Educational Robotics Initiatives in Slovakia

Pavel Petrovič[1], Richard Balogh[2]

[1] Department of Applied Informatics, Faculty of Mathematics, Physics and Informatics, Comenius University, Mlynská dolina, 842 48 Bratislava, Slovakia, ppetrovic@acm.org

[2] Institute of Control and Industrial Informatics, Faculty of Electrical Engineering and Informatics, Slovak Technical University, Ilkovičova 3, 812 19 Bratislava, Slovakia, balogh@elf.stuba.sk

Abstract. We summarize, categorize, and analyze the various kinds of educational robotics initiatives in Slovakia and share our experience we have obtained while organizing the contests and preparing non-contest robotics educational activities. We argue that the team-work is highly undervalued in the current school system, and that robotics contests and project work are a very suitable platform to strengthen team-based education. We describe a proposal for a robotics module curriculum for the 1st year of informatics for the secondary grammar school. We shortly describe the tools and platforms of non-contest initiatives that our group is involved in.

Keywords: educational robotics, robotics contests, Robotnačka, NXT Logo, robotics curriculum

1 Introduction

We believe that team work is much more important than it is currently recognized at all school levels. Those companies, groups, and research centers that are able to orchestrate the team work, where the team members can communicate efficiently, where they do understand and take on their team roles easily, where the workers are able to cooperate with each other despite of various specializations and professions, and where all team members share common goal and good team spirit, those companies have a competitive advantage over others. It becomes more and more of an importance in a highly developed and structured society, where a good team behavior becomes one of the crucial aspects of successful and productive work. Even this fact is not well understood and recognized, not to mention how much our schools are lagging behind, those that prepare the workers of the future. An excellent opportunity for introducing the team work to the schools is the project-based education, and a suitable platform for that are educational robotics activities. Robotics has the advantages of:

- being interdisciplinary,
- being highly attractive to young generation as it deals with some of the technologically most advanced equipment man has ever produced,
- robotics is becoming part of every day life, it is useful to learn about it,

Workshop Proceedings of SIMPAR 2008
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Venice(Italy) 2008 November,3-4
ISBN 978-88-95872-01-8
pp. 122-131

- it suits perfectly the didactic concept of constructionism [6],
- preparing the students for the technological and scientific fields,
- due to its interdisciplinary nature, it can provide projects in multiple subjects: mathematics, physics, science and technology courses, art courses, or even biology, but more than that: it is an invitation to cross-subject topics.

Obviously, it also has very challenging disadvantages, in particular:

- extra space required,
- high purchase and maintenance cost,
- teachers' extra time, efforts and skills,
- relative short living time,
- difficult to reuse in parallel classes if the activities exceed a single lecture.

Therefore, the introduction of robotics in the schools on a broad scale is very controversial issue, requires careful planning, and good resources. It is most suitable when the school can cooperate with a research university. However, we would rather like to see establishment of specialized robotics centers that could provide courses and excursions of various types for all the schools in the region and that would have a qualified, specialized and skilled staff. These centers could provide life-long education courses, after-school club activities, and public events.

Among the robotics educational activities, we identify two streams – robotics contests, and non-contest activities. Competitions have the advantages of:

- fixed deadline,
- clearly and exactly specified task, which is usually defined so that it is solvable,
- typically a standardized platform, meaning that building parts and experiences can be acquired and shared easier, a large community of users is available,
- possibility to reflect on and compare one's abilities against peers,
- an opportunity to acquire a prestigious prize and let others know about one's club,
- the possibility to meet other teams, exchange experience, learn from the ideas of others,
- the good spirit that is present at the competitions, often combined with seminars or lectures.

However, the non-contest initiatives also have very strong advantages, and we believe they provide higher quality as we are sometimes tired of seeing 70 line-follower robots most of them alike one another:

- they do not force the teacher into a predefined framework, rather allow him or her to setup the experiments to fit his or her pedagogical goals,
- allow the groups in the classroom to work on different projects,
- are open-ended and more suitable for research and scientific training.

In the following parts of our paper, we review both the contest and non-contest initiatives in Slovakia, most of them where we are involved in some way.

