



PROGRAMMING WITH MOTION SENSOR USING LEGO WEDO AT LOWER SECONDARY SCHOOL

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Abstract

Educational robotics has become one of the popular and motivational tools of learning for mostly science and technology oriented classes. Its application in teaching specific subject is not very simple. Initiative teachers have encountered many questions, which include the selection and development of specific types of activities that can allow students to extensively utilize the potential of the selected robotic kit. In our research we have been working with educational robotics in informatics at lower secondary school. In this paper we focus on the fifth grade students, which worked with robotic kit LEGO WeDo. We analysed different types of activities, where pupils were programming the robotic model with usage of motion sensor. Our aim was to identify what types of activities the pupils resolved correctly and in what types of activities pupils most often made mistakes. In pursuit of that, we can create a more concise and easier to understand version of tasks to program the robotic model. These activities are part of the curriculum with educational robotics, which we have been developing within our doctoral research. We have been conducting design base research within we chose qualitative methods of data collection and data analysis. Based on data analysis, we found that in most cases pupils solved prepared tasks, in which they worked with programs from the worksheets (modifying the program, explaining the differences between the two programs and completing programs). Pupils mostly made mistakes in explaining a particular program and in creating a certain sequence of commands in program. In the next phase of our research we are going to modify mentioned activities so pupils can better acquire problem solving skills, programming skills and communication and collaboration skills.

Keywords

educational robotics, robotic kits LEGO WeDo, activities with motion sensor, lower secondary school

Introduction

In many countries educational robotics increasingly occurs from preschool to university courses (Cappelleri, Vitoroulis, 2013; Detsikas, Alimisis, 2010; Benitti, 2012; Bers et al., 2014). Researches and teachers have been trying to motivate students to learn mostly science and technology classes and there students can acquire and develop for example problem solving skills (Hussain, Lindh, Shukur, 2006; Sullivan, 2011; Castledine, Chalmers, 2011; Denis, Hubert, 2001), programming skills (Atmatzidou, Markelis, Demetriadis, 2008; Burbaite, Stuikeys, Marcinkevicius, 2012), creativity, communication and collaboration skills (De Michele, Demo, Siega, 2008; Demo, Siega, De Michele, 2009). Application of educational robotics in teaching specific subject is not very simple. Initiative teachers have encountered many questions, which include the selection and development of specific types of activities that can allow students to extensively utilize the potential of the selected robotic kit. In our research we have been trying to integrate educational robotics into informatics at lower secondary school.

Research methods

In this article we describe different types of activities with selected robotic kit LEGO WeDo, in which we focus on programming robotic model with motion sensor. These activities are part of our curriculum with educational robotics, which we have been iteratively developing during our doctoral research. In activities with motion sensor we used qualitative data collection and data analysis (Švaříček et al., 2007) including observations (fieldnotes and transcriptions), audio-visual materials (photographs and recorded videos of pupils' work and pupils' products). We conducted our research with two classes of fifth grade pupils at lower secondary school in Stupava (small town near the capital city of Slovakia). At first we designed activities with educational materials. We created methodological materials for teacher and worksheets for pupils. Afterwards selected teacher taught her pupils according our materials – one lesson per week. There were approximately from 10 to 11 pupils in one class – boys and girls in different ratio each week. During all of these classes with robotic kits there were present also two researchers, who were collecting data.

Motion sensor in robotic kit LEGO WeDo

During designing activities with motion sensor we were examining its properties, functionality and different ways to program robotic model with it. LEGO Education WeDo Construction Set includes carefully selected bricks in different colour, gears, axles and pulleys, which can bring motion to models, special components, such as rope and elastic bands, which can increase varied range of models pupils can create and two minifigures. There are also Power Functions M Motor, two sensors (motion sensor and tilt sensor) and WeDo USB Hub. It controls motor and sensors via software for WeDo robotic kit, when it is connected to a computer. Motion sensor can detect objects within 15cm range (The LEGO Group, 2015). It is automatically detected by software, when we connect it with USB Hub to a computer (see Figure 1).



