# Summer League: Supporting FLL Competition

**Pavel Petrovič,** *ppetrovic@acm.org*
Dept of Applied Informatics, Comenius University, Bratislava

**Richard Balogh,** *balogh@elf.stuba.sk*
Institute of Automotive Mechatronics, Slovak University of Technology, Bratislava

## Abstract

In the years 2013-2015, we organized three years of a competition in building and programming robots in Slovakia named Letná liga FLL (Summer League of FLL). We invented and designed the competition format. All the tasks are our original ones. The competition has a unique format allowing the teams to compete remotely, eliminating all travel costs. It drops the requirement of time-demanding preparations lasting many weeks that is present in most common robotics competitions, such as RoboCup Junior, FIRST® LEGO® League, and World Robot Olympiad. However, this competition stimulates an exceptional level of creativity and provides an early and manifold feedback in a repetitive fashion. All solutions of the teams are published after the deadline, each being unique and special. After extensive, but well-motivated work on every task, each team compares their own solution with a plethora of other ways of thinking about the same problem. In this way, children learn from each other on a great scale. We experience a series of surprises and unexpected unforeseen approaches to the tasks when evaluating the various solutions after each round. The feedback from the participants has been positive and the dedication of many is beyond our early expectations. This format stimulates a regular and goal-oriented work in the after-school robotics clubs. An additional valuable outcome of our work is the set of 30 creative activities focused on various aspects such as robot design, robot control, and programming, use of sensors, navigation, manipulation, physics, art, and other. Each task has multiple and inspiring solutions. Activities can be solved in 1-3 club meetings. Tasks, solutions and evaluations are freely available on-line.

*Figure 1: Different solutions of the skier task: from top left: teams Tobias, Amazing Team, Too lazy, LeGorazda, and Gamčabot.*

## Keywords

robotics competition, constructionism, after-school activities

# Introduction

During an approximately 20 years of existence of robotics competitions for elementary and secondary schools (Petrovič & Balogh, 2008, Petrovič, 2011, Petrovič, Balogh & Lúčny 2010), basic types of competitions have crystalized. Some of them are successful in Slovakia too. For instance FIRST® LEGO® League in the Central European region has saturated from the point of view of the number of teams (Figure 2 left), source: Hands-on-Technology, Leipzig. On the contrary, Slovakia still holds a potential for a development (Figure 2 right), source: fll.sk. Even though Slovakia performs better than other counties in the V4 group in this measure, its development is hindered by the financial situation of the schools and the developing regions.

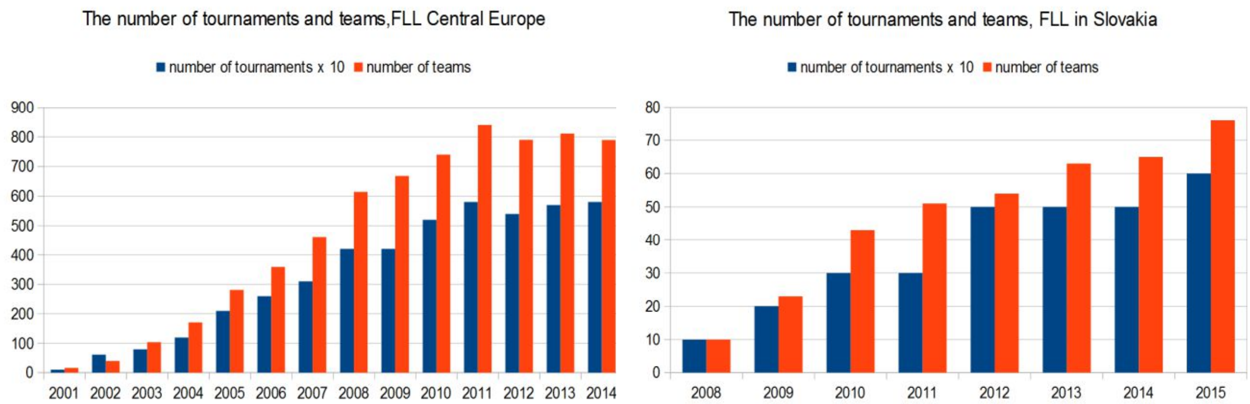



*Figure 2: Saturation of the number of tournaments and teams, FLL Central Europe (left) and a potential for a further growth, FLL in Slovakia (R).*

A classification of robot contests should take into account at least the following factors:

