THE EDUCATION OF PROGRAMMING WITH THE HELP OF PROGRAMMABLE ROBOTS AT COLLEGE AND AT UNIVERSITY

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ABSTRACT:
A great emphasis is being put on teaching programming and robotics in our present day technical higher education. For each IT student it is extremely important to improve competence in programming, furthermore it is more important to get their algorithmic thinking and problem solving ability onto a high level. Without these abilities their later work will be impossible. Beyond teaching the different programming languages and techniques our task is to form such an aptitude that makes them being able to understand and solve both theoretical and practical problems of different fields. Programmable mobile robots can play an important role in this development.
KEYWORDS:
programmable mobile robots, effective learning

1. INTRODUCTION

This article, deals with some problems in teaching programming and how new innovative devices can be used in the education of programming both at beginner and intermediate levels. By using model robots we can make teaching programming more interesting and we can also give the students the impression of just playing. Building and programming robots motivate the beginners just as well as the intermediate students' creativeness. The robots make students able to meet several simple but real problems and give them the possibility to try in practice much already studied theoretical knowledge from other fields of informatics. Students at intermediate level can employ their knowledge that they have already studied in Algorithms, Artificial Intelligence, Shape-recognition, Communication and Networks subjects.

2. WHY DO NOT LIKE THE STUDENTS PROGRAMMING ?

At the Kecskemét College Faculty of GAMF IT students study programming in C/C++ language, four lessons per week, during three semesters. Together with my colleagues we have seen that students' results are getting worse and worse over the years and more and more students have to study programming again, because of their unsuccessful exams. Furthermore they like this subject less and less. In order to

explore the reason of these bad results we have made a survey among students who have already finished the first semester.(1) The survey was made with one hundred participants and it turned out that students entering into higher education have various knowledge in programming.
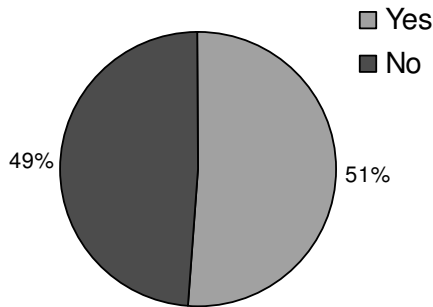
Did you study to program at high scool ?

Yes
No

49%
51%

Table1: Did you study to pogram?

Forty-nine per cent of them have never studied programming at all and the other half was varied. Some studied it for only one hour per week while others had six or eight lessons per week for years.

Of course the exams' marks show that students who already had background knowledge, reached better results, the average marks of students, who have not studied informatics before was 2.86, while the average marks was 3.31 for those who have studied informatics before. Much more beginners failed their first, second and third exams. The survey results clearly show that only twenty-two out of forty-nine of those students who have not studied informatics at all in high school passed the exams for the first time, compared to thirty-nine out of fifty-one of those who have already studied informatics.

How do you like programming ?

5%   8%
13%

hate   dislike
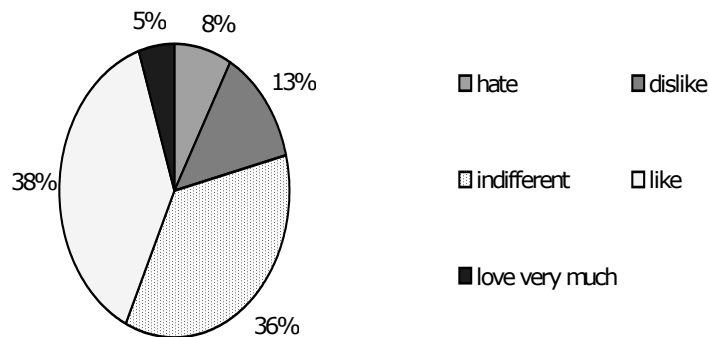
38%

indifferent   like

love very much

36%

Table 2: How do you like programming?

These bad results (see Table 2) were depressing, sixty per cent were indifferent or did not like programming and fifty per cent did not think that programming could be important in their future carrier.

Because of these bad results together with my colleges we started to search such new methods and devices which can help us teach in a more effective, spectacular and easier way, as well as make learning more enjoyable.