Workshop Proceedings of SIMPAR 2008
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Venice(Italy) 2008 November,3-4
ISBN 978-88-95872-01-8
pp. 122-131

2 Contest initiatives

The popular **Istrobot** contest is held at the end of April at Slovak Technical University, this year already for the 8th time. It consists of several standard categories – Line-following (with obstacle, tunnel, and interrupted line), MiniSumo – pushing robots: a category focused mainly on mechanical design, and Micromouse – robot maze navigating contest for more advanced roboticists. Istrobot enjoys rich international participation and recognition mainly from Czech Republic and Austria. The target group for this contest are all age categories, however every year, significant number of teams from elementary and secondary schools participate. The contestants can use any type of material, hardware and software, and the participants are usually individuals. There is no particular educational concept involved and the people participating have robotics as their hobby. Istrobot is the kind of contest aiming at promoting robotics as a goal. The popularity of this contest reaches so far that it is duplicated in a separate event Metodbot, organized by enthusiastic contestants from one secondary school in Bratislava.

More than 10 years ago, Czech and Slovak initiatives established a competition in **building and programming LEGO robots** for primary (and later also secondary) schools. The task in this contest is very creative one, and participants do not bring completed robots to the contest. Instead, they bring a construction set and during

Fig. 1. The popular Istrobot contest attracts participants of all age categories. Photo: Robotika.SK.

Workshop Proceedings of SIMPAR 2008
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Venice(Italy) 2008 November,3-4
ISBN 978-88-95872-01-8
pp. 122-131

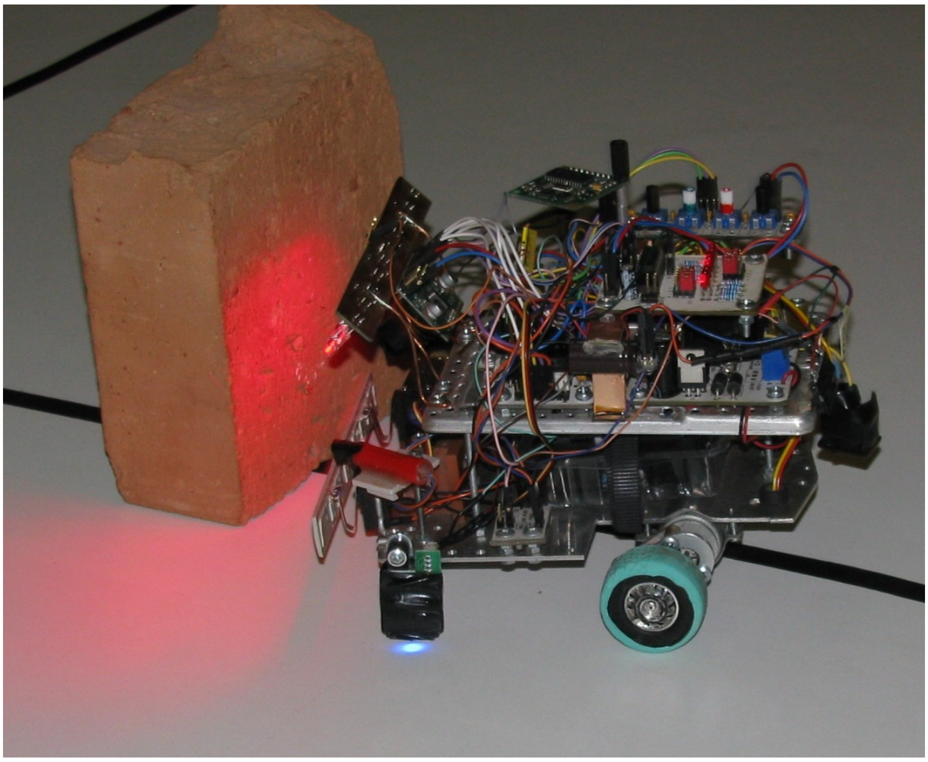

Fig. 2. Participants of Istrobot contest are primarily robotics hobbyists and/or engineering students who construct their robots from arbitrary materials and use various control platforms. Photo: Robotika.SK.

the contest, they spend several hours building and programming LEGO robots based on the topic they have learned at the start of the contest. Better prepared participants have higher chances to succeed, but the real abilities of the contestants are the main factor contributing to the team achievement, i.e. this type of contest completely eliminates any external help from the tutor, teacher, or parent. This contest continues until today, although, this year, experimentally, we have tested a different approach: instead of telling the students a topic (such as agriculture, or tourism), they received a very specific task, two training fields, and used about 5 hours to solve the task at their best (the task was a slightly modified task from the World Robot Olympiad contest). The advantage of a specific task is that the evaluation is objective and fair. In the previous creative version of the contest, the models were evaluated either directly by the contestants or by a jury, however the evaluation was a difficult discussion. The feedback we received from the participants was that the task-specific version is more interesting and more fun. In the creative version of the contest, participants often built the very same model as they already built in their club before, and modified it only a little bit to fit the assigned topic. In the task-specific version, this is impossible, and everybody has the same starting conditions. The only challenge relates to another feedback we have received from the most successful participants, who were disturbed

Workshop Proceedings of SIMPAR 2008
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Venice(Italy) 2008 November,3-4
ISBN 978-88-95872-01-8
pp. 122-131

by the possibility of other teams copying their working ideas when testing and debugging their robots on the field. This could possibly be avoided by always allowing only a single team in the practice area.

