PILOT STUDY: EDUCATIONAL ROBOTICS AT LOWER SECONDARY SCHOOL

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Abstract

For over a year we have been developing a curriculum for using educational robotics at lower secondary school. We conducted a pilot study at the fifth grade where we tried to identify how pupils of that age work during designing of a robotic project, building and programming it and presenting the whole project, which is focused on a selected topic: Fairyland. We used qualitative methods for data collection and analysis. Based on the results of data analysis we concluded that pupils had several problems with working at designing the robotic model, because they had unreasonable expectations of a robot's structure and robot's capability. So in some cases pupils could not implement their robotic model designs. During making presentations pupils met some problems too. Nevertheless, almost all pupils designed, built and presented their created robotic models. We concluded that pupils have not mastered several important skills (communication and collaboration skills, problem solving skills and skills to perform before audience) which are necessary both for a fully functioning life in society and for realizing leisure time activities. So we assume that pupils should develop mentioned skills at first during creating smaller robotic projects and then they can work at longer robotic projects.

Keywords educational robotics, LEGO, project based learning, lower secondary school, constructionism

1. Introduction

Application of robotics in education has been explored for more than a decade by many teachers, scientists, researchers, educational institutions and other organizations [1]. Robotics in the education provides a platform for developing different skills that support very naturally not least essential ideas of constructionism [2]. Based on an analysis of actual researches, we found that the educational robotics is mainly used in teaching technical subjects or science [3]-[10]. Rarely is used in the teaching of art, native or foreign languages [11]-[14]. Majority of studies implemented during lessons were used robotic LEGO Mindstorms, either the older version of RCX with RoboLab software, or later NXT programming language NXT-G [15], [16]. Researches [17] dealing with programming languages for LEGO and their appropriateness for a particular age group. They recommend students to use for first-contact an adapted version of the programming language NXT-G and about a year later, the original version of programming language NXT-G. Customized version of the programming language NXT-G was suggested on the basis of the expected arrival of the new LEGO. This LEGO WeDo is now available on the market. Also other studies recommend

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Lego WeDo for the selected age group of 10 – 12 years [18], [19]. Another interesting alternative of LEGO WeDo is its possibility to connect to the programming language Scratch [20]. There are many studies that used constructivist [21]-[25] and also constructionist [15], [16], [26] methods in the teaching with robotic kits. Robots and robotic kits can be used also for storytelling [11], [27]. In our research we want to create, implement and renew such activities that would be appropriate and interesting for our target group (10 – 12 years old pupils). They should contain basic elements from the field of informatics, Slovak language, storytelling and lots of elements from various other subjects.

2. Pilot study

In this article we describe pilot study with 10 – 11 years old pupils, who worked with robotic kit LEGO WeDo at lower secondary school. This study is part of doctoral research, in which we try to create, test and iteratively enhance curriculum for educational robotics for pupils in selected age (10 – 12 years old) with mentioned robotic kit. During past three years we have been conducting almost similar research with primary school children [28], [29], where we have acquired some knowledge about how children perceived concept robot [30].
We divided our pilot study into two parts. In first part we conducted several types of introduction activities, where we decided which robotic kit and which software for this kit are appropriate for our new curriculum. We described in detail this part of our research at conference in Slovakia [30]. Based on the results of first part of research we assume that robotics kit LEGO WeDo with its original software is the most appropriate robotic kit for our research [19]. In second part of our pilot study we continued in working with pupils, who had been working with selected kit and selected software from first part of study. In this part of pilot study we followed principles of „creative robotics for all" by Rusk et al. [11]: focus on the theme, combine art and engineering, support storytelling, organize exhibition. In this study we used several qualitative methods of data collection and data analysis including observation (fieldnotes, transcriptions and drawings), focus groups, audiovisual materials (pictures, photographs and recorded videos of pupil's products). In data analysis we used qualitative technique "show of cards" [31], [32] based on video recorded data, which we transcribed into text and coded it. In those codes we found system, which we will try partly explain in next chapter.