Fig. 1: Connection of motion sensor in software for LEGO WeDo robotic kit

We provided description of software environment for LEGO WeDo in (Mayerová, Veselovská, 2014). Here we focus primarily on types of activities within programming with motion sensor. In this software motion sensor is located in the form of parameter, which can be represented by integer or state. Value of motion sensor parameter can acquire integer value from 0 to 10 (0 – object is further than 15 cm from sensor, 10 – object is right in front of sensor). On Figure 1 we can see sensor, which detects object at a distance of nearly 15 cm and parameter of motion sensor contains an integer value 1. Value of motion sensor parameter can also have two states: it does detect a movement and it does not detect a movement. It is not dependent on whether motion sensor detect object or not at the first time. We can use this parameter in different ways and in mentioned software it can be connect with various icons of commands. On Figure 2 we can see five icons of commands (motor power, sounds, display text on computer screen, display background on computer screen, add value of number to display), connecting with them parameter can contain integer value.



Fig. 2: Icons with motion sensor as a parameter with integer value

On the left of Figure 3 we can see three icons of commands, connecting with them parameter can contain two states. These icons are representing from left:

- motor on until sensor detect motion,
- wait until sensor detect motion,
- count loops (a loop with a known number of repetitions, but without an explicit loop variable) until sensor detect motion.

These commands can be parameterized to produce different behaviour of robotic model / program (on the right of Figure 3). These icons are representing from left:

- motor on for ten periods of time (we labelled it as ten LEGO seconds),
- wait for ten LEGO seconds,
- count loops with three repetitions.



Fig. 3: Icons with motion sensor with state parameter (on left) and same icons with integer value as a parameter (on right)

When we were designing activities with motion sensor, we were carefully creating and selecting tasks for pupils. We tried to prevent possible misconceptions with application of known icons of commands (icons previously connected with integer value as parameter). At first pupils worked with these icons of commands with motion sensor as parameter, where it can acquire integer value. So this motion sensor as a parameter worked like known integer value as parameter. And later pupils worked with combination of icons with motion sensor as parameter, which can acquire a state value.

Activities with motion sensor

Activities with motion sensor are part of our curriculum with educational robotics, which currently has 12 lessons (one lesson = 45 minutes, one lesson per week). During all these activities pupils were working in pairs (alternatively one pupil worked alone, when there was uneven quantity of pupils). Before activities with motion sensor we had been conducting four lessons with pupils. During first three lessons pupils had clarified a term of robot, constructed robotic models according building instructions and examined basic icons of commands (icons for motor control and icons, which play sound) in software. In fourth lesson we had followed principles of “creative robotics for all” (Rusk et al., 2007):

- focus on theme,
- combine art and engineering,
- support storytelling,
- organize exhibitions.

During this lesson pupils had created their own robotic models and their own programs for controlling them. Then we were conducting activities with motion sensor, which we had divided into three lessons. We can see specific types of tasks with motion sensor in Table 1. We divided these activities into three categories, which include constructing robotic model, programming robotic model and presenting robotic model. Then we evaluated pupils work according these three categories.

	Types of tasks with robotic model		
	Programming	Constructing	Presenting
1. lesson	Acquaintance with different ways of usage motion sensor	Build a model according instructions in worksheet	Explain your work to teacher
	Describe the behaviour of the model (describe the program)		
	Create a program exactly as ordered		
Bonus	Create your own program with specific icons: loop, motor power, motor on for, sounds, motion sensor	Edit a model according to your imagination	Explain your work to teacher and your classmates
2. lesson	Create your own program with icons: loop, motor power, motor on for, wait, motion sensor	Create your own model with motor and motion sensor	Explain your work to teacher and your classmates
3. lesson	Describe the behaviour of the model (describe the program)	Create part of model with motion sensor according a picture in worksheet	Explain each task to teacher
	Change program as ordered		
	Describe the differences in the behaviour of the model in the control of program A and program B	Complete model to contain the motor	
	Complete program by request		
Bonus	Create your own program		Explain your work to teacher and your classmates

Tab. 1: Different types of tasks with robotic model

First lesson with motion sensor

At the beginning of the first lesson selected teacher started with frontal form of teaching, where she was asking pupils open questions, for example: “Do you know how motion sensor looks like? How can we connect motion sensor to computer? Which icon is representing motion sensor in software? With which icons can we connect motion sensor? How many are there? ...”. These way pupils could have feedback from teacher almost immediately and also they could discuss it with their classmates. This part of the lesson is marked as *Acquaintance with different ways of usage motion sensor* in section *Programming* of Table 1. Then pupils were building robotic model according instructions. We can see final model on Figure 4.



