Learning how to teach robotics

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Abstract

For over three years we have been developing and implementing a curriculum for the pre-service teachers that would introduce them to both educational robotics and core constructionist concepts. Activities with robotic models, programmable kits and toys are attractive opportunity to organize lessons in the constructionist way. In this paper we **describe our robotics course**, we **compare two robotic kits**, we **observe how creative robotic principles work with our target group** and we **scrutinize how to provide instructions to boost construction of knowledge**.

We prepared and taught the seminar consisting of about 11 lessons each term. The seminar is regularly attended by 10 to 23 students from various study specializations. During the course they work both on small close-ended tasks and their own big projects that include: design of a model, construction, programming and solving mechanics problems. In this process we encourage partnership and dialogue. We have used two kinds of robotic kits: LEGO Mindstorms NXT and LEGO WeDo - designed for younger children with lots of simplifications in comparison to NXT. That's why while working with WeDo set, we chose less structured activities. A group using WeDo solved several smaller tasks until they got a grip on what the kit and programming language were like. The final project started with discussion and we introduced the principles of creative robotics for all as they are proposed in (Rusk et al., 2008): focus on theme, combine art and engineering, support storytelling, organize exhibitions. There are two different levels of applying these principles: (1) our students are learners and they should experience robotics same way as any other learners, thus we encourage them to experience every aspect of designing, building, programming themselves; (2) our students are pre-service teachers and they should reflect what they do with robotics kit in a teacher's perspective.

Figure 1. Four robotic models built using LEGO WeDo programmable kit

We consider these principles to be a good way to teach students of informatics education robotics creatively. Finally we propose basic framework for robotics course. In both proposed phases some instructions are in order, the amount and their nature depend i.a. on the robotic kit.

Keywords

robotics; constructionism; pre-service teachers; LEGO WeDo; LEGO NXT

Educational robotics and constructionism

For over three years we have been developing and implementing a curriculum for pre-service teachers that would introduce them both educational robotics and core constructionist concepts. We take inspiration from several existing robotics courses, e.g. (Alimisis et al., 2007). Future teachers should get at least basic education in this field since robotics is included in our national informatics curriculum and various researches reveal that learning with programmable toys and robotic kits is an attractive opportunity for **developing vast set of skills and knowledge**.