3. LEGO MINDSTORMS RCX ROBOTS IN THE EDUCATION

The new innovative device that we found in Hungary was introduced by Zoltán Istenes in the ICAI conference in 2004 (2). It was a programmable robot set by LEGO. The robot can be seen as a toy for the first sight but with the help of it teaching can be more interesting, effective and the programming can be more spectacular.
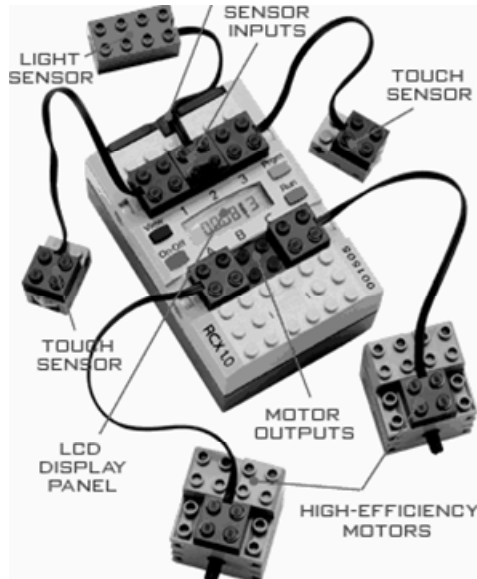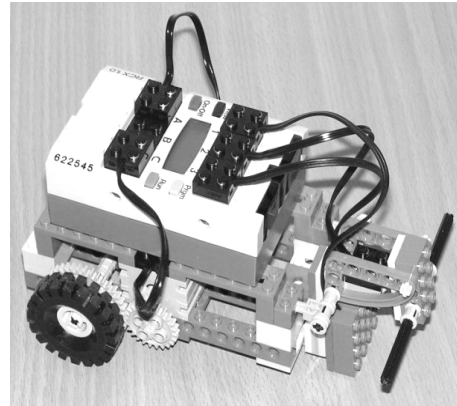
Figure 1: Parts of the robot

Figure 2 : A Lego RCX robot

The main part of the robot is the Mindstorm Bricks which has three input ports and three output ports and a small display. Motors, lamps, touch sensors, light sensors, temperature sensors and rotation sensors can be connected on the ports. In the brick there are 16KB ROM and 32 KB RAM memories, a processor and the link between the robots and the computer is done trough the infra red communication port.

A proper operating system runs in the robot, and it is loaded through the infra red port. To control the robot several programming languages have been developed. In our College we use C/C++ programming language that is why we have chosen NQC (3) language to write robot control program.   In this language there are various loops, if – than and switch – case branches, function with value and reference passes, task, subroutines and include files like in the most C- type programming languages. Its greatest advantage is that after loading the ready-made programs into the robot the results can be seen visually.

During the practical lessons when they plan and solve their tasks students can apply the well-proved teamwork. Teachers' inflexible teaching role changes. They become coordinators who raise problems. The participants plan the working process, they share the job, communicate with each other finally they summarize and present the result together. While doing their task they can get such theoretical and practical experience which can be very useful in their later career.

4. SIMPLE APPLICATIONS WRITTEN BY BEGINNERS

4.1. Route – following

The robot follows a route with the help of one, two or three light sensors. Other similar example when the robot goes around in one determined area. In this practical application the RCX uses a light sensor (see in figure 3). The program which controls the robot was made by students after six- seven hours of practice. The program is written in NQC language can bee seen here:

```
int x, time=1,direction=0;
task main()
{
    SetSensor(SENSOR_1,SENSOR_LIGHT);
    x=SENSOR_1;
    start look;
    start turn;
}
task look()
{
    while(true)
    {
        if(abs(x-SENSOR_1)<2)
                {stop turn;

        time=1;direction=0;OnFwd(OUT_A+OUT_C);}
        else {if (time==1) start turn;}
    }
}
task turn()
{
    while(1)
    {
        time=2*time;
        Off(OUT_A);
        if(direction==1){OnFwd(OUT_C); direction--;}
        else{OnRev(OUT_C);direction++;}
     Wait(time);
    }
}
}
```
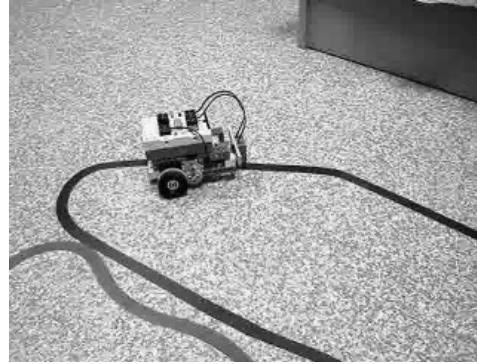

