Pilot Activities: LEGO WeDo at Primary School

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Abstract. In this thesis we study the first-contact situation in which 3rd grade pupils in primary school encounter LEGO WeDo for the first time. We compare reactions and the work of two groups of 3rd graders – only one of these groups had previously worked with virtual robotic software and developed their logical and algorithmic thinking. We look for signs that signify using virtual robotic software considerably influenced their ability to solve problems in a LEGO WeDo programming language. We also use these pilot lessons to prove our introductory activities with LEGO WeDo and we make several enhancements for the next iteration. We have made several interesting observations that will serve us as foundations for our next research.

Keywords: primary school, education, Robotics, LEGO WeDo.

1 Introduction: LEGO at school

In Slovakia there was introduced an educational reform in 2008. The educational reform secured a continuous education of information technology for from first-grade pupils in elementary school to A-level pupils. The education of information technology introduced was adopted in the form of a subject in elementary school so the pupils of the first, third and fourth grade have been taught a lesson of the subject each week. Due to the reform being accepted so quickly, there was not enough room for developing methodical and tutorial materials for teachers. The problem has not been solved yet. Therefore we see in here an opportunity to suggest activities for teachers to choose from. We are trying to suggest these activities in accordance with the recent curriculum which the teachers use to create their lesson plans. The education of information technology is divided into five themes:

- information around us,
- communication by ICT,
- methods, solving problems, algorithmic thinking,
- principles of ICT,
- information society.

Each of five themes should develop the competences and skills of pupils. They should teach pupils how to work with new concepts introduced. The thematic scope "Methods, solving problems, algorithmic thinking" includes concepts and competences that can be developed by using robotic kits.

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The concepts pupils familiarize with within the thematic scope:

- a technique, instructions, a formula,
- control of a robot, a series of steps,
- a programming language for children, basic instructions, a program,
- a robotic kit.

Another list of relations, techniques and methods for children to develop:

- to build according to instructions
- to create a technique, a formula, instructions and to learn how to follow step by step the instructions
- to solve tasks with the help of a robot, image puzzles – assembly of an image from its parts, to instantly follow instructions, to carry out instructions according to the sequence in a computer environment.

Here can be seen that the majority of concepts and related directly or at least partially to a robotic kits. Here emerges a question as to which robotic kit is suitable for a development of the concepts mentioned above.

2 Robotic Kits

At the beginning of our project many robots and robotic kits offered on the market were taken into consideration.

A **MoWay** [1] is a small, autonomous, quick robot equipped with attractive sensors, which caught our attention at the exhibition BETT in 2012. The programming language of a MoWay with methodical and tutorial materials for teachers is free to download. However, we think that a Moway with its programming language is not suitable for first-grade pupils in elementary school. This robot cannot change its shape which is considered a disadvantage.

A **PicoCricket** [2] is a tiny computer that can make things spin light up, and play music. You can plug lights, motors, sensors, and other devices into a PicoCricket, then program them to react, interact, and communicate. It is possible to use a wide range of materials to create your own robotic model. From a practical point of view, A PicoCricket is very expensive kit to buy in Europe (due to customs tax and postal fees) which is considered a huge disadvantage. It is very important that robotic kit is available on the market and for a reasonable prize to be accessible for schools.

A **FischerTechnik Universal 3** [3] is a robotic kit developed by FischerTechnik. It is rather focused on models and constructions. A FischerTechnik Universal 3 does not support any programming language. This set provides pathway for introducing younger pupils to everyday technology and to enable them to understand how the things around them actually work. Pupils can build numerous models. Several models can be built simultaneously.

A **LEGO WeDo™ Construction Set** [4] is a classic set designed by Lego. It is a set of pieces and mechanical parts used to build and design LEGO models. The construction contains robot bricks, two sensors, LEGO USB hub and a motor. The set comes with easy-to-use icon-based software providing an intuitive programming environment with building instructions, programming examples, activity tips.

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Nowadays a LEGO WeDo™ Resource Set [5] has been developed. The set allows building more complex and interesting LEGO models or constructions.

After considering all the criteria – financial resources included – we chose the set LEGO WeDo. The possibilities and variety it offered prevailed over its shortcomings. One of its advantages is the software and Activity Pack which contains simple guides for building models, either from imagination or by instruction.

The fact that pupils learn through action is very important according to Ilieva [6]: “Working with LEGO constructional material the children come to know the surrounding world by recreating it.” In a different article [7], the same author mentions another advantage of using LEGO sets: “The lessons in robotics gives the teacher themes and situations that make teamwork appear absolutely natural. So the children will agree to subordinate their own wishes to the aims and objectives of the whole team.” This attribute of robotic sets of bricks used during tuition is considered convenient, since most of our schools are unable to supply each pupil with a separate set of bricks, hence pupils work in teams.

LEGO WeDo can be also programmed through the freeware programming environment Scratch that provides a variety of attractive tools, and recently experienced a significant increase in its usage as available alternative to Imagine. However, we believe that Scratch is not suitable for primary school children.

We find original LEGO WeDo software complex enough and has another advantages: absence of extra advanced elements, simplicity of environment, easy to use iconic design and absence of any textual instructions.