Fig. 4: Robotic model, which was built according to instructions

Subsequently pupils were programming robotic model according two different types of tasks in worksheet (column *Programming* in Table 1):

- they were describing the behaviour of the robotic model - describe the program.
- they were creating a program exactly as instructed.

Also we can see examples of mentioned tasks on Figure 5. In first example (in top of Figure 5) pupils were describing the behaviour of the robotic model to teacher and they were also writing it down into worksheets. In second example pupils were creating program according instructions in worksheet. We can see final program is in the bottom of Figure 5.



Fig. 5: Two programs from two different types of tasks from worksheet

During this lesson pupils can also work on Bonus task, in which they were creating their own program, but with specific icons: loop, motor power, motor on for, sounds, motion sensor.

Second lesson with motion sensor

In this lesson we followed principles of “creative robotics for all” (Rusk et al., 2007), which we mentioned earlier and some constructionist ideas (Papert):

- learning by doing, hand-on activities,
- genuine achievement and own solutions, problem finding,
- hard fun and playful learning,
- learning through designing and creating,
- freedom to make mistakes,
- teamwork, communication, collaboration, sharing work and ideas.

During this lesson pupils were building and programming their own robotic models with some specific conditions within the selected theme **Intelligent servant**. Robotic model should contain motor and motion sensor. Program to control robotic model should contain selected icons of commands: loop, motor power, motor on for, wait and motion sensor. Pupils could connect motion sensor with each of selected icons, but minimum was connection of motion sensor and one of mentioned icons. At the end of lesson pupils was presenting their robotic models and programs to teacher and classmates. Pupils had to introduce a name of robotic model and they had to explain its purpose and behaviour. We can see examples of pupils’ robotic models on Figure 6 and their programs on Figure 7.

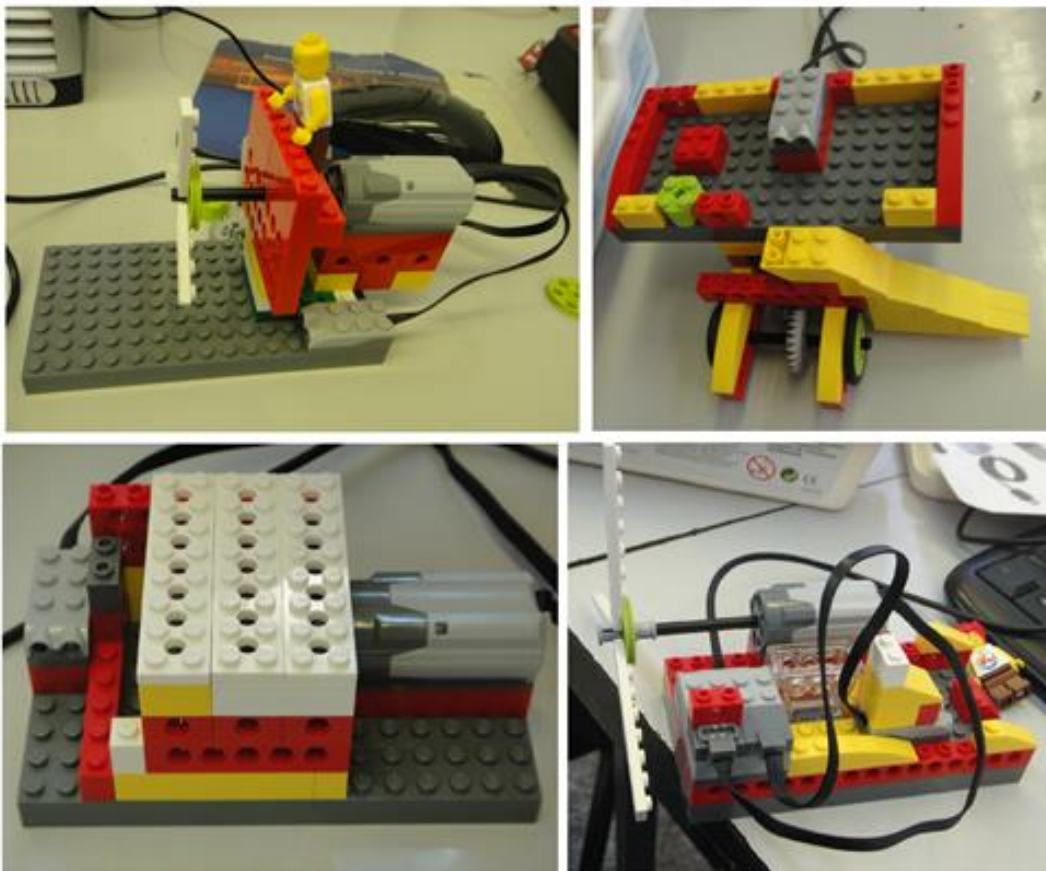


Fig. 6: Pupils’ original robotic models, which they constructed within selected theme Intelligent servant



