Lifelong Playing Instead of Lifelong Learning
Teaching Robotics without Robots and Computers

László Csink, and Károly Farkas

Óbuda University, Softwertechnology Institute, Bécsi u. 96/b,
1034 Budapest, Hungary
csink.laszlo@nik.uni-obuda.hu
farkas.karoly@nik.uni-obuda.hu

Abstract. Teaching robotics is not only possible but recommended even for small children; clearly in a careful, playful way adapted to kids. Based on decades of research and teaching experience [1], we suggest some methodological tips: Robotics in the kindergarten, Robot Games, "Feed the turtle" Game, Match Logo, Lego-Logo, Brick-Logo, Logodrio, the use of LEGO set in the start of teaching robotics.

Keywords: infancy, robot game, turtle, LEGO-Logo, Logodrio

1 Introduction

We started teaching informatics at primary school around 1980. We called computer technology as informatics and it was not just a buzzword but rather an interpretation. Computer technology is an important part of informatics. The computer is not just a tool for performing computations but also the controlling element of technological systems. In this sense, the computer is the brain of a robot.

Robotics is an interesting area that is getting increasingly important. Is it possible to teach it at an early age? We think that it not is important but it is also possible and necessary.

Of course, it can only be taught adequately fitted to kids' age and previous knowledge, just like all other science.

2 Robotics in the kindergarten

Some think that to small children a robot, even a toy robot, can be frightful so it should be avoided. Robots of the sci-fi world are really unfriendly.

The servants of Hephaestus made of gold, the robot guarding Crete's shores, or Golem are just as unfriendly with strangers as the clone soldiers in Star Wars. Even the „Future Eve" of the film Metropolis cannot be considered a real beauty. The creatures of imagination have by now „learned" Asimov's rule of robotics and it is clear that they obey to human commands. It is one of our first tasks in technology

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education that we should form a correct image of technical tools and we should make it understood that human tools, including robots, are neither vicious nor good-hearted.

Their value or uselessness or perhaps harm depends only on the way they are used, in other words it depends on us. Technology can serve life or it may endanger life. The scythe can be a basic tool serving life but it can also be a weapon. The same is true for atomic energy. Technology must be taught so that it could be used for the god of mankind. Playing with robots can be a very good way of technological education. For a child at a young age, if he/she has not been frightened away, a toy robot is not frightful but a rather interesting toy.

Playing with the robot the child can live through the experience and responsibility of commanding technology. We have experienced several times that a toy robot may cause the same joy as a little dog (although the teacher may have more difficulties in taking care of the dog as the toy robot). Children are happy to run in front of or behind mobile robots and cars. It is not a methodological task to present robot programming. Children are brave enough to press keys themselves and find out, typically without help, how to govern the machine.

Out of various programmable toys the turtle has an outstanding significance pedagogically.

The ROAMER floor turtle was acknowledged by Papert too when he called it he best in its category from didactical point of view [2].

We often use it as well when working with little children. We think that informatics in the kindergarten should be started with informatics role-plays and 3D games instead of the computer. The main advantage of ROAMER is the step and turning units can be previously set by the teacher according to the children's needs.

The ROAMER and the other such tools are the first elements of our Playful Informatics teaching methodology and curriculum both in chronological and logical sequence. After playing with ROAMER, after getting acquainted with it, a group play may follow.

3 Robot Game

The robot game is a commonly used methodological element listed in the Hungarian curriculum for first-year primary school students that we developed experimentally (Playful Informatics Teaching, JIO).

Papert often emphasized the role of syntonicity and he strongly suggests, not only for children, that the turtle should be imaginatively personalized while studying turtle geometry. We wrote a sequence of books titled „Play the Turtle". Papert uses the term syntonic learning as the opposite of dissociated learning. Turtle geometry is body syntonic as it is strongly connected with our sensation of our physiological and physical states and our knowledge thereof. Drawing with Logo and rather personalizing the turtle and playing its motion is self-syntonic as the child (or adult) working on a task senses herself as a controlling and monitoring human being having intentions, goals and options. If he has not been able to find out how to draw a geometric shape, even an adult can stand up and try to walk through the envisioned

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algorithm. Thus through his sensation of his own motion a possible mistake might be detected or the right solution might be found.

Incidentally, the muscle tension due to actual or imagined movements has a positive impact on the ability to concentrate.