3. Second part of pilot study: Fairyland

Main aim of this part of pilot study was to find out how pupils proceed in a designing of robotic project, building and programming robotic models and presenting whole project, which is focused on selected topic: Fairyland. During this part pupils were working in five teams, which consisted of pairs or triplets. This part took place in the range of three lessons. Pupils' informatics teacher and two researchers were present at all of these lessons. One researcher was teaching each lesson and other researcher was collecting data.

2.1. First lesson – Design of robotic project

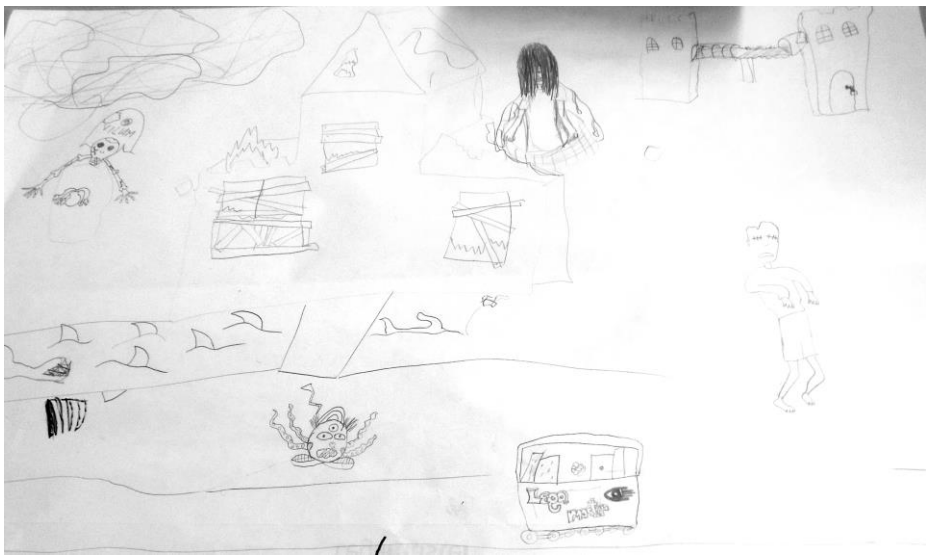
At first lesson pupils were creating design of robotic project. This design should contain name of robotic model along with partial description of its construction and its future behaviour (functions). Design should contain even story with this particular robotic model. Pupils should write about that in text editor and then they should send it to e-mail address of one researcher. During creating this

design more than half of all teams (three teams of five) were focusing on writing stories. We can see example of such a story (story about Haunted castle) in picture 1. These teams were describing neither construction nor behaviour of their robotic models. Two teams (of mentioned three teams) tried to draw main characters and scenery of their story (example of it is in picture 2). The other two teams were not describing story about robotic models, but they were focusing on writing several names of main characters or they were describing different powers of main character and its purpose in their future story, although they were not describing the story itself.

HAUNTED CASTLE

Hello, my name is Miriam Robert and name of my step brother is Tomas Bruder. One time we went for a trip to forbidden street. Its name is Clown milk. This street was abandoned for a long time and bad rumours were spreading there. But I decided that I and my brother will visit this place. In the morning I yelled on him: "Tomas wake up, it's time!" He wasn't responding and I had to wake him up, so I pushed him from bed. At that moment he waked up.

