Robotic Activities for Visually Impaired Secondary School Children

Martina Kabátová[1], Ľudmila Jašková[1], Peter Lecký[2], Vladimíra Laššáková[3]

[1] Comenius University, Department of Informatics Education,
[2] Comenius University, Department of Applied Informatics,
[3] Comenius University
Mlynska dolina,84248 Bratislava, Slovak Republic
kabatova@fmph.uniba.sk, jaskova@fmph.uniba.sk, lecky@cezap.ii.fmph.uniba.sk, vladka.lassakova@gmail.com

Abstract. In this article we describe our experience with teaching visually impaired children at special secondary school in Slovakia. We have used robotic toys (Bee-Bot) and programmable robotic kit (LEGO WeDo) with 5 groups ranging from 10 years old to 15 years old. We will discuss various possibilities of teaching educational robotics to this SEN target group and summarize some findings.

Keywords: educational robotics, Bee-Bot, LEGO WeDo, SEN, visual impairment

1 Introduction

In current school year we had a unique opportunity to teach informatics at a special school for visually impaired children. We had only little previous experience with teaching this target group but as highly qualified informatics teachers we decided to give it a try.

1.1 Informatics at schools in Slovakia

First we would like to introduce you to the situation at schools in Slovakia. Four years ago the national curriculum was changed and informatics became a standard compulsory subject for all grades of primary and secondary schools except for the 1st grade. Informatics as a separate specialized subject includes: basic ICT literacy, information and data handling, communication via ICT, algorithms, problem solving, user applications, working with internet, text, tables and images, principles of hardware, social aspects of using ICT, ... Those themes are adapted to the age of pupils and separate curriculum is aimed at primary schools and a different one is for secondary schools.

Proceedings of 3rd International Workshop
Teaching Robotics, Teaching with Robotics
Integrating Robotics in School Curriculum
Riva del Garda (Trento, Italy) April 20, 2012
ISBN 978-88-95872-05-6
pp. 22-31

There were several national projects focused on enhancing teacher's qualification so they would be able to teach this subject, but the situation is still far from ideal and informatics teachers are in high demand.

1.2 Our target group – visually impaired pupils

At the school for visually impaired children each grade is only one class with 6-11 children. They are usually split into two groups: (1) totally blind and (2) partially sighted and low vision. In some classes there are also children without visual impairment but they usually have another learning disorder (but there are exceptions for this and we have encountered children without any disorder at all).

During our teaching with robotic kits and programmable toys we have worked with many different children and we divided them into these groups:

- totally blind – children that have no usable vision and have to learn using Braille, screen readers and another non-visual means,
- low vision – children that have heavy visual disorder and have to use special aid to learn,
- children without disability – some children have no disability at all and some children have only minor visual impairment and for our purpose they could be treated as children without impairment.

In our paper we will describe work with the children according to these groups rather than according to their age and grade since we are convinced that the disability factor is much more important. Note that besides the visual disorders these children often have also another learning and behavioural disorders.

Each child of every group had previous experience with computers, but most of them have worked only with web browser, text and graphics editors. Our main goal was to introduce them also to problem solving, algorithms and basic programming. We choose educational robotics to achieve this goal.

1.3 Organization of the lessons

We decided to introduce every grade of secondary school to educational robotics – that means we had separate lessons with each class 5-9 grade. Our 5-graders are 10-11 years old and 9-graders are 14-15 years old. We have planned a 4-week long activity for each class. Each week there is only one lesson of 45 minutes thus each class had 4 such lessons.

The lessons took place in the computer room with more than 6 computers.

2 Educational robotics

Educational robotics is an umbrella term that includes any educative usage of robotic kits and programmable toys in both school and in informal environment. We further scrutinize this term in [1], [2], [3]. In our country robotic kits are mostly used

Proceedings of 3rd International Workshop
Teaching Robotics, Teaching with Robotics
Integrating Robotics in School Curriculum
Riva del Garda (Trento, Italy) April 20, 2012
ISBN 978-88-95872-05-6
pp. 22-31

at informatics classes at primary and secondary schools but some teachers also use them for various cross-curriculum activities. Thank to national project programmable toys are used in many early-years education centers [4].