We found that the Robot Game is a good way to improve the algorithmic skills of young children. This is perhaps the most original and favourite element of JIO. In fact, this means the personalization of the turtle. The main point is that one or more children (children prefer the teacher) carry out the movements according to spoken commands. We should find the playful equivalent to the most important Logo primitives such as advance, retreat, right, left, whose interpretation is obvious. It is very important to previously set the size of parameter units. A step should be foot-size long. The unit of turning should be adapted to the children's studies. First use just quarter turns (in kindergarten cakes are cut in four, the four quarters of the globe, gymnastics commands). Later on, these can be refined (a bigger cake cut in eight, half left-face, north-west). Having taught the analogue clock, the circle can be divided into 12 parts, and the quarter turn is equivalent to 3 p.m. In second class, we may use some basic angles as well. In the third or fourth class, this game may aid in learning the concept of the angle.

The robot game is the simulation of the programmed robot or turtle. There are several variations:

- Perform several commands one after the other after „Uff" (developing memory)
- Perform the inverse of the spoken command (developing logical skills)
- Move with eyes covered (developing sense of orientation)
- Interpret commands spoken in a foreign language (language learning)
- Control with Logo commands (practicing the programming language).

Children may, according to their agreement, play the role of robots of various generations. Commands which do not belong to the previously agreed set or which cannot be executed will not be heard, or they might utter a beeping sound trying to interpret the wrong command.

The main attraction of the game is the competition. The robots which react wrongly will fall out, the winner qualifies for the finals, or may govern the next team, or gets a turtle-medal etc.

Having defined the basic Logo primitives, the lifted pen may be modelled by hopping progress or a lifted hand, so the fictional or real chalk (stick in the courtyard) does not leave a trace.

When the turtle hides, the kids cower so they will not be seen among the benches. Then the inverse commands can also be defined. In third or fourth class the equivalents of commands involving the edge of the screen may also be found, so commands leading to the wall will not be executed or the robot will turn back. A more detailed description of the games can be found in our publications. Not only the children playing the robots participate in the game but the controllers as well, moreover, the inactive students are also needed as jury or audience. They are also expected to concentrate on the game.

Knowledge learnt at other classes can be well linked to robot personalization. We can give various names to the robots. They may have various identifiers and

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coordinates reflecting their positions. A version of the game is the “wall-building” robot which I will describe in the brick-logo section. A great advantage of the robot game is that it needs no educational investment at all.

A university level application of the robot game is Gerald Futschek’s methodological games for finding maxima and minima [3].

3. “Feed the Turtle” Game

The Robot Game realizes the syntonic motion in real size while the child physically moves in the coordinate system of the game’s micro-world. The activity is different for the controller or watcher while he/she is watching the motion from the outside, instead of performing the motion he/she only tries to imagine the algorithm so syntonicity is not aided by modelling through muscle work. The “Feed the Turtle” game practices this harder aspect, moving from the concrete to the abstract.

The story of the game is as follows. Our turtle sodded his garden with turfs; his step size is one turf. Let us lead him to his food. The game area or the step size can be gradually decreased and the game area can be more and more abstract at the same time. First we can move the turtle in his garden represented by a large board made from various elements. Then we can draw the garden on the floor or on the board and move a drawn 2D turtle. As a next step the turtle may be represented with a simple symbol and its motion is modelled by drawing the imagined path. The last step can be moving the screen-turtle in the game area of the screen.

With all above variations, first a dictated algorithm should be performed, and then algorithms leading to the wished goal should be found. To find paths in a specific garden several solutions might be found. When comparing paths, the algorithms can compete. We can point out that in general a best solution may not exist only a ranking according to some selected criteria, e.g. shortest path or least number of steps. Various obstacles may also be put in the garden.

A computer version of the game was developed by Éva Törtely. The program was already developed for C64 and IBM PC’s in various Logo dialects, both in 2D and axonometric versions. Later on, teachers and programmers developed other adaptations and versions and similar other games in Hungary and everywhere else, among the first in Parma, about which they gave a lecture at the Second Eurologo Conference. The later version of the Italian “Martalogo” was welcome by the participants of the Third Eurologo Conference [4].

4. **Match Logo**

In the Match Logo game, we also gradually decrease the game area and move from the concrete to greater and greater abstraction. In the first phase, the children personalize the turtle or robot putting 20-30 centimetre size arrows or bridge elements in front of themselves on which they can move forward. Later on the model this with small sticks, they solve the tasks in drawing, and in the end on the computer screen. While in the Papert style turtle geometry vector control can be seen only in the last

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step, here the vector construction plays a role in the whole process. Possible applications of the game are described in our workbook written for children.