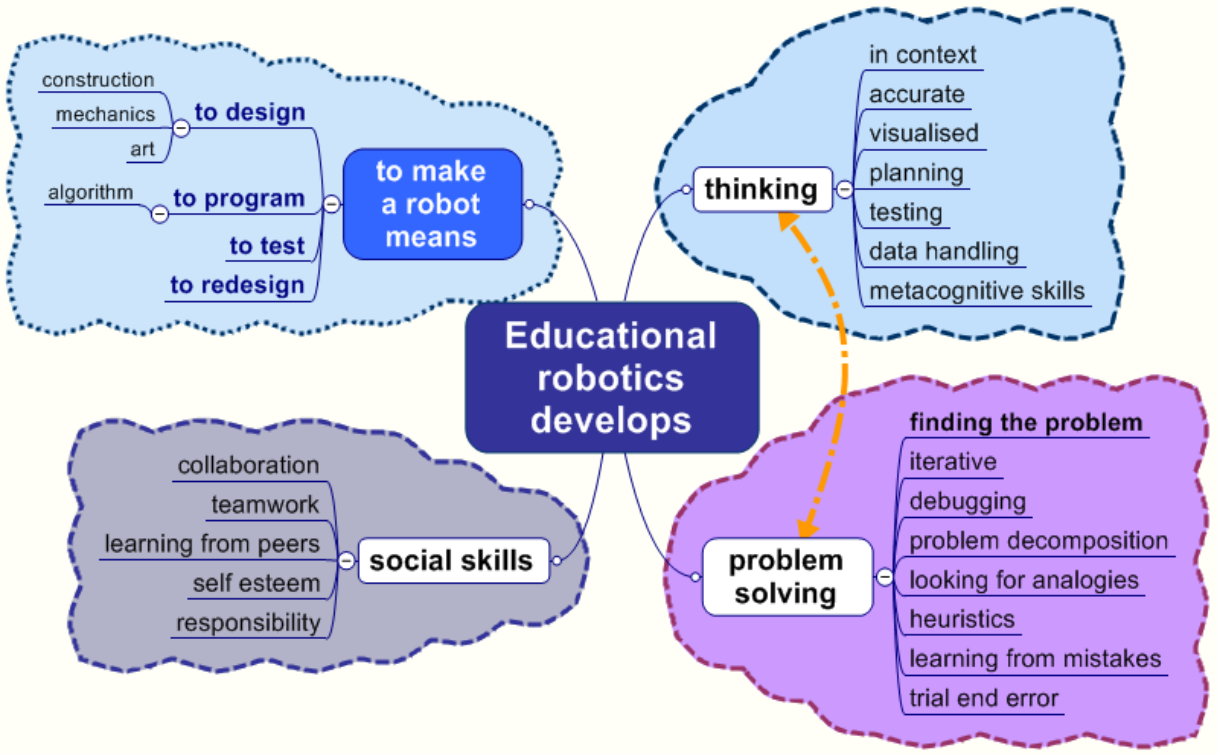

Figure 2. Activities within educational robotics may develop many competences

Activities with robotic models, programmable kits and toys are good opportunity to **organize the lessons in constructionist way**. The hands-on nature of learning with robots "*embodies a distinctly constructionist philosophy of learning*" (Evans, 2006). The constructionist ideas and principles (Papert, 1999; Rusk et al., 2008) we promote in our lessons:

- **learning by doing**, **hands-on** activity through **experience** - building a robotic model,
- **genuine achievement** and **own solutions**, **problem finding** - deciding what the model should do and how to achieve it, which theme to choose, exploring programming language,
- **hard fun** and **playful learning** - robotic kits are basically toys though making fully functioning model could be a hard task, the atmosphere at course is loose and playful,
- **learning through designing**, inventing and creating - creating robotic model involves this,
- technology as building material combined with artistic materials - exhibition settings, props,
- **taking time** - we don't have strictly given syllabus, we can freely explore within this course,
- freedom to **make mistakes** - we provide only limited instructions, students work on their own and they do make mistakes, we usually inquire what the problem is and help to fix it,
- **teamwork**, collaboration, sharing work and ideas - students learn how to manage their work in group, how to divide and assign tasks, some assignments (e.g. robots for contests) are not possible to solve by single person,

- **teachers learn too** - we are often in position when we have to solve unknown problems we are not prepared for, we have learnt quite a lot about robotics while helping the students.

Robotics course for pre-service teachers

We led a robotics course for pre-service teachers since 2006 to 2010. We prepared and taught the seminar consisting of about 11 lessons each term. The seminar is regularly attended by 10 to 23 students from various study specializations - informatics, applied informatics, informatics education, mathematics. It is primarily designed for future informatics teachers. Therefore even if there were none of such students, we constantly introduced problems and projects that were focused on educational issues.

At seminar students usually work in small teams of two or three members. We note that these students have already attended rather comprehensive courses on programming so they are not beginners. During the course they work both on small close-ended tasks and their own big projects that include: design of a model, construction, programming and solving mechanics problems. They also have to prepare a documentation for their project and fill out special worksheet (a lesson plan) that describes in more detail how to do the same model with children. Students are also encouraged to take part in robotics competitions – as volunteers helping with FIRST LEGO League tournament organization or as contestants in local robotics competition.

Last term we had an opportunity to use LEGO WeDo robotic kit with our students. We divided them into two groups – six pre-service teachers and one informatics student worked with this kit, the other students that don't specialize in education proceeded with LEGO NXT. In following section we try to compare our methodology of work with these two groups. We consider the processes running on the seminar as the constructionist ones. Let's have a closer look at them.