Besides there is a vast informal community of robotics enthusiasts that includes robotic clubs, robotic competitions and associated clubs and groups, individuals that have robotic kits at home. Informal learning outside of school is an important part of educational robotics.

2.1 Programmable toys – Bee-Bot

Programmable toys are simpler than robotic kits. Due to their simplicity they are usually usable from early-years. They can't be assembled or disassembled and they usually have no display.

In our activities we have used the Bee-Bot toy. It has 7 color-coded buttons at the top that have also embossed symbols and different shape (these features turned out to be important). Four buttons are for maneuvering the Bee-Bot: it can move one step forward or backward, it can turn right or left without moving a step. GO button executes the sequence of instructions. CLEAR button erases the memory and the PAUSE button temporarily pauses the movement of Bee-Bot. The bee can memorize up to 40 instructions. When instructed to move forward it crosses 15 cm distance.

Fig. 1. Robotic toy Bee-Bot, transparent mat with a grid, LEGO WeDo kit

Variety of activities can be conducted using a transparent grid mat. Under the mat a teacher can place any images or flat objects. We have used paper cards with images of flowers and houses. A typical activity focusing on algorithms lies in instructing the bee that has to travel a specific path to complete a task (e.g. collect the flowers, visit friends). Navigating the robot – either real or virtual – is excellent preparation for future programming tasks in more advanced languages (using Bee-Bot is described e.g. in [5], [6] though with much younger children than our group).

Proceedings of 3rd International Workshop
Teaching Robotics, Teaching with Robotics
Integrating Robotics in School Curriculum
Riva del Garda (Trento, Italy) April 20, 2012
ISBN 978-88-95872-05-6
pp. 22-31

2.2 Robotic kits – LEGO WeDo

LEGO WeDo is a simpler robotic kit than LEGO Mindstorms, it is less costly and can't produce an autonomous robot since the model has to be attached to the computer with USB cable to function. This kit is being produced since 2008 and it is aimed at primary schools (7-11 years old). M. Resnick and several other members of MIT Media Lab have cooperated on the kit and programming language development [7].

Models created with this kit can be programmed also in Scratch which has an advantage of various language mutations [8], [9].

3 Bee-Bot activities

We have decided to begin the robotic activities with playing with Bee-Bot toys. We expected this activity to take one of four lessons we had with each group. We have worked with 2-6 children at a time. At the school for visually impaired children one Bee-Bot was already ready to use, we have brought another two toys and a transparent mat from our department. We have also prepared cards with images to put under the mat. It is crucial to make the images as big as possible and to use high contrast colors; thick black outline might be helpful. The mat has three rows by nine cells, each measuring 15 cm x15 cm. With most children we have worked at the floor in the computer room, with one group we have used a ping-pong table.

In advance we have prepared a set of tasks for the Bee-Bot. All tasks used two houses – one as a starting point and another one as a finish point. The houses were places at opposite sides of mat. Between them we placed 4-8 flowers which the bee should visit and eventually also red "fire fields" where the bee is not permitted to go.

Prepared sequence of tasks proved to be helpful but we haven't always done them all since we soon found out that 3x9 field mat is too vast space for many children with visual impairment. Most of the time we adjusted the tasks to fit the situation.

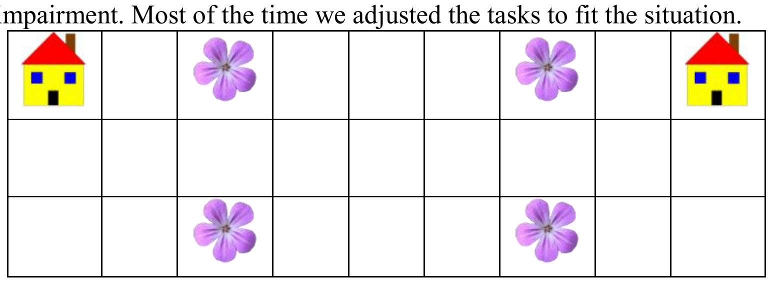

Fig. 2. First task from the prepared set

At first we were not sure how children will react since the Bee-Bot is intended to be used with much younger children, but no problems occurred and many of the pupils loved to play with the Bee-Bot toy.