Picture 1: *The beginning of the story about Haunted castle*

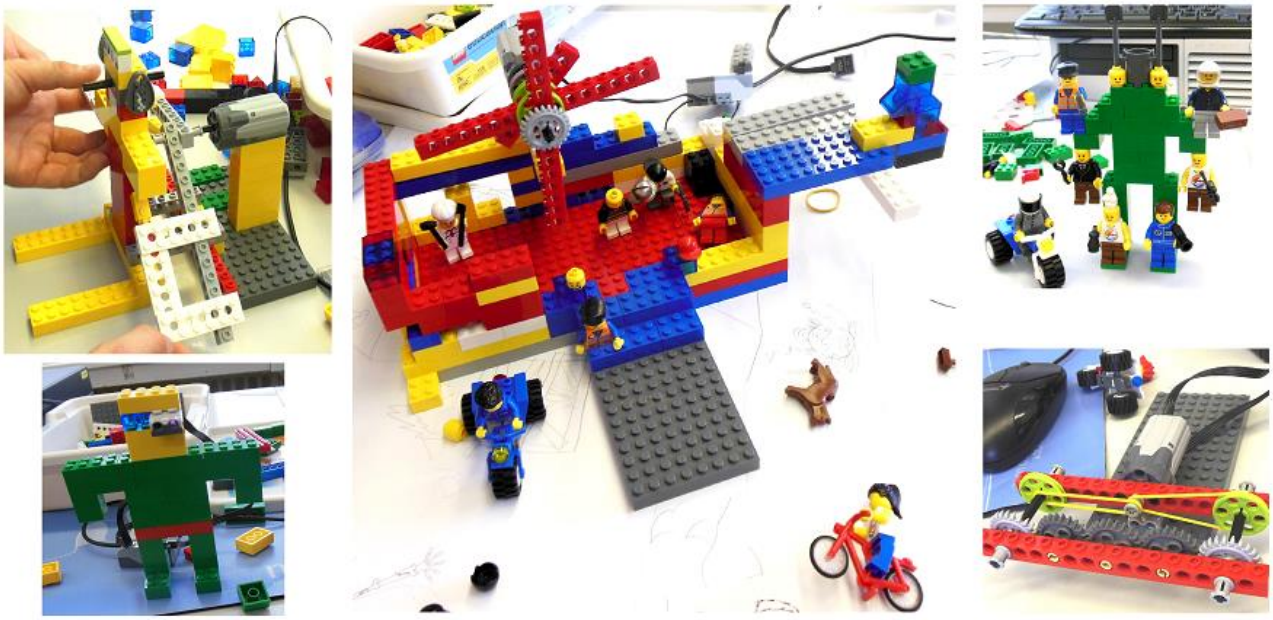


Picture 2: *Picture of scenery and characters of the story about Haunted castle*

2.2. Second lesson – Creating and programming robotic model

At second lesson pupils were working (creating and programming) on their robotic project with robotics kit LEGO WeDo, which they had described at first lesson. Almost all of the teams were following their design of robotic project, which had been created at first lesson. Two teams (which had written story and had drawn it on paper) created scenery of their story from LEGO materials and they also built and programmed robotic model (robotic model must consist motor and/or at least one sensor). Example of robotic model, which was built according to design of robotic project, is Haunted castle and it is located in the middle of picture 3. Pupils in one team figured out that they could not follow their robotic design because they could not create dragon which could breathe fire, lightning, sulphur and which could walk and jump. Pupils in this team changed design of their robotic project and they built robotic model of dragon with moving wings (top left of picture 3). Pupils in another team could not find out how to use motor or sensors on their model, so they built

model only with LEGO bricks (top right of picture 3). Pupils in other team could not follow their design of project, because it contained only names of main characters of their story and it did not contain story itself or description of robotic model. This team found instruction for building simple robotic model with robotic kit LEGO WeDo on internet, although that robotic model was not compatible with their design of robotic project from previous lesson (bottom right of picture 3), they followed it. During this lesson most of pupils were focusing on building robotic model and scenery of their stories. At first pupils created robotic model or some parts of robotic model and at the end of the lesson they tried to program it. So they spent more time on designing and building robotic model than programming it. Example of simple program which initiate spin of mill in Haunted castle is in picture 4.