Figure 3 : The RCX follows a route

4.2. Scanner

In this practical application can be clearly seen how the programming of robot connects to the compulsory subject. In this example the students build a simple scanner which with the help of a light sensor reads a fifty by twenty pixel resolution an ″ A″ character drown on the paper. The robot records the read data in its data log then it sends the data through the infra red port to the computer into a text file. This program written in NQC language is a very simple one; it has only about twenty lines and it was also written by students after fourteen - fifteen hours of practice.

The program :

```
void read()
{
        SetPower(OUT_A,1);
        OnRev(OUT_A);
        repeat(50)
          AddToDatalog(SENSOR_1);
        while(SENSOR_2!=1)
          OnFwd(OUT_A);
        Off(OUT_A);
}
void forward()
{
        SetPower(OUT_B,1);
        OnFwd(OUT_B);
        Wait(4);
        Off(OUT_B);
}
```
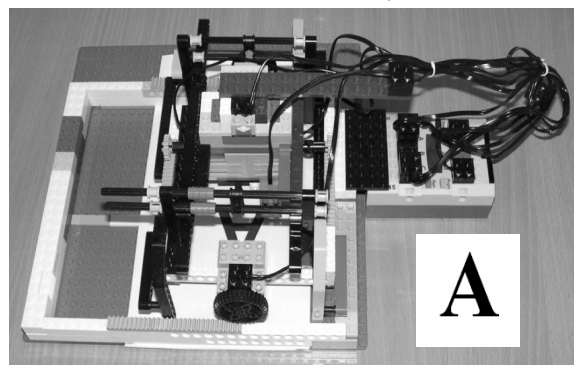

Figure 4: The simple scanner

```
task main()
{
        SetSensor(SENSOR_1, SENSOR_LIGHT);
        SetSensor(SENSOR_2, SENSOR_TOUCH);
        SetSensorMode(SENSOR_1,SENSOR_MODE_RAW);
        CreateDatalog(1000);
        int column;
        for(column=0;column<20;column++)
        {
                read();
                forward();
        }
}
```

At the end of the scanning, the robot sends the collected data log through the infra red port to the computer, into a text file. This file is then processed by a C++ program, running on the computer and written in Visual C environment. The result of the scanning is a"hang over letter A" which is displayed on the computer display.

Figure 5: The result

```
#include <stdio.h>
#include <stdlib.h>
void main()
{
  FILE *f;
  char jel(50*20);
  int ertek;
  char adat(20);
  if((f=fopen("datalog2.txt","rt"))==NULL)
  {
    printf("Error in open file!\n");
    exit(1);
  }
  for(int v=0; v<50*20;v++)
  {
    fscanf(fptr,"%s%s%d",adat, adat,&ertek);
    if(ertek<715) jel(v)=178;
    else jel(v)=' ';
  }
  for(int v=0;v<50;v++)
  {
    for(int i=0;i<20;i++) printf("%c%c", jel(v+i*50), jel(v+i*50));
    printf("\n");
  }
  fclose(fptr);
}
```
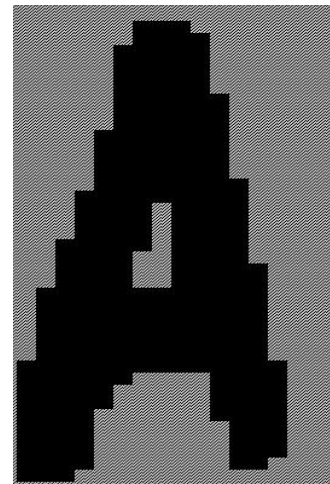
4.3 Maximum selection