Proceedings of 3rd International Workshop
Teaching Robotics, Teaching with Robotics
Integrating Robotics in School Curriculum
Riva del Garda (Trento, Italy) April 20, 2012
ISBN 978-88-95872-05-6
pp. 22-31

3.1 Children without any disorder, children with learning and behavioral disorders

Many children found the task to be rather easy and they were able to input whole series of instructions without any help. Most of them (though there were also exceptions) had none or only mild disorders. These children didn't need any aid while programming the bee and were able to design its path only in their head – whereas many children need to move the bee while programming or divide the path into several smaller parts to accomplish the task.

However, if the path was long and the bee have to cross whole 3x9 mat children made mistakes. They were very keen on attempting to solve the problem again even if it meant they have to input whole sequence again.

Some children had other disorders than visual (or the visual disorder vas not that severe) and the problems that arose were not connected to their sight limitation rather to the learning and behavioral disorders.

3.2 Low vision children

The very first group of children we encountered was three low vision pupils. Each of them needs to use some sort of magnifying software to work with computer. One of them has low peripheral vision and one has a disorder of color perception. Two boys were able to solve the tasks with Bee-Bot immediately, even without simulating its movement across the mat. The girl with color perception disorder had problems with orientation on the mat and she proved to have also poor spatial orientation.

The images placed under the mat should be clearly visible – we recommend the high-contrast colors and thick outline. The mat should be placed on some pale surface, since the grid is black. We also recommend beginning the activity with smaller grid e.g. 3x3 fields as the low vision pupils might have a problem to see the whole mat at once.

3.3 Totally blind children

Teaching algorithms and problem solving in standard class with pupils without vision disorders is usually done via software that heavily leans on visual representations (logo languages, Scratch ...). These educational software products are not usable if we teach totally blind children – they work with computer using a screen reader and the only information they can work with is text and sound. We haven't found any suitable programming environment that would be text-based and friendly to beginners that have no previous experience with programming.

In this situation we have decided to teach basic algorithms using a Bee-Bot. Bee-Bot is by default very well designed and has many features that enable the toy to be used by totally blind:

- the toy has no display and can be controlled without a need to see it,
- the buttons are coded by shape and have embossed signs so blind children easily learned which button is which,

- the bee has a shape with distinct eyes in the front which enable to distinguish easily which way it is facing,
- sounds can be turned on and Bee-Bot signalizes completion of each step as well as completion of whole sequence of instructions,
- and finally the Bee-Bot is tangible object and it's movement can be traced by holding a hand on the top of it.

Even if the toy itself is well prepared for use with the blind, the transparent mat is not. We needed a different mat – one that could be explored by touch. We have made it using a large cardboard and a tape. The tape stripes form a 15 cm x 15 cm grid. We decided to make this mat smaller – 3x4 fields (see Fig. 4.).

Two 9th grade pupils solved simple tasks that mainly consisted of moving the Bee-Bot alongside the mat border, in a shape of "L" or square and visiting every field on the mat. Similar activities were done also with three 6th graders.

Fig. 4. Two Bee-Bots at one mat. Special Bee-Bot mat for blind children

4 LEGO WeDo activities

At this school there were already two LEGO kits but they were used only rarely and almost no teachers knew what to do with them during the lessons. We brought another 3 kits and a box full of spare parts.

We have prepared PDFs with building instructions as we have learned that school has not purchased the LEGO WeDo Activities CD which contains them. Both LEGO WeDo programming language and Scratch were already installed at school computers.

We have prepared a sheet with activities containing e.g. short programs for children to explore and guess what they are doing, short activities to explore the sensors and their function and so on. We have used this sheet only once with kids that have done all other assignments sooner than any other child.