Picture 3: *Examples of robotic models which were created with focus on topic Fairyland*

Picture 4: *Simple program which initiate spin of mill in Haunted castle*

2.3. Third lesson – Presentation of robotic models

During third lesson pupils were presenting their projects which they had been creating on theme Fairyland. Pupils narrated their stories with help of presentation in presentation software. Pupils should create their presentations home (as homework) and they had one week to accomplish it. They should use their designs of projects (text documents or pictures), photos of created robotic models, programs (which should control behaviour of robotic model) and scenery of pupils' stories made from LEGO bricks (we sent them these photos at the end of second lesson to their e-mail addresses). Only one team had done their homework. Therefore third lesson started with creating presentations (even team which already had it). During creating of presentations pupils encountered several problems. For example some pupils could not download the attachment from e-mail or they

could not even insert pictures into presentations. After some instructions on how to do it, they could insert pictures on their own. Several pupils told us that they did not know how to work with presentation software. But their informatics teacher told us, that they had learned it at primary school. During second part of lesson pupils were presenting their presentations with use of projector. Two teams were narrating their story with some insertions about description of project, scenery and main characters. Other two teams were talking about design and construction of their models and about their achievements and failures. However one of these teams did not mention story created at first lesson.

3. Results of analysed activities from a pilot study

Based on data analysis we conclude that pupils which we observed had quite significant defects in planning of robotic project and implementing of robotic project. These arguments are based on two resources: first – it is based on our experiences which we obtained as teachers who conducted the mentioned activities with robotic kits, second – it is based on comparison of designs of robotic projects (in the form of text document) and photos of created robotic models. Next step of our data analysis was comparison of designs of robotic projects and created robotic models which pupils were presenting during third lesson. We concluded that pupils neither worked with the time effectively, nor collaborated effectively. It was confirmed even from analysis of dialogs from videos. On videos we saw that pupils did not want collaborate, they did not respond on suggestions from team member or they did not listen warnings from the teacher to work together and sometimes even members of same team worked on several robotic models (each team member worked on his/her own robotic model). There were some cases when such pupils had to rebuild their robotic models several times – so they finally created one mutual functional robotic model.
In general teams worked on different parts of a robotic project with variant efficiency. One team was good in creating story, other team was better in constructing robotic model and another team was better in programming robotic model than others. Nevertheless every team was successful in accomplishing their respective task/given task, but in various scale of success. We could see it in description of lessons. Although there were some problems, teams worked with enthusiasm, that can be used as motivation for further similar activities, which would develop specifically skills (based on recent studies [1], [2] those skills are important for pupils' future life). In consideration of variability of pupils' skills it is quite difficult to create appropriate activities for them, effectively distribute pupils into teams or estimate time for work on robotic project. So at first we should identify pupils' prior knowledge and skills. And then we will create activities which would be more appropriate for them.

4. Activities with robotic kits and constructionism

Activities with educational robotics can develop several competencies. Educational robotics develops thinking skills, social skills and problem solving skills [2]. According to Kabátová [2] activities with robotic models, programmable kits and toys are good opportunity to arrange classes in a constructionist way. We support some constructionist ideas in our activities [33], [11]: *learning by doing, hands-on activities* – building a robotic model with a robotic kit; *genuine achievement and own solutions, problem finding* – deciding how a robotic model should look like, what it should do, how it should be incorporated in a created story, exploring programming language; *hard fun and playful learning* – making a functioning model with a robotic kit could be a difficult task, but pupils liked it and they took it as playing with toys; *learning through designing and creating* – building and programming a robotic model; *freedom to make mistakes* – we provided only few instructions,

pupils worked on their own and they did make mistakes; if they were not able to solve those mistakes, we tried to help them; *teamwork, communication, collaboration, sharing work and ideas* – pupils worked in small groups and hence they could develop their communication and collaboration skills, they could learn how to manage their work in group.