Fig. 7: Pupils' own programs to control behaviour of their robotic models

Third lesson with motion sensor

During third lesson pupils were building part of the robotic model with motion sensor according a picture (on the left of Figure 8) and then they were completing robotic model according their imagination, but with a one condition: robotic model should contain also motor. We can see example of final robotic model on right of Figure 8.

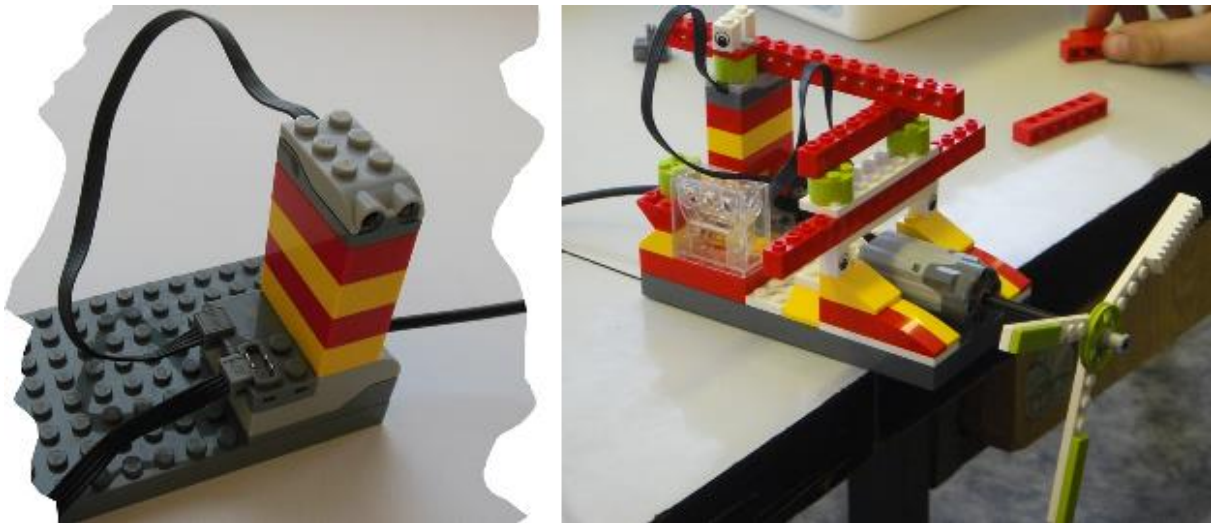


Fig. 8: Part of robotic model (on left), final robotic model (on right)

Afterwards pupils were programming robotic models according four various tasks in worksheets (column *Programming* in Table 1):

- they were describing the behaviour of the model (they were describing the program),
- they were changing program as instructed,
- they were describing the differences in the behaviour of the model in the control of program A and program B,
- they were completing program by request.

During this lesson pupils can also work on Bonus task, in which they were creating their own program without any conditions.

These tasks should provide some clarity of usage several types of icons connected with integer value as a parameter and with motion sensor as a parameter.

Example of one task from worksheet:

Describe the differences in the behaviour of the robotic model in the control of program A and control of program B (on Figure 9).



Fig. 9: Example of programs from worksheet, where pupils described differences between these programs

Correct solutions and identified mistakes

Based on data analysis we concluded that in most cases pupils solved correctly prepared tasks, in which they worked with programs from worksheets:

- modifying the program,
- explaining the differences between the two programs,
- completing programs.

We can see examples of final programs from task with modifying the program on top of Figure 10 and we can see example of program from task with completing programs on bottom of Figure 10. We can see example of programs from worksheet, where pupils described differences between these programs on Figure 9.



Fig. 10: Correctly modified program (on top) and correctly completing program (on bottom)

Pupils mostly made mistakes in explaining a particular program and in creating a certain sequence of commands in formed program. For example pupils were describing program, which we can see on bottom of Figure 11.