We have expected the children to follow this set of assignments:

- choose and build a model according to instructions in the PDF file,
- with a help from the teacher write a program for this model and then experiment with changing the program,
- choose another model, build it and program it,
- design own model and program it.

There were few children that designed their own models but these are exceptions and most of children only built models according instructions and made elementary programs with the teacher.

Most of the children worked in pairs. We encouraged the pairs to split the work – one child may look for the parts and the other assembles them, they should also change these roles.

As a first model most of pupils chose the alligator.

4.1 Children without disorders

We have found out that many pupils didn't have any LEGO kits at home and their manual dexterity and fine motor skills were rather poor. We decided that it would be wise to let the children build enough models so they can train both their dexterity and following the instructions in the building directions. However, we also showed them that the models they build can move if they also program them.

Children without disorders needed only little practice and they improved fast. Building models according to the instructions was quite easy for them. Children familiar with LEGO had no problems building the models.

4.2 Low vision children

This group is probably the most demanding and several problems arose:

- almost none of these children were familiar with LEGO and they had huge problems assembling the bricks,
- they needed much more time than other children to make their model,
- children with color vision disorders used different color scheme on their monitors – that hindered their ability to identify the bricks,
- many of LEGO bricks are rather small and low vision children need time to find among them the right ones (we suggest to use magnifying glass).

In spite of these problems children enjoyed the process of building the model. Unfortunately there was no time left to program the model, but we believe that the experience they gained during building according to instructions is valuable. They learned that they need to execute all the instructions in the recipe and do it in the right order – this experience should help them at programming later.

4.3 Totally blind children

We planned to do robotic activities also with totally blind children as well (two children in 9th grade). Bee-Bot activities described in 3.3 were quite successful and we expected them to be able to program a NXT robot using text-based language and modified linear menu for the NXT brick. Unfortunately we have discovered that both children have no experience with building and we decided to do some build-along-instructions activities instead of programming.

We have prepared a model made of basic LEGO bricks in various stages – this is tangible version of visual building instructions. This activity proved to be too difficult and we focused only at feeling the bricks and making simple objects such as wall, tower and so on. We observed that sorting the bricks into separate containers according to their shape is very helpful.

Fig. 5. Building from LEGO bricks with totally blind

To conduct a real robotic activity with programmable model is impossible in this situation. We would need much more time and there is no text-based language for beginners usable with LEGO WeDo models.

4.4 Programming the robotic alligator; LEGO WeDo language vs. Scratch

Children who were able to finish the construction of alligator model soon enough started to create a program to move it. Many children didn't get to this phase – some haven't finished the model, some we instructed to build another model instead of programming (if we thought this was more suitable for them).

The alligator model has built-in motion sensor and a motor. The most sensible (but also rather advanced) program makes the alligator wait for something to come into its mouth and only then it closes the mouth making sounds of chewing, then he opens the mouth again and waits for another pray. This program contains repeat cycle and works with sensory input and is too difficult for absolute beginners. We decided to break down the actions of the alligator and program its behavior step by step individually with each team. With some groups we programmed in Scratch in others we used LEGO WeDo programming language.

- We showed them what happens if we move the motor by finger one way and the other way. Children observed that the alligator opens and closes its mouth.
- In the programming language we showed them how to move the motor using the blocks. In this phase the Scratch was a better choice since it has a block with a parameter setting the duration of the movement. The same action in WeDo means to use two blocks – one starting the motor and other to set the duration of the movement – we find this to be less intuitive. On the other hand WeDo has a bit more intuitive setting of the direction of the movement - there are two separate blocks that start the motor, each with a different direction. In Scratch we need to use a setting block with a parameter to do that. Children made experiments with these blocks.
- In next step we prompted the children to make the alligator continuously open and close its mouth. Some of them made a long sequence of blocks repeating the open-

close section. Only few of them already knew about the repeat cycle construction. We presented several teams with cycle block, but for their proper understanding of how to use it we would need more time and separate activities focusing at cycle block.
- We showed few children how to make sensors work. But again this concept is rather difficult and there should be more activities devoted to understanding sensors and their programming.

4.5 Children designing their robots

Only few children actually had time to create their own models.