The LEGO competition was augmented with the categories of **RoboCup Junior** contest to form one large robotics contest for primary and secondary schools, including the RoboDance, RoboRescue and RoboSoccer categories. In the year 2008, we were happy to welcome teams from three neighboring countries: Austria, Czech Republic, and Hungary. There is enough information on RoboCup Jurnior available, for an example, see [13]. Teams in this contest usually consist of 2-3 students. We see the main strength in the large project experience that the students acquire: they can learn what does it take to work on and successfully complete larger-scale project. This experience is of a special value as it is not available in many other forms. The notorious challenge in the RoboCup Junior is that the teams are allowed to participate multiple years and pass their knowledge and equipment onto the younger team-mates. In consequence, the best teams are those of a strong tradition and it is very difficult and thus little bit discouraging for newcomer teams to win or even advance to the finals.

Starting in 2008, we are organizing a pilot year of **FIRST LEGO League** in Slovakia (robotika.sk/fll), which we find most suitable in regard to the team-based education. The contest comes with extensive documentation, manual for the couch,

Fig. 3. The goal for the robots in the experimental modified task of World Robot Olympiad was to knock down the tins from the wooden triangular platforms. Photo by Miro Kohút.

Workshop Proceedings of SIMPAR 2008
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Venice(Italy) 2008 November,3-4
ISBN 978-88-95872-01-8
pp. 122-131

with recommended strategies for didactics and it is the first class world standard for the primary school robotics contest. Both RoboCup Junior and FIRST LEGO League are promoting robotics as an instrument (as contrasted to robotics as a goal).
Before closing the section on the contest, it is important to mention the excellent team in **FIRA robotic soccer** (category Mirosot), who are achieving the best results in European and International contests (robosoccer.sk).

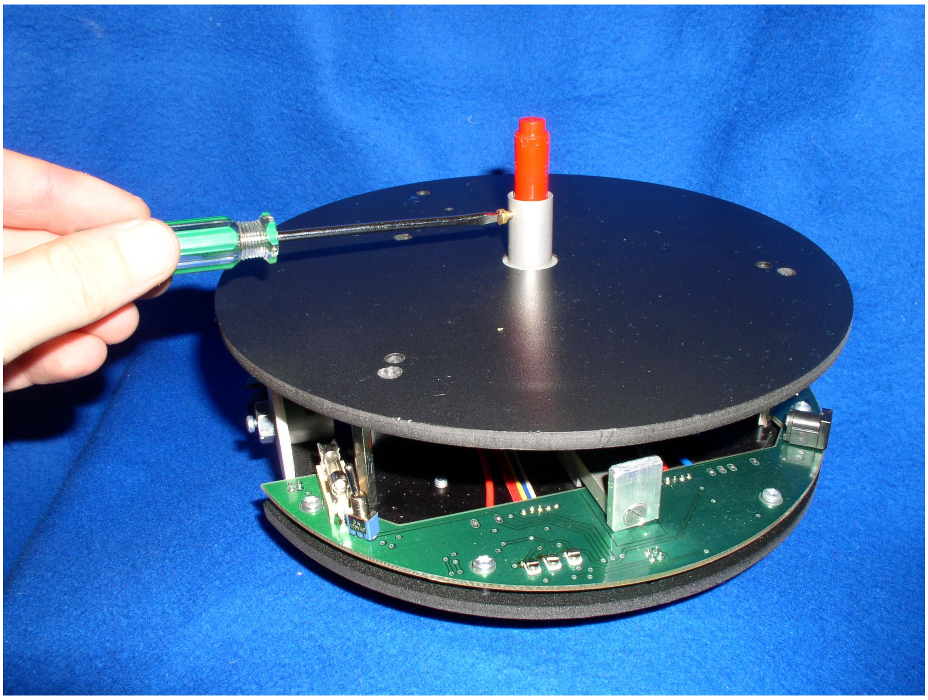

Fig. 4. Robotnačka drawing robot. Photo: Richard Balogh, Robotika.SK.