3 Our Activities

The exemplary lessons were designed for, and observed on the third year pupils of the Joint Elementary School of Cpt. Nálepka in Stupava. Parallel observations had been conducted in two 3rd grade classes, which had the same teacher throughout the whole year. Each class (23-25 children) was divided into two groups (9-12 children) - that means there were four groups. We have worked with two of these groups – one of them had been exposed to a virtual robot in software designed for the development of logical and algorithmic thinking before, and the other had not. Children in these two groups were divided into 4 teams (2-3 children). Our aim was to compare their reactions and work progress. We aimed to find out, whether prior work with such software influenced the pupils problem solving abilities. Since we do not have a tool at our disposal that would enable the exact measurement of influences arising from the usage of such a program (we have not conducted quantitative experiment), and we cannot exclude possible involvement of other outside factors, the issue remains unsettled. Naturally, differences in problem solving in the respective classrooms were present, and will be dealt with later on, but we cannot claim that those were caused by the usage of the given software.
Both of our groups have had information technology classes the previous year. In present they have the same subject - one 45mintes long lesson each week.

3.1 First Lesson

Children of this age have sometimes still trouble telling reality from fiction [8] a thus, may be unable to conceive, whether the robot Wall-e from the animated movie could or couldn't really exist. Since they live surrounded by all kinds of modern technologies, the notion of robot is not at all unknown to them. They are, of course, familiar with a variety of household robots (hairdryers, mixers, automatons, wheelchairs, etc.), or robots connected with transportation (trains, planes, busses, etc.), they just cannot perceive, that those are robots too. We are confident, that via guided structured discussion, we will succeed in helping them organize their thoughts or occurrences they had previously experienced, in ever an abstract sense. Thus we may easily design cross-curriculum activities and develop crucial cognitive, communication and social competences.

The success of such a guided structured discussion may rest on the communicativeness of the pupils in the given group, which became apparent in our case as well. While one of the groups was rather laconic, the other was a lot more talkative. Without doubt, it at least creates an incentive for the children to consider some of the notions or patterns introduced in the discussion.

The guided structured discussion dealt with the following questions:

- What is the purpose of robots?
- What robots do you know? Name them.
- Have you ever encountered them? Have you ever encountered any? What kinds? Where?
- What materials are they built from?
- Can robots think?

We tried to give the children enough time to deal with these questions, to think through what it was they wanted to say. Despite this fact, they often gave the impression, that they said anything that came to their mind. Even then, formulating their ideas took a certain amount of time. They named a few tasks which they believed could be performed by robots, mostly things related to helping people. When we attempted to sum up all the mentioned facts, concluding that these were things robot were capable of, we asked whether they could think up anything else. The children were unable to respond and they continued naming examples that had already been mentioned. They were unable to divide the attributes into those that are helpful, and those that are not. Someone mentioned a robot from a movie, but mostly, they were robots meant to aid the sick, a wheelchair, mechanical arms, that their movements were rigid, etc.

Concerning the question of what those robots can be made of, children were given a small hint, or they by themselves arrived at the conclusion, that the robots could be made of some sort of bricks, for example LEGO. Owing to the previous question, they knew that certain means of transport were robots. Thus, we went to build such a robot – a little plane – which partly served as motivation, which actually was not even necessary, since all the children wanted all along, was to play with the LEGO.

The opening discussion was an asset, because the LEGO WeDo program could be more easily compared to the natural language of the robot. We presented the environments of WeDo and Scratch as two different languages (e.g. Slovak and French), which the robot understands. Eventually, due to practical reasons, such as the fact that one class lasts only 45 minutes, which is a rather short time span, we explored only the WeDo code for programming. Every command in this environment starts with a yellow-green starting button with a “play” sign. This could be easily compared to the beginning of a sentence, pursuant to which the robot knows that it should start listening. The remaining blocks can be compared to the words in the sentence. The simile was understood without problems, and the children were able to apply it further in practice.

The first lesson was introductory in a sense, that it was necessary to collect data about experience of the children with LEGO. However, during the introductory discussion, most of them claimed that they had been working with LEGO before. Besides we wanted to find out

- if the recommended age manufacturer stated corresponds with our experience,
- how much time does it take children to build a model according instructions,
- if the assembly of LEGO bricks together is not too difficult regarding the fine motor skills of these children.

As a first model we choose the airplane which we consider to be intermediate. Pupils worked in pairs and were able to build the whole model in 15-20 minutes. There were some minor problems with attaching the motor and with lack of robustness of the model – some parts were constantly falling apart. In spite of the problems with construction children were not disappointed. We believe they developed they fine motor skills.

Towards the end of the lesson (about 10 minutes before the end) they had to get the motor moving. **The assignment** consisted of three tasks as follows:

- Activate the propeller. Find out which blocks are suitable to do so.
- Have it move once in one way, once in the opposite direction.
- Simulate a situation when the motor is broken.

We have explained details of the assignment and meaning of various blocks to each team separately. The blocks are color-coded and the color indicates common functionality.