This practical application is an example of how we can use spectacularly the previously studied theory with the help of the robot in practice. In this example students put the algorithmic theories into practice, they use the "Maximum choice theory". In their lesson they choose the biggest members of a sequence or a set and put them into practice. The robot with the help of its light sensor starts from any parts of the room to look for the lightest place of the room. A similar problem is when the robot, with its temperature sensor seeks for the hottest part of the room. This practical application was done after ten - twelve hours of practice.

4.4 Simple Communication

The robots can communicate with each other through their IR ports. Taking the advantage of opportunity we can make different kinds of applications in which two or more robots follow each other or play 'stone-paper-scissors', or carry something together.

5. THE ROBOTICS COURSE AT THE INTERMEDIAL LEVEL

At the Eötvös Loránd University, Faculty of Informatics, the robotics course is placed at the MSc level. At this level, the students can already program in several programming languages and have also acquired a lot of knowledge from the different areas of informatics. Therefore the aim of the robotics course is not to help the teaching of programming, but reuse, to try in practice and to reinforce the students previously acquired knowledge from different fields of informatics (4)(5).

5.1. Computer architecture

A simplistic model of a CD player (or rather hard disk) demonstrated the lecture of data blocks from a rotating surface. The model used three light sensors and two motors, one light sensor for data read, one light sensor and motor for positioning the reader arm to the desired cylinder, one light sensor to synchronise the lecture to the sectors and one motor to turn the disk.

An other machine could "read" LEGO blocks having seven positions with hole or without hole corresponding to seven bits. The first three bits were interpreted as instruction code and the last four bits were interpreted as a number. Introducing into the machine different blocks, the machine could simulate a simple accumulator machine and realise simple arithmetic.

5.2. Game playing using artificial intelligence algorithms.

Several game playing projects were realised, such as number guessing, battleship or gomoku (called also five-in-a-row). In the battleship game two RCX were the two players and the third RCX was the game master and plotted the game state on a paper. The three RCX communicated via infrared communication. In the gomoku game a human could play against the robot. After the robot has marked his move on the paper, the human could mark his own move on the paper then the robot scanned the paper to find the human move and according to that, it marked his new move on the paper and so one.

5.3. Using a web camera and image processing to navigate

A number of other projects used a web camera mounted above an environment. The robot moved around in this environment and was assisted by the computer processed image. The robot could avoid obstacles and could find its way out of a labyrinth or a maze. In some projects it could even find and kick a ball into a goal.

6. THE NEAR FUTURE AND THE PRESENT - WITH THE USE OF LEGO NXT

Eliminating the communication problems of RXC robots in 2006 Lego, brought out its third generation NXT sign robot (6), which won the innovative first prize of Nürnberg toy exhibition. Thanks to its new sensors (sound, distance sensor), servo motors and Blue Tooth techniques it became very popular. Furthermore, its rapidly developed several programming languages like NQC, NXC, NBC (7), LeJos (8) as well as the icon-directed Mindstorms NXT programming language developed by LEGO made it more popular. These languages provide a great choice for students at different programming levels from beginners to MSC.

7. THE CONCLUSIONS

The programmable LEGO RCX and NXT robots can be used in education at different levels and ages. These are excellent devices to make programming enjoyable, to increase motivation (beginners at BCS level). They give a chance to put the already studied theories into practice (advanced on MSC level). While using them it is possible to try different programming languages, programming environments in life-like situations (9).

They can also become helps of different subjects as well as new ways of realizing new goals. They can conquer several new fields in the near future so they can become very important devices in the research of the Artificial Intelligence, Algorithm Theory, Picture Theory, Shape Recognition, Communication, Toy Theory, Swarm Intelligence (10).

At Kecskemét College in the beginning of 2008 a new experiment is being started. With the help of control and test groups it is going to examine the effect of these devices on studying programming. The test group will use robots but the control group will not. The result of the case studies will probably be seen by the end of 2008.

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