5. Conclusion

Based on the results of data analysis we concluded that pupils should gain some skills and experience with designing, creating and presenting robotic model (such as communication and collaboration skills, problem solving skills and skills to perform before audience, etc.). Pupils worked at different task with various performances and so it is beneficial to discover, which pupils should be in one team (for example it can be pupils with different skills and they should learn from each other and be profitable). We conclude that almost all pupils did not manage to keep track of their time, they did not distribute the work in the team and they even did not collaborate and communicate effectively. These in particular, are competences, which should all pupils gain at school and they should learn to use them during working with robotic kits. Therefore we are going to extend our curriculum to several lessons, in which pupils can gain and develop the mentioned skills (also according to Kabátová [2]): at first during working at smaller robotic projects (which should take one lesson at most), and then they should work at larger robotic project, which can take two and more lessons. When creating activities to enhance pupils' team work, collaboration and communication during smaller robotic project, we are going to consider several aspects. According [34] we are going to create activities in which pupils can gain or develop some of subcomponent competencies from "Learning to Learn Together" process, e.i. distributed leadership, mutual engagement, help seeking and giving, reflection on the group learning process. Without this support, authors saw many students ignore planning steps, failed to recognize the learning goals related to metalearning, and failed to reflect on the way they collaborate and support each other as a team. In further research we will create explicit learning plans in which pupils can learn not only how to work together as a team, but they will learn it during motivating and also challenging atmosphere within educational robotics activities.

References

[1] M. Gura, *Getting Started with LEGO Robotics: A Guide for K-12 Educators*. Washington; United States of America: International Society for Technology in Education, 2011.

[2] M. Kabátová and J. Pekárová, "Learning how to teach robotics." in *Constructionism 2010,* 2010, pp. 16-20.

[3] J. Ruiz-del-Solar and R. Avilés, "Robotics courses for children as a motivation tool: the Chilean experience." *IEEE Transactions on Education*, vol. 46, no. 4, pp. 474-480, Nov. 2004.

[4] E. Sklar et al.,. "Educational Robotics in Brooklyn." in *AAAI'06 proceedings of the 21st national conference on Artificial intelligence*, 2006, pp. 1978-1979.

[5] D. Williams et al., "Acquisition of physics content knowledge and scientific inquiry skills in a robotics summer camp." *Journal of Research on Technology in Education*, vol. 40, no. 2, pp. 201-216, 2007.

[6] G. Nugent et al., "The effect of 4-H robotics and geospatial technologies on science, technology, engineering, and mathematics learning and attitudes". in *World conference on educational multimedia, hypermedia and telecommunications*, 2008, pp. 447–452.

[7] R. Mitnik, M. Nussabaum, and S. Soto, "An autonomous educational mobile robot mediator." *Autonomous Robots*, vol. 25, no. 4, pp. 367-382, 2008.

[8] G. Nugent et al., "The use of digital manipulatives in k-12: robotics, GPS/GIS and programming" *FIE'09 Proceedings of the 39th IEEE international conference on Frontiers in education conference*, 2009, pp. 1-6.

[9] D. Alimisis et al., “Introducing robotics to teachers and schools: experiences from the TERECoP project.” in *Constructionism 2010*, 2010, pp. 16-20.

[10] F. B. V. Benitti, “Exploring the educational potential of robotics in schools: A systematic review.” *Computers & Education*, vol. 58, no. 3, pp. 978–988, 2012.

[11] N. Rusk et al., “New Pathways into Robotics: Strategies for Broadening Participation.” *Journal of Science Education and Technology*, vol. 17, no. 1, pp. 59-69, 2008.

[12] Ch. W. Chsng et al., “Exploring the Possibility of Using Humanoid Robots as Instructional Tools for Teaching a Second Language in Primary School.” *Educational Technology & Society*, vol. 13, no. 2, pp. 13-24, 2010.

[13] O. Mubin et al., “Improving Speech Recognition with the Robot Interaction Language.” *Disruptive Science and Technology*, vol. 1, no. 2, pp. 79-88, 2012.

[14] M. Veltman, B. Deyell, and V. Davidson. (2012, summer.). Advances in Engineering Education: Richer Connections to Robotics through Project Personalization. American Society for Education Engineering., CA. [Online]. Available: http://advances.asee.org/vol03/issue02/papers/aee-vol03-issue02-p11.pdf

[15] M. S. Demichele, G. B. Demo, and S. Siega, “A piedmont schoolnet for a k-12 mini-robots programming project: Experiences in primary schools.” in *Proceedings of the TERECoP Workshop on Teaching with robotics,* 2008, pp. 90-99.