We let them to discover the functionality of each individual block group. However, as we were short of time, we had to abandon the idea that pupils would manage to fulfill the task in both environments, Scratch and WeDo. Only one pair of girls managed to do it. Boys were quite skilful, but they did not follow the task; instead, they tried out various blocks such as the cycle or sound block. In result, they either did not manage to finish the tasks or completed them among the last ones.

Here are several interesting **observations** we made while watching both groups:

- We think that the use of the Scratch program during pupils’ first encounter with the WeDo kit is not suitable for several reasons, unless pupils have used the program beforehand.
- Boys were faster in building up the models than girls.
- Girls were faster in completing the tasks focused on programming than boys.
- The group of pupils who had previously worked with a program to develop logical thinking, which included programming language elements, was not significantly more skilful than the group who had not worked with such program before.

3.2 Second Lesson

The lesson focused on testing the depth and difficulty that pupils of the given age can manage. Likewise, we had to try out how we are to formulate the tasks and choose level of demand.

Pupils worked in pairs, as they did at the first lesson. They were distributed models for their work, already built by the teacher. And again, we used airplanes. Every team received one work sheet and one airplane connected to a computer. The nature of tasks on the work sheet was varied. Most of them were partially constructivist. For example: Try this out. (Next to this was a picture of block they had to use). Write down what happens if you put these two "sentences" together.

We can assess retrospectively that there were too many tasks on the work sheet for one lesson. We learned that most of tasks must be split in several subtasks. The pupils must be given more time to understand individual functions, which were the focus of our tasks. The progress was slow, because every team needed personal attention, further explanation of findings that they might have made but were unable to describe. All pupils had trouble with formulating their own thoughts into sentences.

Work in pairs was an advantage, because while one pupil worked with the program, the other one was filling in the work sheet and then they swapped.

When one pair of pupils discovered the work sheet has a reverse page to be filled in too, this made them unhappy because they preferred building models to writing. Now a question arises: Why are children more interested in building the model then programming it and making it move?

This question remains unexplained but we find it interesting and plan to investigate further.

The second lesson showed that bigger difference between the two groups under observation. The first group, which already worked with a program developing logical thinking, managed to complete much fewer tasks during the lesson than the other group. However, after studying the filled-in work sheets, we may conclude that their thoughts are more profound and these pupils tried hard to understand principles of functioning of individual control elements. Their answers in fact disclosed that their responses were algorithmically more sophisticated. They even joined one another during the lesson to explain things they had discovered. On the other hand, the answers of the other group implied that they wanted to have it done quickly and they did not think over their answers deep enough. During the lesson, they even did not ask why things are as they are and what they should do to make it work. They skipped certain tasks completely.

We do not want to attribute this only to the use of single software in the past; there are strong reasons to assume that this could be the result of previous tutoring by different teachers.

Here are several interesting **observations** we made while watching both groups:

- Working in pairs is suitable.
- Pupils were unable to clearly formulate sentences regarding their ideas and what they discovered.
- Pupils find building models more attractive than programming.
- Girls worked on tasks systemically and finished sooner than boys.

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- The group of pupils who had previously worked with a program to develop logical thinking, which included programming language elements, completed fewer tasks, but understood them more profoundly. They were curious why certain things do not work and what they should do to make them function.

4 Further research

As we mentioned in the introduction, our goal is to design LEGO WeDo activities for the pupils in second, third and fourth grade of primary school. On average, it will be about 5 lessons each year. In general, work with robotic kits is not very common in educational work in primary schools. We haven't found much information about work with LEGO WeDo in primary schools. It is possible that our search was not thorough enough but we suspect that after a long time devoted to this task some useful material would come up. There are lots of materials that deal with using Pico Cricket [9], but the activities are conducted in much different educational environment (in the USA). For example presenting of own work is not common in primary schools in Slovakia and the children are not encouraged and used to do so.

We will use this study and preliminary data collection in next phases of our research. We plan to conduct qualitative design-based research using modified grounded theory [10] in which we will go through several iterations. Our current stage is the orientation iteration – we intentionally came to the classroom with "zero knowledge" of the situation and using the qualitative data collection methods we gradually build this knowledge solely based on the observed phenomena. Therefore we designed the first and the second lesson to the width incorporating wide range of various tasks.

During the activities various key competences are developed as both we (researchers) and the teacher have observed. Which particular competences are developed and how is difficult to describe yet. We will continue to scrutinize this in our further research.

Meanwhile we have conducted another 3 lessons with 3 different groups (2^{nd} 3^{rd} 4^{th} graders). We have observed particular skills that the children developed and we will match them with corresponding key competences. Besides we have observed and described interesting process of knowledge acquisition during the work with LEGO WeDo. We scrutinize this in a different paper (that is not published yet). Later we will examine also the process of communication and knowledge transfer in the classroom among the pupils. The ongoing research confirms also the findings from this paper.

5 Conclusion

We believe that teaching with educational robotics is an attractive form of education for many pupils. It contains motivational element itself and provides many unexplored opportunities for pupils' development. We are sure that this is the spot, where pupils can see and understand the link between real physical world and abstract

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programs. We perceive educational robotics using tangible objects is the easiest way for children to understand programming language.

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