Work on seminar – constructionism vs. instructions

First four lessons focus at the basics of **LEGO Mindstorms NXT** robot programming. Using the set of close-ended tasks students should investigate what possibilities NXT robotics kit and its programming language offer. There are various reasons for that, some of them **practical**: at the beginning of the term we don't really know which students will really attend the whole course, the teams are switching members, some people quit and new ones can come. Therefore we can't let them do continuous bigger project. More important reasons are **didactical ones**: students get familiar with basic programming rules in NXT programming environment and learn to design simple programs for specific robotic model. They can experience data-logging by sensors, estimate the actions of the robot and analyze expected outcomes of their program in real conditions.

Smart cars are dream of each tired driver. Your robotic car also knows several tricks. Create following program:

- *If the car is out of petrol, it will slowly speed down to speed level 10. Afterwards it will beep and stop. There will be gas station image blinking on display.*
- *After car owner's whistling a car will move from its parking place to the restaurant.*

(Example of close-ended task)

Introduction to simple programs on the pre-built robotic model is the commonly used approach in robotics courses, see (Sklar and Eguchi, 2004) or (Lau et al., 1999). Still, there is great difference: we don't provide students with many instructions how to solve problems. We give them challenges containing little hints and let them proceed at their own speed. We assume that they should use their previous experiences as programmers to be able to understand programming language. If they ask for advice, we help them solve problems and we answer questions. Sometimes we work as catalysts for finding mistake – we try to invoke an idea what the students should change in environment in order to test their robot's behavior more effectively

or help them read the codes they made from different point of view. Occasionally we also help students with deciding what their model should do and if it's possible to create such robot using this particular kit.

We encourage **partnership and dialogue** between students and us. If a team doesn't like the assignment, but suggests different idea what to do with robotic model, they can execute their idea. However, we inquire what they are doing and why, how it relates to their learning of robotics or how this could be used at the school in classroom environment.

A group of students was offered to program a golf player. At first, they have explored demo programs in Help section of programming environment. The idea of robot moving its arm has inspired them to program the fisherman – it could reel the fishing rod after the sensor is pressed.

While working with WeDo set, we chose less structured activities. LEGO WeDo is designed for younger children than NXT kit and there are lots of simplifications in comparison to NXT:

LEGO Mindstorms NXT

- Age recommendation 8+
- Programmable brick
- Three motors
- Four types of sensors (sound, light, ultrasonic, touch)
- More parts – bricks, gears, wheels etc.
- Autonomous device - not necessary connected to computer

LEGO WeDo

- 7 to 11 years old children
- Programmable USB hub
- One motor
- Two sensors (tilt sensor that detects 6 different positions, motion sensor that detects objects)
- Small number of classic LEGO pieces
- Necessity to be connected to computer

Programming languages for both robotics kits are **drag-and-drop** and **icon-based**. WeDo language is much simpler and contains cycle, wait command, motor motion commands, parameters (sensor input, number, text, random), sound replay, value display, background display etc. Both languages enable parallel processing of instructions.

Figure 3. LEGO WeDo kit - simple program that moves the motor according to sensor tilt

WeDo group started to explore the possibilities of the robotic kit directly – they were asked to build and program some of **demo examples** presented in the kit materials. Each team completed the task within one seminar, a team of two boys managed to build and program even two models. On next seminar they should have designed, built and programmed new **models linked by common topic**: playground equipment. All teams succeed. Still, we couldn't see much enthusiasm among the students. Later we found out it was not caused by too simple interface of the kit as we had supposed. We undertook some changes in project initialization which proved to be successful.

Figure 4. LEGO WeDo models built by students during first lessons

After completing Playground project the students tested their understanding of the language on the **set of close-ended tasks**. They should have also evaluated their skills – they felt they knew basics of the language and are ready to use it with children.