- *Required time for preparation*: how many weeks, months, or years of work are required to participate successfully?
- *Dependence on external technical support and consultations*: are the average participants able to join the challenges without having experts in their circles? Is the help from the experts needed to help them with constructing and programming the robots?
- *Recidivism*: is the challenge the same – or very similar year after year? Are the teams that already participated in the challenge for several consecutive years already in a particular advantage compared to newcomers?
- *Creativity degree*: are the typical solutions to the task notoriously known? one of the few expected designs with several small modifications? Or alternately, almost every solution is a surprise? In the first case, a steady performance improvement can be observed from year to year. The alternate approach underlines grasping the problem in a creative, original and elegant manner.
- *Team-work focus*: some of the competitions focus on the technical solution only, they are strictly focused on robotics. Other competitions attempt to have a balanced approach, combining teamwork skills, searching and presenting information, solving problems.
- *Narrow focus*: is there a single objective in the competition? Alternately, does the challenge consist of a set of relatively independent little tasks?
- *Platform standardization*: at one end of this axis, the teams are required to use a standardized platform for all aspects of their solution, which is useful to develop their ability to improvise and work within a given set of constraints. The other end drops all constraints on creativity, use of materials, and technologically more suitable solutions.

- *Competing teams' expenses*: how much do the teams need to invest into: registration, material and equipment, tools, software, sets, travel cost, food and accommodation?
- *Organizers expenses*: what are the typical costs that require fund raising and/or sponsor support on the side of the organizers? How difficult it is to organize an event? How many volunteers are needed, how much planning and management in advance is required?

FIRST® LEGO® League is by far the largest and the most popular robotics contest for young people. Among other advantages, its strengths lie in 1) *a common platform* – all children use the same software and hardware platform, which is available and easy to access. It means all participants work with the same set of constraints, which is fair; 2) *a new set of tasks every year* – which allows and motivates newcomer teams to be successful – an important advantage over RoboCup Junior leagues, for instance; 3) *explicitly stimulates team-work* learning and experiences by its format. Team-work is essential in the contemporary world, however often very neglected in school systems. It is an important factor in school reforms in many countries, see for instance (Bjorke et al 2015). More research and didactic work must be done in this direction. FLL provides a suitable research platform on this topic; 4) avoids over-focusing on technology by combining the Robot Game with *Research Project* – making it easier to setup interdisciplinary and gender-mixed teams, plus it builds an entry path to the technological fields for girls. Moreover, its research project provides an excellent platform for learning about how to search, process, and present information (Oppliger, 2002, Timcenko, 2011); 5) a relatively short and well defined *intensive work period* – during this time, teams are able to dedicate extra efforts, produce, and focus. They learn to be goal-oriented. However, large part of the year still remains FLL-free and allows for recovery, motivation-gain for the next season, and leaves space for some other activities as we will show in this paper.

As a regular jury members, organizers, and occasional mentors at the regional FLL contests, we saw a lot of unused potential after the contest finishes. Many teams that are involved in the competition stop their work on robots and programming until the next season. Then they start again from the beginning. We understand the need to work continuously and to keep learning, improving existing skills, gaining new knowledge during the quiet time between the seasons. During the competition period, teams are focused on the specific task. Teams seldom find an additional time for learning new things. They need to play with the robots, make experiments, learn how to work with sensors, find new programming methods, and discover new mechanical concepts also outside the regular competition. In an ideal world, team leaders use this time for learning and improving the skills. In real, coaches don't know what to do with the team in the meantime and lack ideas of what to do more, often dropping the meetings completely. This is the idea behind the Summer League. To give the teams a chance to learn new things, give them additional challenges and some space for more experiments.

# Summer League

## Organization

In the first year of the SL, we started in May 2013. We published a new task every week, however, the teams had time two weeks to solve it, thus they could already see the specification of another round while they were working on the previous one, and think in advance, let their ideas to develop over time. Alternately, they could divide into dedicated groups, each solving one of the available tasks. We did not advertise the competition in any particular way, but six teams still joined in, and brought interesting solutions. We continued during summer holidays with somewhat longer period for solutions until we reached 10 rounds, but there were very few contestants after the school year was over. We manually extracted all the submitted solutions from e-mails and made them available on a dedicated website, which was part of the homepage of FLL in Slovakia. The main idea was to support the FLL competition, although our initiative was completely independent from FLL. One of the authors is responsible for localization of FLL competition to Slovak language (rules, task descriptions) and maintains the website, while the other author is a member of an association that supports FLL by many different ways.