3 Non-contest initiatives

While contest initiatives are very important for increasing the popularity of robotics, we find the non-contest initiatives to bear greater potential. A set of projects originates from the association Robotika.SK i.e. the Institute of Control and Industrial Informatics of Slovak Technical University and Department of Applied Informatics of Comenius University, and a commercial company Microstep-MIS. This consortium has built the educational drawing robot shown at Fig.4, Robotnacka [2], which can be controlled directly from the Imagine Logo programming environment [4], and can be used in the classroom to teach mathematics, physics, and programming [7]. Modified versions of Robotnacka are permanently installed in Remotely-accessible robotics laboratory, where teachers and students from anywhere on the Internet can connect directly from Imagine Logo, or any other programming language [9]. Recent member

Workshop Proceedings of SIMPAR 2008
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Venice(Italy) 2008 November,3-4
ISBN 978-88-95872-01-8
pp. 122-131

of this family is an educational robot Sbot, a simple low-cost differential-drive robot with multiple sensors and extension possibilities.

Informatics teachers training at the Faculty of Mathematics, Physics and Informatics provides two courses introducing the future students to LEGO robotics programmable sets in a series of practical hands-on seminars [3].

Secondary grammar school of Jur Hronec, Bratislava is preparing to teach robotics with the LEGO construction sets in the 1st class as part of the informatics classes after gaining experience in after-school robotics activities earlier this year. The proposed syllabus for this course module is provided in the next section.

Robotika.SK in cooperation with BEST and Slovak Technical University organized its first robotics summer school in 2008 with approximately 25 participants attending lectures, tutorials, workshops and hands-on lab sessions: one with well-prepared course on basics of control using the Boe-Bot educational robot [1], and one with creative hands-on LEGO robotics experience.

4 Proposal for a syllabus of robotics course module for first year of secondary grammar school

Based on our cooperation with a secondary school in Bratislava, where we run an after-school robotics club, the school decided to incorporate a robotics module into their informatics curriculum. This section describes the curriculum in detail.

1. Introduction to principles of robotics – theoretical lesson with video and graphics presentations. Concepts: sensor, sensor types, motor, motor types (DC-motor, servo-motor, stepper-motor), principles of controlling robotics systems, manipulators, inverse kinematics, feedback, safety rules [5].

2. Lab – building the first model with the touch sensor based on the Constructopedia instructions in LEGO Mindstorms NXT-G. The first program. Principles of operation of sensors and motors. Modification of the model with application of the sound sensor. Disassemble the model at the end of lesson.

3. Lab – building the second model utilizing the ultrasound distance sensor, tasks/exercises:

- program the robot so that it will drive forward, but it will avoid collisions with obstacles
- program the robot so that it will stand still, and avoid approaching objects
- program the robot so that it will follow a near moving target (you can use two distance sensors)

Disassemble the robots.

4. Theoretical lesson – theoretical solution to the problem of finding shortest path in a maze (category Micromouse in Istrobot contest), solving the problem in simulation, robotic simulators, the challenges faces in robotics simulation.

5. Lab – line-following robot. The principle of the light sensor, various approaches to line following. In-depth understanding of robot interaction with its environment using sensors.

6. Lab – extending the model from the 5th lesson with obstacle avoidance, navigating an interrupted line and locating victims (category Rescue from RoboCup

Workshop Proceedings of SIMPAR 2008
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Venice(Italy) 2008 November,3-4
ISBN 978-88-95872-01-8
pp. 122-131

Junior, and Line-follower from Istrobot).

7. Theoretical lesson – state automata, programming robots using state automata. Event-driven programs. Measuring and sampling data. Transmission of measured data to the computer and their visualization. NXT Logo – programming environment for interactive robotics projects.

8. Lab – simple football player programmed using state-automaton. Students build a football player robot based on a simple instruction sheets and program it using state automaton so that it will play the role of a football player.

9. Lab – further work on football player, improving the programs, tournament.

10. Theoretical lesson – Designing 3D graphical models for LEGO robots on PC with LEGO Digital Designer (LDD) software, exporting building instructions. Communication of robots using radio BlueTooth connection. Hardware: principles of sensors, A/D converters, pulse-width modulation for controlling motors, measuring signals using oscilloscope (topics selected based on students' interests).