Both NXT and WeDo group proceeded their robotics education with planning **own big project**. We can find some differences between their work process: while NXT group spent most time with construction issues and some minor problems in programming couldn't be solved due to the end of the term, WeDo group prepared complex set of robotic models, programmed them and added some extra artistic effects too. Their success is partially subject to the simplicity of the interface. We suppose the other reason is the way how we organized the work on the project. Therefore we will describe it in more detail.

LEGO WeDo: The spooky castle project and creative robotics

After finishing the activities with WeDo playground models we introduced new big project that will include all four kits and seven students working together as one team. We opened this activity with discussion and we introduced the principles of creative robotics for all as they are proposed by MIT Lifelong kindergarten group (Rusk et al., 2008):

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

There are two different levels of applying these principles: (1) **our students are learners** and they should experience robotics same way as any other learners, thus we encourage them to experience every aspect of designing, building, programming themselves; (2) **our students are pre-service teachers** and they should reflect what they do with robotics kit in a teacher's perspective.

The theme

The students discussed two themes we have offered: Intelligent house and Spooky castle. Their discussion was focused on robotic kit - it's feasibility and programming language restraints. They reasoned against Intelligent house project: *"This kit is NOT intelligent. I can't code even an IF statement. It will be easier to make something that moves, makes noises."* This statement persuaded whole group to take on the Spooky castle project. The lector acted as supervising teammate and helped the students draw a map of their ideas while they were brainstorming and throwing in the ideas for individual models. After short revision of the map the group realized some of them were not possible to construct and program via WeDo means. They picked four that seemed possible to make and came up with the idea that the Spooky castle is in fact an amusement park attraction. We didn't provide the students with examples of premade models in this period, though we suppose it would be helpful.

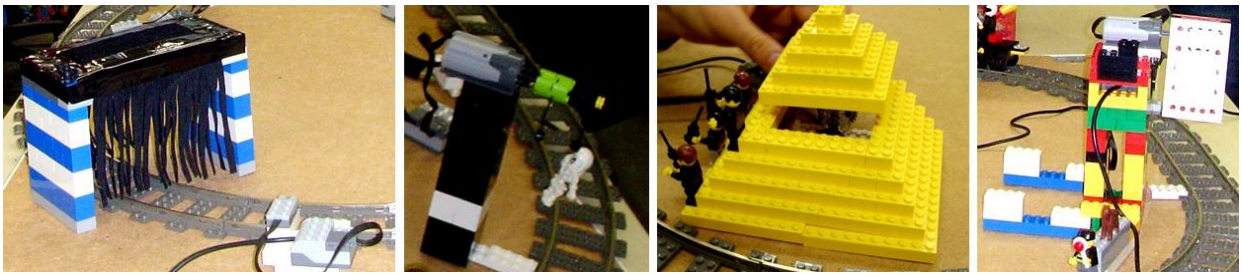

Figure 5. The Spooky castle models: the tunnel, skeleton, jumping pyramid monster, paper ball shower

Artistic design and LEGO models

We asked the group to put down a list of resources they will need, we have hinted that we would bring even artistic material for some decorations. They asked for cardboard, paint, paper, scissors and other materials. After some experience with WeDo they knew they will need some longer cables to attach WeDo USB hub since it has to be plugged in order to work. One of girls brought her own LEGO train and the group built their models on its route. The students (especially girls) spent lot of time making the cardboard castle using all the artistic material we gave them. The girls also explored how to record and play custom sound effects. They recorded their own sounds (various screams, spooky ambient) and used them in WeDo program. All four models feature the motion sensor. Three of four models have motor attached. Students were discussing usage of the tilt sensor, but they were not able to come up with any reasonable use of it in this particular project.

Teamwork

We've observed closely the dynamics in group teamwork. The tasks were defined very soon and distributed among the students. Boys were assigned to build and program 2 models, girls made the other 2 models. The models were rebuild and repaired several times by the boys and the girls as well. Mostly girls made the castle prop and recorded the sounds. Whole group cooperated each seminar at assembling and disassembling the project set since we had to move it to another room. At one point when the group was told they need to finish the work and conclude the project they were in need of better work management. In this situation a dominant girl took the leading role and told everyone what needs to be done. After this the group quickly finished everything and prepared the project for exhibition.