The second year, we started after the start of our summer semester, in March, and still provided a new task approximately every week, leaving longer time during holiday seasons (spring holidays, Easter, May). In this way, we managed to reach our goal to finish before the long summer holidays. This time however, teams had longer time to submit the solution – usually around three weeks, and thus there always was time of about three weeks to work on each of them. Our idea was to give the teams a selection of tasks to work on all the time, allowing them to skip some of the tasks, or better put, to select those they like or prefer for any particular reason. The number of participating teams tripled in the second year, in total there were 18 teams participating, while five of them kept very active until the tenth round, six additional teams tried at least three different tasks, and the remaining teams participated once or two times only. We were very happy about the increased interest and tried to accommodate the feedback from the teams into the third year – most importantly, decrease the frequency to allow for better quality solutions in longer time.

In the third year, we started even a month earlier. A new task was published every 14 days. Teams could use 3 weeks to work on each task. The total number of participating teams raised to 24, but nine of them solved at least 9 out of 10 rounds, seven additional teams solved at least half of the tasks, and four additional teams solved at least three rounds. In total we have received and evaluated 140 unique solutions (on average 14 per round), however, not the quantity, but the endeavor, and the quality of the solutions was the most satisfying. Both years 2014 and 2015 were organized with the support of a specialized web application implemented using a CodeIgniter MVC framework. It was designed and implemented by a group of students under the supervision of the first author to fulfill their group-project duties in our course on Development of Information Systems (a sort of introduction to Software Engineering).

## About the Rules

The contest is run in a friendly, open and trustful spirit, the main focus is to have fun while learning something new. In the first year, there were no particular prizes. We sent the teams a signed and stamped participation certificates and one solution was awarded with a little bag with spare plastic parts and some sweets every week. In the third year, we tried to motivate the teams, and arranged with the association Robotika.SK to sponsor the contest with one LEGO MINDSTORMS robotics set to the overall winner with the highest score after all ten rounds. The rules were formulated as follows:

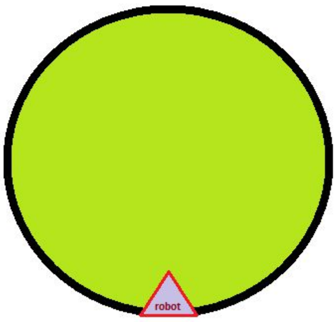
1. competing teams consist of participants in the age of 10-16 years;
2. teams do not need to register for FLL, we are open to other teams as well;
3. in the school, in the club, or at home, team solves the task, and submits their solution to our on-line system;
4. each solution should contain: photograph of the team, one or more pictures of the robot, program, a video showing how the robot solves the task (link to an unlisted YouTube video), and a description of the solution;
5. the hardware must be LEGO MINDSTORMS (as in FLL);
6. the software must be NXT-G, EV3, or Robolab (as in FLL);
7. each solution is awarded by 0-3 points that sum up to the overall score;
8. solutions are evaluated by an independent group of judges (in practice we use 3 or 4 judges and use the average of their evaluations);
9. every team is allowed to make changes to the task specification – to simplify it, if they find it too difficult, earning somewhat reduced score.

The submitted solutions are hidden until the very time of the task deadline when they automatically become visible to all other teams. In this way, the participants receive a very early feedback, and compare their best idea on how to solve the task with all other teams – watch their videos, which is often a lot of fun, and this motivates them to try to understand how other teams were thinking, and what design choices and tricks they used in their programs. Since the teams have already been thinking and working with the task for more than a week, there is a large substance of matter in their mind to connect with this new information, which facilitates their learning in the best possible ways, building on the very principles of constructionism: discovering and learning about the world by doing, and sharing the results with others. We find this contest to be a manifestation and a unique case-study of how constructionism principles extend in an on-line context.

## Example Tasks

In this section, we present seven different tasks, each focused on a subset of competences.

1. **Golf (round 4, year 1)**. In this task, the robot is placed on a circular golf green area and its job is to sprinkle it with the fertilizer, represented by tiny plastic parts. The circle is surrounded by a black line, and the fertilizer must be spread evenly, and cover the whole area systematically. The teams must find a mechanical solution to slowly distribute many little parts over time, while the robot successfully navigates of the area. Even though the task focus is on mechanics of the spreading machine, teams had to pay attention to successfully navigate throughout the green, usually using the color or light sensor. Thus a successful solution requires the capability to process and react to input sensory information.