5. Lego-Logo, Brick Logo, Logodrio

Crawford Craig published a paper [5] on the application of Logo for Lego. The Lego-Logo artificial language is similar to turtle geometry. Any construction from LEGO bricks can be described with turtle geometry. To select the set of commands Craig suggested the following. The 8-LEGO-element is signed 4,2 (four times two). Assume our turtle has such a shape. In JIO methodology, Brick Logo (Hungarian Lego-Logo) is taught by starting to transform the brick to a turtle by drawing a nose and legs, colouring its sides, maybe clothing it to turtle clothes. Then we draw it. The ornamented brick will be called the main turtle. The turtle's position reflects a geometrical point and a vector. The motion of the LEGO element is described in a polar coordinate system. Craig uses the following commands:

```
FORWARD n
BACK n
UP n
DOWN n
RIGHT n
LEFT n
BUILD
```

The above set of commands we simply took over, but we translated them to Hungarian.

Lego-Logo and Brick Logo uses rotation only in the horizontal plane. In the first four classes of elementary school this is enough, as many constructions can be built without rotation around the horizontal axis or without moving out of the horizontal plane.

We use a relative coordinate system based on the current position of the turtle.

Brick Logo uses various bricks in addition to or in spite of the LEGO elements. According to the task, different size and form of bricks are optimal to use. When we wish to simulate structured programming, we can use premade brick elements. For simple buildings a domino or a matchbox can be used. The latter is bigger and cheaper. By drawing the box, the size ratio 4:2:1 can be set. For teacher demonstration real bricks can be used. The basic turtle position is the following:

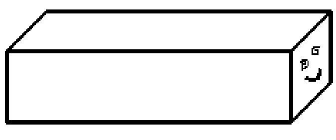

Fig. 1. The basic turtle position

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We selected a quarter-brick-size as the unit of movement. The command of such movement is called “forwardh ”. Thus “forwardh 4” means movement with one brick. Moving backwards does not really need a new command as we use the minus sign. However, in the first and second class we need a new word for negative directions, so “backwards” is introduced. Step size in the vertical direction is one brick. “up 1” can be used for putting a brick on the top of another. 1 is a default, so “up 1” is the same as “up”. For moving down we use “down”. For turning we use “righth” and “lefth” which mean a turn with ¼ if used without an argument. For rotation several interpretations are possible of which we selected the following:

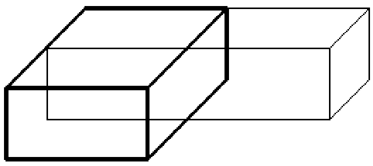


Fig. 2. Interpretation of the turtle’s moving righth

By selecting the rotation angle this way the construction algorithms could be made shortest. We use like in Logo the REPEAT and to-end words. To fix a brick to a position we use “put”. Thus “put” also means the repositioning of the origin. An example is:

```
   TO wall :H :N
   REPEAT  :H/2  [line  :N  up  backwards  4  *  :N  -  2  line  :N  up
backwards 4 * :N + 2]
   end
      TO line: N
      REPEAT: N [put forwardh 4]
      end
```

put refers to fixed points, we do not abbreviate it so it remains clear and it is easy to understand.

TO and REPEAT are operators, to show their different roles we write them in capitals.

We included some examples of Brick Logo in our second workbook for children. Brick Logo is a good way to illustrate some thinking operations and to teach turtle geometry without a computer, to teach symmetry and architectural knowledge in a playful way.

It is especially suitable to teach the symmetry law as the model of the right and left staircase can be compared with the way it is described in speech:

```
REPEAT 5[put up forwardh]
REPEAT 5[put down forwardh]
```

The invariance of change-symmetry can also be displayed:

```
REPEAT 5[put up backwards]
```

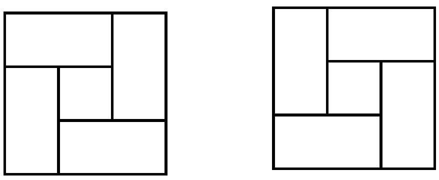
This can be a good way to demonstrate structured programming, as a building element can be built using bricks of the same colour or can be glued together and used later on as one unit. The module principle can be clearly seen. The brick operations are well suited to teaching elementary robotics. When the bricks are put together by a child personalizing the robot, the movement of the robot arm with an empty hand can be well differentiated from the “put” command when the brick coming from the conveyor (personalized by another child) slides to the idle hands. The Brick Logo game is suitable to demonstrate the teaching of the robot. Another advantage is that each child has a “computer”.

