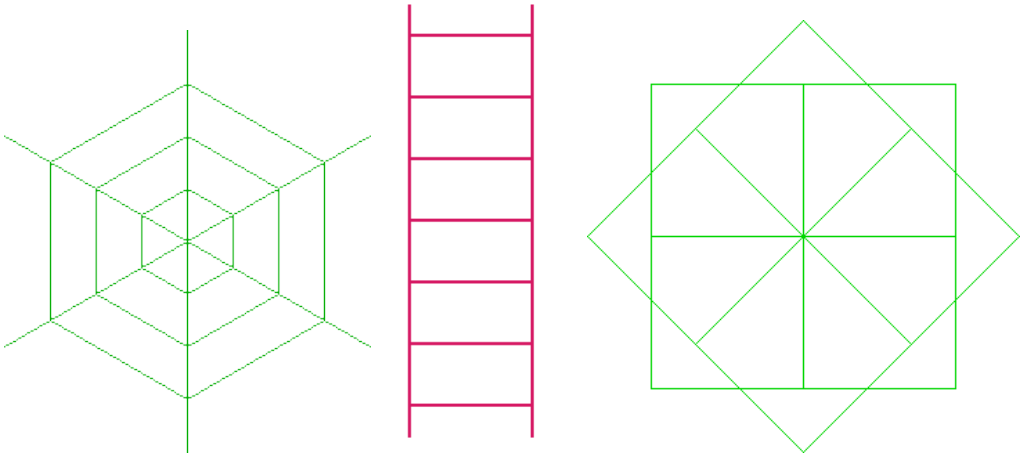


Figure 4. How a turtle can draw such pictures?

During the workshop the students are asked to write some procedures in order to create specific drawing like these:

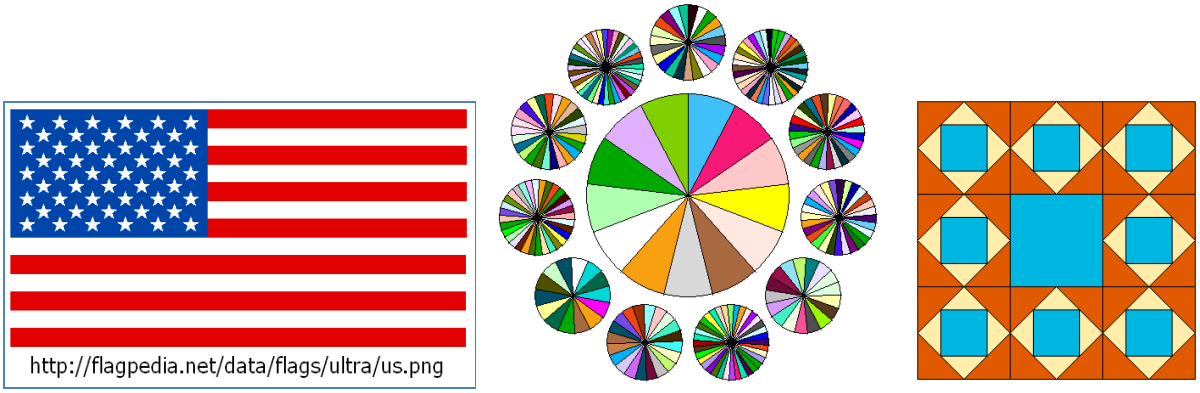


Figure 5. Some algorithmic problems

The students solve variety problems to develop programming skills - perceiving and formulating algorithm problems, constructing and analyzing solutions in the form of algorithms, expressing algorithms as procedures and testing them. Each time students have to reformulate a seemingly difficult problem into one they know how to solve. We encourage students to read instructions carefully and to consider variety of ways to solve a problem and to choose the best solution. In the beginning we give students simple tasks which gradually become more complicated. They learn computational thinking using abstraction and decomposition when they face a complex task. We also try to make them thinking recursively.

Besides typical programming tasks, there were also projects to be done. For example there is a project made by Dawid (10 years old) “Where is the cat?”.

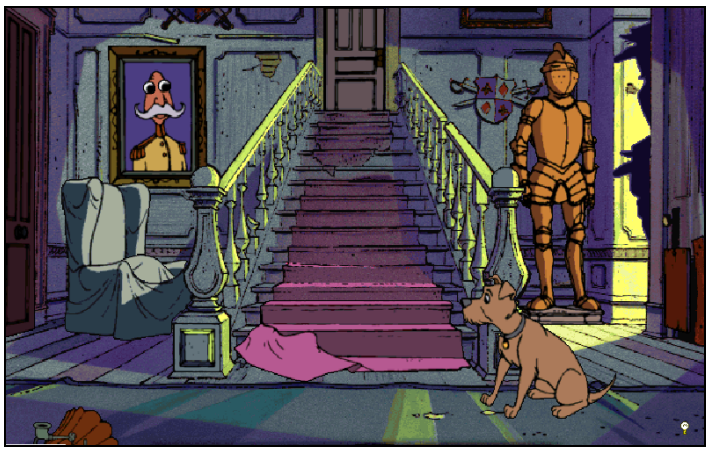


Figure 6. “Where is the cat?”