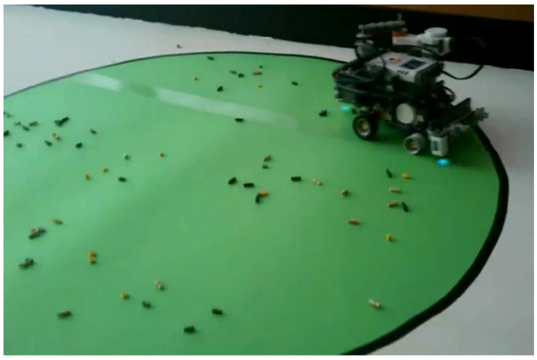


*Figure 3: Situation at the start of the task Golf (left) and an example solution of RJMTeam (right).*

2. **Rossie has worries (round 6, year 1)**. A family has a personal robot Rossie and leaves for a holiday. The flowers must be watered. In this case, a real water and real flower pots should be used, and thus the task is an example of connecting the learned knowledge to everyday life situation in the real world. Teams must solve two main challenges: localizing and navigating towards the flower pots, operating a watering mechanism – for instance by holding a cup, and tilting it to pour the water. Please see Figure 4 for an example solution.

3. **Skiing robot (round 1, year 2)**. Robot "skier" is placed in the middle of a skiing slope represented by a tilted board in a random orientation. It does not know whether it is facing uphill or downhill or in any arbitrary direction. It may not use accelerometers, gyroscopes or inclinometers. The task is to turn until the robot is facing up, climb the hill to the top, turn around, and "ski" all the way down. This task stimulates thinking out of the box. The teams must realize that what they need is to detect the direction of the gravity, and then find some way how to do that. Figure 1 shows different solutions of five teams: Team Tobias installed a loose hanging plate about 15cm in front of an ultrasonic distance sensor. While turning, the plate moves nearer or farther of the sensor. The moment it is closest to the sensor is the moment robot is facing uphill. Solution of Amazing Team has a simple touch sensor at its back, which is pressed by the robot's own gravity due to a special design of the caterpillars. Teams "Too lazy" and LeGorazda used a weight on top of the robot that tilts in one of the directions, pressing one of the attached touch sensors – the one corresponding to the instant inclination of the robot. Finally, the most impressive solution of Gamčabot team uses a ball rotating around a circle on top of the robot as it changes its tilt in various directions. A light sensor detects the wished direction.

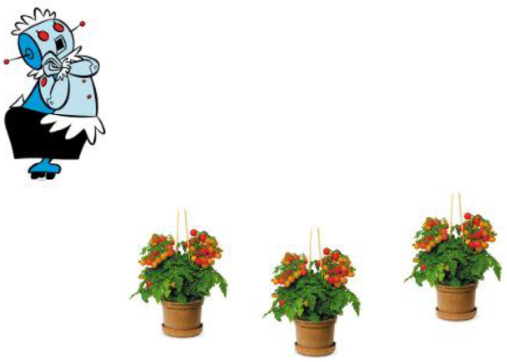
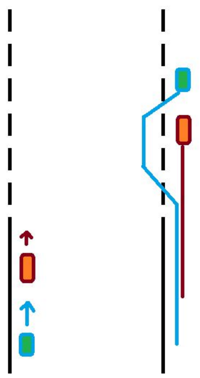


*Figure 4: Situation at the start of Rossie has worries task (L), and a solution of RJMTeam (R).*

4. **Safe car overtaking (round 6, year 2)** is an example of a motivating task for less advanced learners – they learn the interaction with the environment utilizing the light sensor to detect solid or dashed line, ultrasonic or infrared distance sensor in a closed loop with the motors to control the speed of the robot and a proper navigation to successfully take over the slower car.

5. **Secret hiding place (round 7, year 2)** is an advanced task that requires the robot to memorize a pattern, and to classify further patterns shown as valid or not. The teams built their secret treasures that can only be open using a correct card. Cards contain various patterns of white and black stripes (see figure 6 left). The robot must be able to learn a new pattern that can then repeatedly open the treasure. Incorrect patterns must be rejected and the treasure remains closed. Some teams simplified the task and detected the black/white sensor readings into 4 different variables. The team Benders (figure 6 right) used 16 different positions and encoded the card pattern using binary notation into a single 16-bit integer. The most advanced solution used timers to measure the widths of the black and white stripes. The widths were recorded to a file. The stored and read pattern were compared. If their difference summed under certain allowed error threshold, the opening card has been detected.