[16] G. B. Demo, S. Siega, and M. S. Demichele, ”University and Primary Schools Cooperation for Small Robots Programming.” in *Visioning and Engineering the Knowledge Society. A Web Science Perspective*, 2009, pp. 238-247.

[17] E. Micheli, M. Avidano, and F. Oerto, “Semantic and epistemological continuity in educational robots’ programming languages.” in *International Conference on Simulation, Modeling, and Programming for Autonomous Robots*, 2008, pp. 80-90.

[18] N. Detsikas and D. Alimisis, “Status and trends in educational robotics worldwide with special consideration of educational experiences from Greek schools.” in *5th International Conference on Informatics in Schools: Situation, Evolution and Perspectives*, 2011, pp. 1-12.

[19] M. Veselovská and K. Mayerová, “Robotic kits in secondary school.” *Journal of Technology and Information Education*, vol. 5, no 1, pp. 96-101, 2013.

[20] M. Kabátová, Ľ. Jašková, and V. Laššáková, “Robotika na ZŠ pre deti s poruchami zraku.” in *Didinfo 2012*, 2012, pp. 108-113.

[21] S. Atmatzidou, I. Markelis, and S. Demetriadis, “The use of LEGO Mindstorms in elementary and secondary education: game as a way of triggering learning.” in *Workshop proceedings of International Conference on Simulation, Modeling, and Programming for Autonomous Robots,* 2008, pp. 22-30.

[22] R. Burbaite, V. Stuikys, and R. Marcinkevicius, “The LEGO NXT Robot-based e-Learning Environment to Teach Computer Science Topics.” *Electronics and Electrical Engineering*, vol. 18, no. 9, pp. 113-116, 2012.

[23] B. Denis and S. Hubert, “Collaborative learning in an educational robotics environment.” *Computers in human behavior*, vol. 17, no. 5, pp. 465-480, 2001.

[24] S. Hussain, J. Lindh, and G. Shukur, “The effect of LEGO Training on Pupils’ School Performance in Mathematics, Problem Solving Ability and Attitude: Swedish Data.” *Journal of Educational Technology & Society*, vol. 9, no. 3, pp. 182-194, 2006.

[25] F. R. Sullivan, "Serious and Playful Inquiry: Epistemological Aspects of Collaborative Creativity.” *International Forum of Educational Technology & Society*, vol. 14, no. 1, pp. 55-65, 2011.

[26] T. A. Mikropoulos and I. Bellou, “Educational Robotics as Mindtools.” *Themes in Science and Technology Education*, vol. *6, no*. 1, pp. 5-14, 2013.

[27] K. Ryokai, M. J. Lee, and J. M. Breitbart, “Children's storytelling and programming with robotic characters.” in *Proceedings of the seventh ACM conference on Creativity and cognition*, 2009, pp. 19-28.

[28] K. Mayerová, "Pilot Activities: LEGO WeDo at Primary School." In *Proceedings of 3rd International Workshop Teaching Robotics, Teaching with Robotics*, 2012, pp. 32-39.

[29] K. Mayerová and M. Veselovská, “Robot kits and key competences in primary school.” *Information and Communication Technology in Education*, 2012, pp. 175-183.

[30] M. Veselovská and K. Mayerová, “Čo si žiaci predstavujú pod pojmom „robot“?” in *DidInfo 2013*, 2013, pp. 263-271.

[31] R. Švaříček, et al., *Kvalitativní výzkum v pedagogických vědách*. Praha; Czech Republic: Portál, 2007.

]

[32] J. Creswell, *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research.* New Jersey: Pearson Education, 2008.

[33] S. Papert, S. “The Eight Big Ideas of the Constructionist Learning Laboratory.” unpublished.

[34] T. Dragon, et al., “Metafora: A web-based platform for learning to learn together in science and mathematics.” In *Learning Technologies, IEEE Transactions on*, vol. 6, no. 3, 2013, pp. 197-207.