In the group of 5-graders 3 children experimented during the last lesson with building their own robots. They settled on simple fans with bricks attached directly to the motor. One of them – a girl – expressed a big disappointment over the simplicity of motor movement and refused to explore its use further.

The most successful was a boy in 9th grade who asked for some extra bricks and within 40 minutes built a car that moved to front and back according to a simple program. This boy had a lot of experience with LEGO from home.

5 Conclusion

During the lessons we have described we found out that activities with a programmable toy Bee-Bot are suitable even for the secondary school pupils especially if they have some sort of disorder and/or are beginners at problem solving and programming. However, we have observed that younger children were more motivated to play with this toy and in general they were also more successful. One lesson with Bee-Bots proved to be enough.

We suggest that if we are working with children who have no experience with LEGO bricks, building along the instructions and programming, it is sensible to focus robotic activities first at building. These children can also explore programs made by teacher, but anything more advanced is probably out of the given time limit.

If we want to focus the robotic activity more at the programming, we suggest teaching some basic programming concepts before engaging in robotic activity. We haven't tried to teach programming solely via robotics – in that case the scenario would be probably much different.

We considered also a possibility to let the children do their own projects from the start in a constructionist way, but due to time constraint we decided against this idea. Different scenarios with robotics for this target group should be explored.

References

1. Kabátová, M. 2010. Konštrukcionistický prístup vo vyučovaní robotiky v príprave budúcich učiteľov : dizertačná práca. (Constructionist approach at teaching pre-service teachers

educational robotics : PhD thesis.) Bratislava : Univerzita Komenského, Fakulta matematiky, fyziky a informatiky, 2010. Website [10.2.2012]: <http://edi.fmph.uniba.sk/~kabatova/clanky/kabatova_dizertacna2010.pdf>

2. Kabátová, M. – Pekárová, J. - Onačilová, D. 2011. Didaktika robotických stavebníc. (Technology of teaching educational robotics.) Bratislava : Štátny pedagogický ústav, 2011.
3. Kabátová, M. 2011. Edukačná robotika a jej didaktika. (Educatioanl robotics and its technology of teaching.) Zborník príspevkov konferencie DidInfo 2011. Banská Bystrica : Univerzita Mateja Bela, 2011. s. 24. ISBN 978-80-557-0142-4
4. Krommerová, A. 2011. Digitálne technológie pre učiteľky materských skôl. (Digital technology for early-years teachers.) Zborník príspevkov konferencie DidInfo 2011. Banská Bystrica : Univerzita Mateja Bela, 2011. s. 29. ISBN 978-80-557-0142-4
5. Pekarova, J. 2008. Using a Programmable Toy at Preschool Age: Why and How? In Workshop Proceedings of SIMPAR 2008, international conference. pp. 112-121. ISBN 978-88-95872-01-8
6. De Michele, M. S. – Demo, B. G. – Siega, S. 2008. A Piedmont SchoolNet for a K-12 Mini-Robots Programming Project: Experiences in Primary Schools. In Workshop Proceedings of SIMPAR 2008, international conference. pp. 90-99. ISBN 978-88-95872-01-8
7. MIT Media Lab. *LEGO's WeDo: An Innovative Robotic Kit for Children.* Website about sponsor activities of MIT Media Lab. Website [12.02.1212]: <http://www.media.mit.edu/sponsorship/getting-value/collaborations/wedo>
8. Lifelong Kindergarten Group. *Scratch*. Homepage of Scratch. MIT Media Lab, 2012. Website [12.02.1212]: <http://scratch.mit.edu>
9. Resnick, M. et al. 2009. Scratch: programming for all. In Magazine Communications of the ACM - Scratch Programming for All CACM Homepage archive, Volume 52 Issue 11, November 2009. ACM New York, NY, USA.

Proceedings of 3rd International Workshop
Teaching Robotics, Teaching with Robotics
Integrating Robotics in School Curriculum
Riva del Garda (Trento, Italy) April 20, 2012
ISBN 978-88-95872-05-6
pp. 22-31