We can ask after Seymour Papert “What will children learn by making a game? They will learn some technical things, for example to program computers. They will learn some knowledge traditionally incorporated in the school curriculum, for example in order to make shapes and program movements, they will have to think about geometry and about numbers. They will develop some psychological, social and moral kinds of thinking. Most important of all in my view is that children will develop their sense of self and of control. For instance, they will begin to learn what it’s like to control their own intellectual activity.”(Papert 1996,. 47)

Our last meeting is devoted to solve some more difficult algorithmics tasks in Logo graphics. Especially we pay attention for difficulties which the participants have had during the course. Usually, the most exciting part is chatting with people known from working via the Internet and watching other participants’ work.

Generally speaking, putting emphasis on working online results in high activity of participants and requires methodical learning. Working on e-learning platform allows pupil not to waste their time on travelling. In addition, it is easier to save up some time for learning without strict hours, but of course there were deadlines for each task. Participating in the project is a good opportunity to create a collaborative community and to discusses problems with fellow classmates from others schools. It is a chance for pupils to interact with similar interests students, to exchange experience in forum discussions and presenting their own work.

Our problems connected with such courses became our routine. When we organised the course for the first time everything was new to us – we learned and played with children going through different e-learning activities. Now the situation has changed. We have a kind of conventional train of thought. As a result, our students are less spontaneous. The next problem our students face is lack of teachers support in their schools. Of course, they can find help in their parents and older siblings. But it is not enough.

This is why, along with the course for children, we organise a course for teachers with some methodical advice. They could improve their knowledge connected with programming and what is more - teaching skills. It is also a great opportunity to discuss problems with fellow teachers and share various ideas.

Moreover, we prepared an offer for higher level of education. We organised courses in programming in Logo with more difficult tasks for lower secondary students and programming in C++ both for students and teachers. We invited professor Krzysztof Diks from the University of Warsaw to enrich our lectures. Strictly connected with courses are competitions which we organise for students on different levels. While participating in our courses, students have an opportunity to prepare for the competition.

COMPETITIONS FOR STUDENTS

It is an important branch of our educational work. The Centre for Informatics and Technology in Education in Warsaw has organised Logo Competitions for children since 1994. (Jochemczyk, W., Olędzka, K., 2005) The main objective of these competitions is to solve algorithmic tasks in Logo environment. There is a competition for primary school children called miniLOGIA and Lower secondary (gymnasium) called Logia. Since the previous year, we have started to organise national competition POLLOGIA with the cooperation with Microsoft's educational programme "Partners in Learning".

The organisation of these three competitions is similar. Each one consists of three stages. At the first level, which lasts several weeks – students independently solve some graphical tasks. At that stage, tasks can be solved at home or at school. The standard task is to write a procedure which would draw an expected picture on the screen. The second stage is regional one. The competitions are conducted in computer labs. The time for solving the tasks is limited to 120 minutes. In competition for primary school children all the tasks are from turtle graphics, whereas for others, they include also problems connected with operations on words. The team of experts assess all answers according to established criteria and presents outcomes in points along with a list of participants of the third stage (finalists). The third stage is organised in one place. The time is also strictly limited and the tasks are similar to those of the second, but they are more difficult. The tasks for older students also include problems connected with processing lists.

Each competitions has its own website

- miniLOGIA – http://minilogia.oeiizk.waw.pl
- Logia - http://logia.oeiizk.waw.pl
- POLLOGIA – in Microsoft's educational platform "Partners in Learning" http://www.pdp.edu.pl/logo

It is possible to find there organisational information, contents of the former competitions, some advice for students interested in participation.

I would like to add that quite often students participating in our competitions win for the first time in their lives. That is why, it is a very motivating event for them. Many students, with Andrzej Gasienica-Samek among them, have started their prominent career from taking part in our competitions. Andrzej was the World Champion in the International Collegiate Programming Contest, Beverly Hills, California, USA in March 2003.

SUMMARY

Living and learning in 21st century requires new skills. We live in a society which is global, hi-tech, diverse and information centred. Apart from reading, writing and arithmetic, such skills like thinking, problem solving, synthesising, communicating, designing and developing new products really count. Educational approach seems to lead in the direction where students work in a constructivist learning environment. A new role of teacher requires leading to active engagement, with encouragement, support, and resources to enable children to construct and communicate what they know and how they know it to others in a social context.

Our response to 21st century demands is teaching algorithmics at early stages of children development in constructvistic way. We combine face-to-face workshops in a computer laboratory with distance learning. We try to introduce students in the world of algorithms and programming by organising competition. But there are questions which come to our minds - Do the children take advantages of activities prepared for them? Is it enough to prepare children for their future?

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E-LEARNING & DISTANCE LEARNING