Fig. 11: short program (on top) and longer program (on bottom), with which pupils were describing behaviour of robotic model

In mentioned program pupils often did not describe each icon of commands:

“Motor was spinning, then it was waiting for 20 LEGO seconds and then it was turning to other side.”

“Motor was turning right with its power 7 and for 10 LEGO seconds, then motor was waiting for 20 LEGO seconds.”

“Robotic model was turning right with power 7 and for 10 LEGO seconds. Then it was waiting for 20 LEGO seconds. Then it was turning left for 10 LEGO seconds and then motor stopped.”

As we can see pupils did not describe all icons of commands in program. They did not describe:

- some of lasts icons of commands,
- some of icons, with which we can set direction of rotation of motor, motor power and motor on for specific number of LEGO seconds,
- icon of display text on computer screen.

When pupils were describing short program such as on top of Figure 11, they created imprecise descriptions, for example:

“Motion sensor adapts to the speed of motor.”

“When sensor detects minifigure, motor started to spin.”

Pupils made mistakes, when they were explaining not only programs from worksheets, but even when they were explaining their own programs. One team of girls was describing their program, which we can see on bottom of Figure 6 such as:

“When we run the program, minifigure starts to put clothes to washing machine. So motion sensor detects minifigure and washing machine start to wash. It will stop, when minifigure go away.”

This team described their program completely incorrect. At first they did not describe icons of commands in their program precisely and they did not describe behaviour of their robotic model at all. One of correct explanations of their program could be:

“When we run the program, washing machine starts to wash in one direction and its power basis on minifigures distance from motion sensor. When motion sensor detects motion again, washing machine starts to wash in other direction and also we can hear a sound basis on minifigures distance from motion sensor. This repeats twice.”

When pupils were programming robotic model according the tasks in worksheet, they were creating incorrect sequence of icons and they were not using all icons within the particular task. When pupils were programming their own robotic models, they did not use all required icons (they did not use loop or motor on for), because they wanted to create their own program according only to their imagination. We can see examples of pupils programs on Figure 7.

How programming robotic model can achieve educational aims of informatics in Slovakia?

Within programming robotic model pupils could acquire problem solving skills and programming skills. Pupils used programming language to define robots' behaviour, so they applied the rules on the construction of a simple educational programming language for robotic kit LEGO WeDo by direct manipulation of icons of commands assembled into sequence.

Pupils:

- evaluated this sequence of commands,
- found mistakes in sequence of commands,
- modified sequence of commands.

They also interpreted the differences between two various sequences of commands and they specified integer number of repetitions of particular sequence of commands.

Conclusion

In this article we described various types of activities with motion sensor, which are part of our curriculum for educational robotics at lower secondary school. We divided these activities into three lessons and we provided list of different types of tasks within each lesson. In data analysis we focused on various types of tasks with programming robotic model. We identified types of tasks, where pupils created correct solutions and types of tasks, where pupils made mistakes. In next phase of our research we are going to modify mainly types of tasks, where pupils mostly made mistakes and also we are going to edit whole activities, so for example pupils can better acquire problem solving skills, programming skills and communication and collaboration skills. We believe that our iteratively created activities for educational robotics will serve mainly for achievement of educational aims in informatics at lower secondary schools in Slovakia and they

will serve for development of various important knowledge, ability and skills, which pupils can use not only at school, but even during leisure time activities.