Figure 6. The Spooky castle made of cardboard

Exhibition

The other group of students which have worked with LEGO NXT by then was invited to watch the Spooky castle presentation. We have also recorded whole event. WeDo group was proud to

present their work and it met with appreciation of the NXT group. They even asked some question how the models were made.

Storytelling

This aspect of creative robotics have never had any success in our seminars. We suspect that the groups we work with are not average groups - they are students of various informatics specializations and thus it is possible they don't have a special like for storytelling.

Educational reflection of the project

We concluded the project with a discussion with WeDo group.

- The students valued the opportunity to work in bigger team, to work on common long-term project and to make props and work with artistic materials. They suggested that same experience could be suitable also for children.
- They labeled the WeDo programming language as fairly easy and potentially appropriate for primary kids, but they also pointed out several bugs and strange behavior.
- They haven't noticed we hadn’t given them any instruction on how to create WeDo programs, they actually liked discovering on their own.
- They expressed a fear that untrained primary school teachers might have serious problems with teaching WeDo robotics because there occur various problems that are often solved only with broad knowledge of computers and programming.
- They stated that the biggest issue with robotics activities was that they needed lot of time to identify the problems first, prior to solving them. This could lead to organizational problems in classroom.

Conclusion

We have come to conclusion that these principles are a good way to teach students of informatics education robotics and creative robotics is a concept worth introducing to them. To give students the opportunity to create the setting, the props and use different kinds of materials is valuable experience. Final exhibition is a also good experience for pre-service teachers. Storytelling opportunity is not necessary for this particular target group.

We suggest that the robotics course should take place in two phases:

- first introduce the particular robotics kit via **smaller projects** that would reveal it's applicability and constraints. The amount of instructions in this phase depends on the robotic kit and programming language. We feel the need for more instructions while using NXT than while using WeDo.
- The next step is one **bigger project** (or more if there is a time) that is **based on teamwork**.

We think that **some guidance is appropriate** while discussing and identifying the problems that are to be solved, that involves also the discussion of project theme (we suppose that if pre-made model examples are provided along with theme names, this discussion might be less needed). **Guided discussion** about possible problems with robotic models can reduce difficulties students might have with execution of their ideas and can reduce time that they need to finalize what they want to create.

References

Alimisis, D., Moro, M., Arlegui, J., Frangou, S. and Papanikolaou, K. (2007) *Robotics & Constructivism in Education: the TERECoP project*. In Proceedings of EuroLogo 2007. Edited by I. Kalas. Bratislava, August. pp. 39.

Evans, D. (2006) *Teaching robotics with LEGO Mindstorms*. Futurelab. Retrieved online, 10.3.2010, http://www.futurelab.org.uk/resources/publications-reports-articles/web-articles/Web-Article495.

Lau K. W., Tan H. K., Erwin B. T., Petrovic P. (1999) *Creative Learning in School with LEGO Programmable Robotics Products*. In Proceedings to Frontiers in Education'99, IEEE CS Press, pp. 12D4/26 - 12D4/31 vol.2.

Papert, S. (1999) *The Eight Big Ideas of the Constructionist Learning Laboratory*. Unpublished internal document. South Portland, Maine. Quoted in Stager, G. (2005) Papertian Constructionism and the Design of Productive Contexts for Learning. Plennary Session Paper – EuroLogo X, Warsaw, Poland. Retrieved online, 10.3.2010, http://www.stager.org/articles/eurologo2005.pdf.

Rusk, N., Resnick, M., Berg, R., & Pezalla-Granlund, M. (2008) New Pathways into Robotics: Strategies for Broadening Participation. *Journal of Science Education and Technology*, vol. 17, no. 1, pp. 59-69.

Sklar, E., Eguchi, A. (2004) *Learning while Teaching Robotics*. In The AAAI Symposium Series: Accessible Hands-on Artificial Intelligence and Robotics Education.