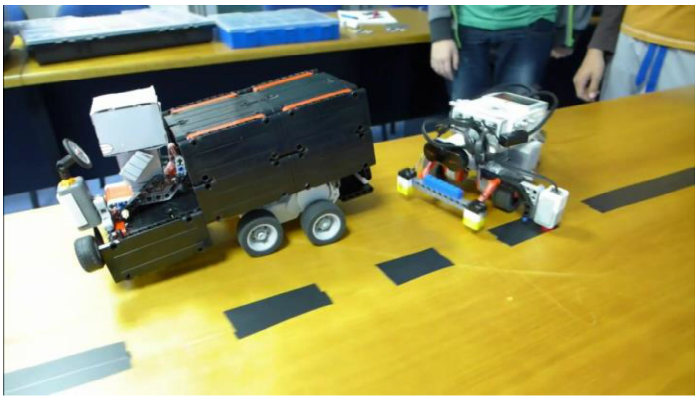


*Figure 5: Safe car overtaking task, situation (L), an example solution of Benders Team (R).*

*Figure 6: Various card patterns (L) and the best secret treasure – team Benders (R).*

6. **Swing (round 1, year 3).** Robot is sitting on a hanging swinging seat, its task is to start swinging, and then, when it enjoys swinging, to stop. In addition to the design challenge, the interesting part of this task is the changing time pattern of the required movements depending on how much swinging is already taking place. Some teams used distance sensor to detect the swing-position of the robot. Team Ladybirds (figure 7 right) approached this creative challenge with files – they have made a robot that can be trained to swing using a touch sensor. It records the correct timings and then performs the learned sequence. In fact, this task would be suitable even for students of control theory at university.

7. **Art (round 5, year 3).** In the middle of the season, one task is usually dedicated to a creative artistic topic. In the second year, we focused on music, while in the third year on fine arts. Teams have made: beautiful T-shirt that was painted by a robot, 3D drilling machine, various artistic plotters, 3D printer with LEGO Bricks, Easter eggs painting, and even machine that can draw with glowing light in the dark, see figure 8. We found solutions to this task inspiring.