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References

- ATMATZIDOU, Soumela, Iraklis MARKELIS and Stavros DEMETRIADIS. The use of LEGO Mindstorms in elementary and secondary education: game as a way of triggering learning. *Workshop proceedings of International Conference on Simulation, Modeling, and Programming for Autonomous Robots (SIMPAN)* [online]. 2008, p. 22-30 [cit. 2015-03-05]. ISBN 978-88-95872-01-8.
- BENITTI, Fabiane Barreto Vavassori. Exploring the educational potential of robotics in schools: A systematic review. *Computers & Education* [online]. 2012, vol. 58, issue 3, pp. 978-988 [cit. 2015-03-05]. DOI: 10.1016/j.compedu.2011.10.006.
- BERS, Marina Umaschi, Louise FLANNERY, Elizabeth R. KAZAKOFF, Amanda SULLIVAN and Veronicah LARKIN. Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education* [online]. 2014, vol. 72, p. 145-157 [cit. 2015-03-05]. DOI: 10.4324/9780203808849.
- BURBAITE, R., V. STUIKYS and R. MARCINKEVICIUS. The LEGO NXT Robot-based e-Learning Environment to Teach Computer Science Topics. *Electronics and Electrical Engineering* [online]. 2012, vol. 18, issue 9 [cit. 2015-03-05]. DOI: 10.5755/j01.eee.18.9.2825.
- CAPPELLERI, David J. and Nikolaos VITOROULIS. The Robotic Decathlon: Project-Based Learning Labs and Curriculum Design for an Introductory Robotics Course. *IEEE Transactions on Education* [online]. 2013, vol. 56, issue 1, pp. 73-81 [cit. 2015-03-05]. DOI: 10.1109/te.2012.2215329.
- CASTLEDINE, Alanah-Rei and Chris CHALMERS. LEGO Robotics: An Authentic Problem Solving Tool?. *Design and Technology Education* [online]. 2011, vol 16, issue 3, pp. 19-27 [cit. 2015-03-05]. ISSN 1360-1431.
- DE MICHELE, M. Stella, G. Barbara DEMO and Simonetta SIEGA. A piedmont schoolnet for a k-12 mini-robots programming project: Experiences in primary schools. *Workshop proceedings of SIMPAR 2008 Intl. Conf. on simulation, modeling and programming for autonomous robots* [online]. 2008, pp. 90-99 [cit. 2015-03-05]. ISBN 978-88-95872-01-8.
- DEMO, G. Barbara, Simonetta SIEGA and M. Stella DE MICHELE. *University and primary schools cooperation for small robots programming*. Springer Berlin Heidelberg, 2009. ISBN 978-3-642-04753-4.
- DENIS, Brigitte and Sylviane HUBERT. Collaborative learning in an educational robotics environment. *Computers in Human Behavior* [online]. 2001, vol. 17, 5-6, pp. 465-480 [cit. 2015-03-05]. DOI: 10.1016/s0747-5632(01)00018-8.

DETSIKAS, Nikolaos and Dimitris ALIMISIS,. Status and trends in educational robotics worldwide with special consideration of educational experiences from Greek schools. *5th International Conference on Informatics in Schools: Situation, Evolution and Perspectives* [online]. 2011, pp. 1-12 [cit. 2015-03-05]. ISBN 978-3-642-24721-7.

HUSSAIN, Shakir, Jörgen LINDH and Ghazi SHUKUR. The effect of LEGO training on pupils' school performance in mathematics, problem solving ability and attitude: Swedish data. *Educational Technology & Society* [online]. 2006, vol 9, issue 3, pp. 182-194 [cit. 2015-03-05]. ISSN 1436-4522.

MAYEROVÁ, Karolína and Michaela VESELOVSKÁ. The Programming Environment For the Lego WeDo Robotic Construction Set. In: *Information and Communication Technology in Education*. Ostrava: University of Ostrava, Pedagogical Faculty, 2014, pp. 149-157. ISBN 978-80-7464-561-7.

PAPERT, Seymour. The Eight Big Ideas of the Constructionist Learning Laboratory. Unpublished.

RUSK, Natalie, Mitchel RESNICK, Robbie BERG, Margaret PEZALLA-GRANLUND and Stephanie LUDI. New Pathways into Robotics: Strategies for Broadening Participation. *Journal of Science Education and Technology* [online]. 2007, vol. 17, issue 1, pp. 343-361 [cit. 2015-03-05]. DOI: 10.4018/978-1-4666-0182-6.ch017.

SULLIVAN, Florence R. Serious and Playful Inquiry: Epistemological Aspects of Collaborative Creativity. *Educational Technology & Society* [online]. 2011, vol 14, issue 1, pp. 55-65 [cit. 2015-03-05]. ISSN 1436-4522.

ŠVARŤÍČEK, Roman and Klára ŠEĎOVÁ. *Kvalitativní výzkum v pedagogických vědách*. Vyd. 1. Praha: Portál, 2007, 377 s. ISBN 978-80-7367-313-0.

THE LEGO GROUP. *LEGO Education: Brick Set Introduction*. [online]. 2015, [cit. 2015-02-05] Available from: <http://education.lego.com/es-ar/learn/elementary/wedo/teaching-resources/brick-set/brick-set-introduction>