11. Lab – robot communication. Simple example of remotely-controlled robot, cooperating robots (team search of exit from a maze using radio communication).

12. Lab – Measuring, processing and visualization of data: quality-measurement system. Measuring the profile of objects using ultrasound sensor. Project using the NXT Logo system. Students build a system that will measure the profiles of objects moving on a conveyor belt, and transmit this information to the PC, where it will be further processed and visualized. The system will identify the faulty objects (those that do not fit the specification) and notify the user.

General rules: The pairs of the lab lessons should be combined in 2-hour sessions. It is possible to adopt a slower pace, and spread the material over larger number of lessons. During lab, the students work in pairs, and use prepared work-sheets, where they note all their progress during the lesson, measurement results, etc. They deliver these sheets to the teacher, who provides a short feedback at the start of the next lesson. The practical lab lessons are designed so that the students disassemble their robots at the end to make them available for the next group. All the programming is performed using the NXT-G system, manual is enclosed on the CD from LEGO, NXC, documentation is available at: http://bricxcc.sourceforge.net/nbc/), and NXT Logo in combination with Imagine Logo, documentation is available at http://robotika.sk/NXTLogo.

5 NXT Logo

A particular non-contest initiative focused on providing a rich and children-friendly learning environment for interactive projects, NXT Logo, is available as a prototype, while it is implemented in an interpreted language [8]. Currently, we are designing a newer version of the system [10] in standard GNU C compiler based on the open-source firmware from LEGO, which allows for higher performance, larger memory storage capacity, cleaner code structure, and tuning the low-level functionality, which is not particularly good in the standard LEGO firmware (very complex motor model, poor memory management, limited manipulation with arrays to mention a few issues). The unique combination of features of NXT Logo include: it is a general-purpose educational Lisp-like functional language; it introduces new level of LEGO Robots programming: students can create interactive educational LOGO projects that control LEGO robots with easy button/turtle controls, and finally, it allows flexible visualization of data collected by robots – programmable by children Logo programmers! It is implemented in Imagine Logo and Next Byte Codes (NBC). NXT Logo has three levels of use 1) Interactive Imagine Logo projects with direct GUI controls that allow steering NXT robots over Bluetooth radio, 2) Loadable imagine library (`nxt.imt`) that contains a set of procedures for direct control of NXT robot over Bluetooth from your Imagine projects, 3) Interpreter of Logo running on the NXT that can run logo programs (with restricted syntax), which can communicate with Imagine projects and control the robot motors and sensors. In addition, NXT Logo is a self-contained programming language and can be used completely without Imagine Logo. The latest addition to NXT Logo is the library for data visualization for Imagine Logo, named Charts [11,12]. It allows automatic plotting of collected data in bar-charts, line-charts, xy-charts, visualization and editing of the data in tables, connecting the tables and charts, and providing logo call-back functions that can update the data based on the user entry or input from robot, see Fig. 5 and 6 for examples of charts and tables.

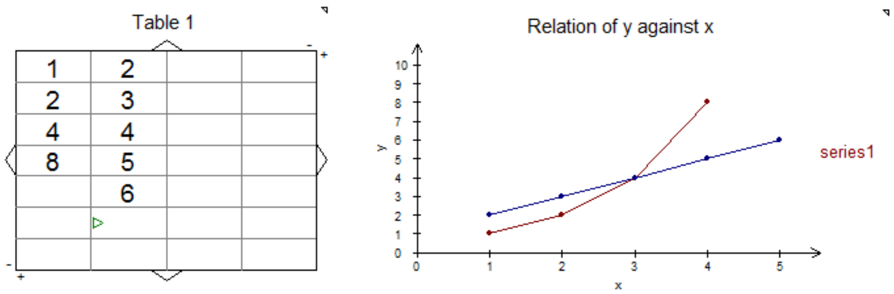

Fig. 5. The Charts library provides a set of classes with transparent interface for manipulating charts and tables in Imagine Logo. The chart on the right is updates with the table on the left.