*Figure 7: Two swinging robots (teams Dunajská Lužná and LadyBirds).*

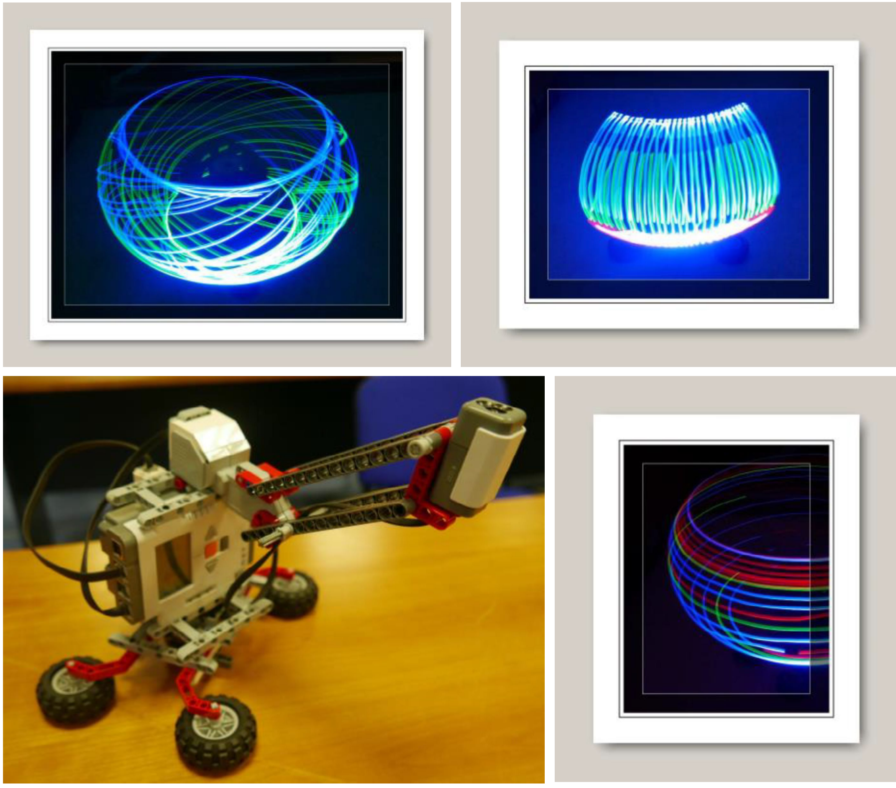


*Figure 8: Drawing in the dark – team Benders.*

### Supporting Software

In the first year, we have manually published the submitted solutions on-line, which even for 6 teams turned out to be a too demanding and time-consuming task. Therefore, a student project at the faculty of the first author has been assigned. The students have successfully created a web application in a usual LAMP environment using CodeIgniter MVC framework. The application allows the team leaders to register a new team at any time, view all passed and current task specification, submit their description, pictures, attachments, video links, and edit their solution before the deadline. Their solutions are nicely formatted and integrated into the whole website of FLL in Slovakia that runs under a version of MODx CMS. Judges can view the solutions, assign scores, write their textual evaluation, select the best team in each round, and make their evaluation public. The resulting scores are computed automatically and shown in a table on the website. Organizers can enter their task descriptions with pictures and maintain a pool of tasks to be used later in the contest, providing a starting and ending dates when the task description becomes visible and when no more new solutions are accepted. This system has simplified the organizers work and made it more convenient for the teams to adjust the presentation of their solution as they wish. Another group of talented students is currently working on a complete rewrite of the web application, this time allowing for multiple languages and better user interface to prepare the system for our future goals.

## Discussion

Should the rules be limited in the same way as the original FLL competition rules? It seems to open creativity doors when we allow to use additional components, not strictly limited to LEGO parts. Also programming experience can be wider when not stuck on the graphical programming environment only. On the other side, wider base here can later be limiting when teams start to prepare for regular FLL competition. Children can easily forget some important limitations (this sensor was allowed in SL, so why we can't use it now?). Is there an “optimal” time interval for solving the tasks? Are three weeks sufficient? Usually the clubs meetings are organized once a week, so they may need more time to discuss and solve the task.

# Conclusions

We have organized three years of creative constructionist robotics on-line competition for young people in Slovakia aged 10-16, with 10 tasks each year. Its main aim is to prepare the pupils for the FIRST® LEGO® League competition, but it proved to have even larger impact. We have experienced a growing interest and a positive feedback from the participants. We are opening the competition to a global international participation. Participation in the contest is free and easy, emphasizes learning, and creativity, it does not include stress and frustrations from failures at tournament day – which are inevitable in on-site single-day events. The amount of sharing ideas that takes place in this contest is among its strongest advantages. We efficiently utilize modern media – such as YouTube videos and a dedicated web application that allows the participants, referees, and organizers to maintain the contest automatically on their own without any other assistance from a system administrator.

# References

Bjorke, S.Å., Lazareva, A., Mayende, G.and Nampijja, D. (2015) Together we can. Team and online collaborative work, PULS; http://grimstad.uia.no/puls/Groupwork/main.htm, accessed 11 May 15.

Petrovič, P., Balogh, R. (2008) *Educational Robotics Initiatives in Slovakia*. In Proceedings of Teaching with Robotics Workshop, SIMPAR 2008, Venice, Italy.

Petrovič, P. (2011) *Ten years of Creative Robotics Contests.* ISSEP 2011, Bratislava.

Petrovič, P. Balogh, R., Lúčny A. (2010), *Robotika.SK Approach to Educational Robotics from Elementary Schools to Universities*, In Proceedints of the 1st International Conference on Robotics in Education RIE2010, September 2010, Bratislava. Jones, A. B. and Smith, W. (1984) *Statistical Methods for Scientists*. Wiley, New York.

Oppliger, D. (2002) *Using ® LEGO League to enhance engineering education and to increase the pool of future engineering students (work in progress)*, Frontiers in Education, 2002. FIE 2002. 32nd Annual , vol.3, no., pp.S4D-11,S4D-15 vol.3, 6-9 Nov. 2002.

Timcenko, O., Friesel, A. (2011) *Competition-motivated teamwork and narratives to motivate girls for engineering,* EAEEIE Annual Conference (EAEEIE), 2011 Proceedings of the 22nd , vol., no., pp.1,6, 13-15 June 2011.