The computerized version of Brick Logo is Logodrio. We have written a logo program that displays the results of operations on the screen in an axonometric or projected form. The program makes the game and computer usage more complete. An additional advantage is that we can use this program to set up obstacles in the garden of the turtle in the “feed game”. Brick Logo helps in forming the concept of model and similarity. The didactic sequence using Brick Logo and Logodrio is suggested as follows:

1. Constructing the building
2. Making a drawing of the building
3. Algorithm
4. Display on the screen

While practising, all variations of comparisons of mathematical model and physical reality (on paper, on board or on screen) should be used. Brick Logo is a valuable tool for teaching in higher education as well. Using it some basic architectural methods can be described in a linguistic and exact way-As an example, the algorithm of building of a column of 12 bricks is:

```
REPEAT 12 [up put]
```



The building of the most frequent 12*12 chimney pillar is simple and beautiful:

Fig. 3. Chimney pillar

```
to first.line
REPEAT 4 [put forwardh 4 righth]
end
```

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```
to first.lift
Up righth
end
to second.line
REPEAT 4 [put forwardh 4 lefth]
end
to second.lift
Up righth
end
to chimney :H
REPEAT :H/2 [fisrt.line first.lift second.line second.lift]
end
```

6. LEGO and Robotics

LEGO is one of the most useful educational tools. Lego is part of the technology curriculum in Hungary.

The LEGO family incorporates hi-tech elements. The set constitutes a system, the elements are standardised and modularised. Joints can be done without additional tools and they hold if constructed suitably. Deconstruction is possible and the elements are reusable. Manufacturing is precise. Many people advocate toys made of natural material, e.g. wood. However, wood as a material for toys is handled and transformed in such a way that it is not really more natural than Lego. We think that the Lego sets can aid the technological and informatical education of children. An additional advantage of Technic LEGO is the box that ensures the possibility of orderly storing. The attached notes are masterpieces of technical education. The photos describing technical history and the real world, the visual and planning documentations as well as the architectural building algorithms demonstrate good planning methods. As an example how to use Lego products in a complex way we describe a task which we took over from the Lego TC Research Group:

1. Let us build a LEGO car

Various constructions can be made depending on the set we have. There are no "good" or "bad " solutions, only models that are better or worse according to some criteria, e.g. which car rolls better, how many elements were used, which looks more real, which looks more modern etc.

2. Equip the model with a motor

How to mount the driving motor? How to solve propulsion and energy supply?

3. Control the car.

By switching off the current we can stop the car. How can we navigate?

4. Programmed control

To store a program, Electronic Lego sets contain a microprocessor unit. Programming can be done in a manipulate way, running is automatic.

5. Control by computer

LEGO manufactures model interfaces to various computers but a cheaper Hungarian solution also exists (TechnoMir). The computer program controls the

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machine. The programs are written in Basic, Comal and Logo. When the child writes his/her own program, not just uses the menu, he6she can realise the advantages of the application of motion oriented Logo.

6. Feedback control

Latest sets contain sensors as well, so the car movement can be controlled. Through feedback the computer can get signals which can be processed and the computer can change the car movement. Thus automatisation can also be demonstrated.

The above educational line is one of the basic lines of JIO. The steps reflect the classes in which they are realized but the concept can be taught in a shorter time as well. In case of good equipment and high teaching level, the six steps can be done in the lower four classes as well.

There is a special set of Lego and Fischer sets of which the roof turtle can be built. Even a third or fourth grade child can put together the elements, and turtle control is tried by young pupils as well. There exists a set of which a working plotter or an industrial robot model can be built. We propose their application in the fifth or sixth grade, as well as the kit which can be used for building LINETRACER, the tracing robot, the inverse of the roof turtle. Lately we can use the Mindstorms Lego element too.

We hope that instead of the very expensive, stupid, shooting games our children will play with more and more ability developing educational games.

7. Comments on Playful Informatics (JIO)

Playful Informatics (JIO) as a whole was tested by experiments ([1]). The methodological elements were not examined separately. Their effectiveness is underlined by the fact that they are widely used in Hungary and the EuroLogo conferences discussed several similar applications.

Brick-Logo is used in higher education as well. One of its greatest advantages is that it is very effective in testing basic algorithmic thinking fast and exactly. The result of an architectural algorithm can be easily drawn and its correctness can be tested at a glance.

References

1. Farkas, K.: Játékos Informatika (Playful Informatics). Hungarian Academy of Sciences Dissertation. D17799 I-II. (1993).
2. Papert, S.: Mindstorms: children, computers, and powerful ideas. (1980).
3. Futschek. G., Moschltz. J.: Developing Algorithmic Thinking by Inventing and Playing Algorithms. In: James. E., Kalaš. I. (eds.) Proceedings Constructionism 2010 12th European Logo Conference 16-20 August 2010 Paris, France, p 56. AUP (2010).
4. Calabrese, E.: Martha Logo. In: Proceedings Third European Logo Conference, Parma, Italy. (1991).
5. Craig, C.: Lego-Logo. In: Micromath Vol. 1 (1986).

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