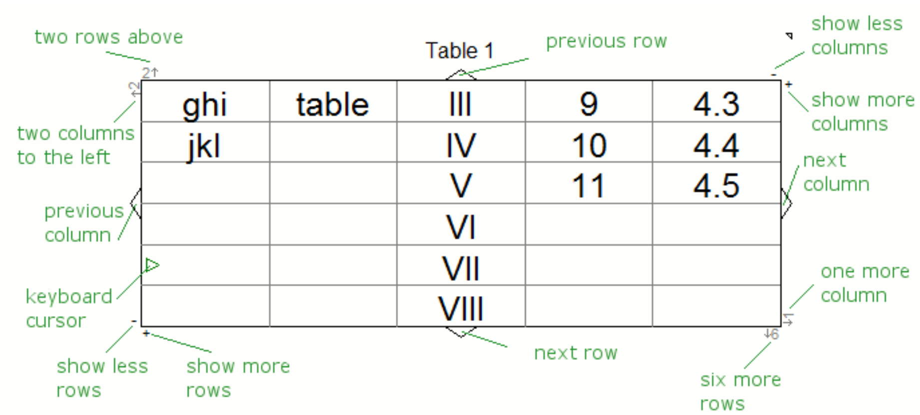

Fig. 6. The Table Logo class implements many controls for easy navigation.

Workshop Proceedings of SIMPAR 2008
Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS
Venice(Italy) 2008 November,3-4
ISBN 978-88-95872-01-8
pp. 122-131

6 Conclusions

Robotics in our latitudes and longitudes is still not recognized as an individual field requiring a lot of resources and attention and it struggles for support, recognition and understanding its potential and value. Therefore, promoting educational robotics depends primarily on endeavors of strongly-motivated and dedicated individuals. Broad implementation of educational robotics in the schools is not yet ready and would have to cope with large challenges, although it can be very beneficiary at the locations with sufficient resources and staff. The article describes the robotics educational initiatives in Slovakia, most of which we are involved with in some way. While the contest initiatives are very effective way of popularizing robotics, the non-contest initiatives provide more pedagogical value, and flexibility. Most important of all is to provide sufficient and good-quality tools, teaching materials, student worksheets, curriculum, platforms and options. In addition to three different contests, we are developing a rich programming environment NXT Logo, and are cooperating with the secondary grammar school that is starting to implement a robotics curriculum module in the 1st year of informatics class, which is also described in this paper.

Acknowledgments. Part of the work is supported by grant APVV LPP-0301-06.

References

1. Balogh, R.: Basic Activities with the Boe-Bot Mobile Robot, In: Proceedings of conference DidInfo 2008, FPV UMB, Banská Bystrica, Slovakia (2008)
2. Ďurina, D., Petrovic, P., Balogh, R.: Robotnačka – The Drawing Robot. Robtep 2006. Acta Mechanica Slovaca, 2-A/2006, ISSN 1335-2393, pp. 113-118. (2006)
3. Kabátová, M., Pekárová J.: Hra = učenie sa, lego a robotika vo vyučovaní budúcich učiteľov. In: Proceedings Didinfo'2008, FPV UMB, Banská Bystrica, Slovakia (2008)
4. Kalaš, I., Hrušecká, A.: The Great Big Imagine Logo Project book. Logotron (2004)
5. Kalaš, V: Tridsať rokov svetovej robotiky, STU Bratislava (2006)
6. Papert, S., Harel I. (ed.): research reports and essays 1985 – 1990. MIT Media Lab, Ablex Pub. Corp (1991)
7. Petrovic, P.: Mathematics with Robotnačka and Imagine Logo. In Proceedings to Eurologo 2005, pp. 353-360. DrukSfera (2005)
8. Petrovic, P., Lucny, A., Balogh, R., Ďurina, D.: Remotely-Accessible Robotics Laboratory, Robtep 2006. Acta Mechanica Slovaca 2-A/2006, pp. 389-394 (2006)
9. Petrovic, P.: Program Your NXT Robot with Imagine. In: Hungarologo 2007, XII. nemzeti konferencia a Logo programnyelvroel logo-pedagogiarol, pp. 16-27, Budapest (2007)
10. Petrovic, P.: Low-level programming of NXT robots, Robolution summer school. http://www.robotika.sk/holls/2008/ (2008)
11. Petrovic, P.: Riadenie modelov a spracovanie udajov v systeme NXT Logo, In: Proceedings to conference Didinfo 2008, FPV UMB, Banská Bystrica, Slovakia (2008)
12. Petrovic, P.: Charts for Imagine, Tutorial and Reference Guide. http://wiki.robotika.sk/index.php/Charts_for_Imagine (2008)
13. Sklar, E., Johnson, J.H., Lund, H.H.: The Educational Value of Children's Team Robotics: A Case Study of RoboCup Junior. In: Proocedings to the Seventh International Symposium on Artificial Life and Robotics (AROB) (2002)