# Robot competitions trick students into learning

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***Abstract*—It has been shown in the past that robots help to bring theoretical concepts into practice, while at the same time increasing the motivation of the students. Despite these benefits, robots are hardly ever integrated in education programs and at the same time students feel that they have the competences nor the infrastructure to build a robot on their own. Therefore the workgroup electronics (WELEK) of Ghent University gives students the opportunity to build a robot by organizing workshops and competitions. Up until now, four competitions were organized in which over 200 students voluntarily participated. This paper describes our approach in the hope that it will inspire other educators to do the same thing. We also measured the effectiveness of our competitions by sending each of the participants a questionnaire. The results confirm that students acquire relevant technical competences by building a robot, learn to work as a team and are challenged to use their creativity.**

## I. Introduction

There is no doubt that we live in the dawn of the robot era. Just like the introduction of personal computers changed our lives, robots have started to revolutionize our way of living. Since long, people have been fascinated by robots, but only now we have the technology and the knowledge to build cheap robots that can take over some of our daily chores. This fascination for robots is especially prominent in engineering students, which feel the urge of being part of the robot revolution. However, many of them are discouraged from building their own robot because they believe that building even a simple robot requires lots of skills and infrastructure. This is of course not entirely untrue, but in this paper we show that by opening up some of your universities infrastructures and with the right goal in mind, a screeching robot battle, they will gladly learn all the skills they need and have fun doing so.

It has been shown before that using the students fascination for robotics early in the curriculum can be very beneficial: students from varying disciplines learn to value and utilize each others' knowledge, by means of a basic robotics course [1]; Integrating a robot project in a undergraduate education program increases students interest in research [2]; Robots motivate students to solve problems which they otherwise find tedious [3]; The opportunity to participate in a robot competition boosts the interest of both high school students and undergraduates in robotics and engineering in general [4]. Robot competitions encouraged students to apply their knowledge to a real-world problem and motivates them to learn new concepts on their own [5]. This paper confirms these finding and further strengthens the motivational claims.

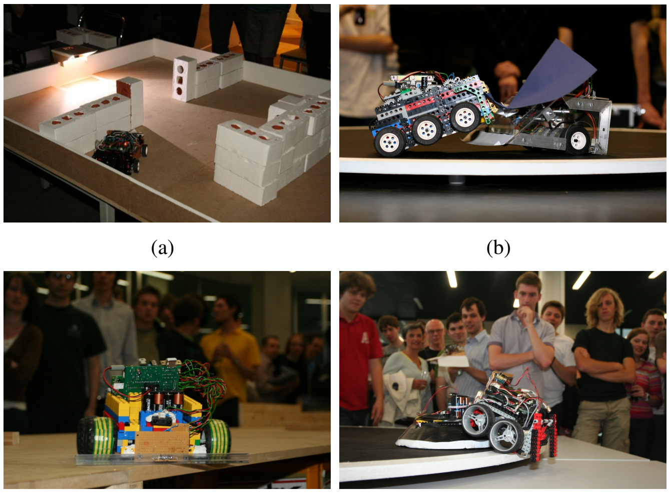
It all started at the engineering faculty of Ghent University, where PhD students founded the workgroup electronics (WELEK) with the aim to organize practical workshops on electronics for students. These workshops give students the opportunity to gain more hands-on experience with electronics. Students can build one of many electronic devices such as an FM-transmitter, a VU-meter or an electronic bat detector, or they can use the infrastructure to work on their own electronics project. Besides the standard workshops, WELEK yearly organizes a series of workshops on robotics which concludes with a robot competition for autonomous robots, since 2008. The goal of WELEK is actually three-fold: (1) lower the threshold for students to get involved into electronics and robotics by providing guidance and infrastructure, (2) teach several concepts in electronics and robotics in a more practical way and as such, (3) motivate students towards electronics and robotics.

More than 200 students have participated in one of the four robot competitions that WELEK has organized so far. This paper describes the results of a questionnaire that was send to all of these students. The questionnaire was answered by more than one third of them (76 students). In the next two sections we describe the details of the four robot competitions we organized and the hardware that was used by the students. Later, in Section IV we describe how our workshops are organized and relate this to the outcome of our questionnaire. We also questioned the students about the knowledge they have gained and whether they enjoyed these robot competitions or not; these results are discussed in Sections V and VI. Finally, some conclusions are drawn.

## II. Robot competitions

The electronics workgroup[1] (WELEK) is a student organization that was established at the faculty of engineering at Ghent University in the early nineties. WELEK organizes hands-on workshops which give the students the opportunity to use the universities infrastructure to build one of the available projects or to work on their own application. The universities infrastructure was kindly opened by the head of the ELIS department at Ghent University. During the sessions the students can get assistance from more experienced students and PhD students if needed. The sessions are held every two

[1]See http://www.ieeesb.ugent.be/welek for more information



(a) (b) (c) (d)

Fig. 1. Overview of four year robot competitions: (a) a light eating robot competition in 2008, (b) a sumo robot competition in 2009, (c) an autonomous robot navigation contest in 2010, and (c) a sumo robot competition in 2011.

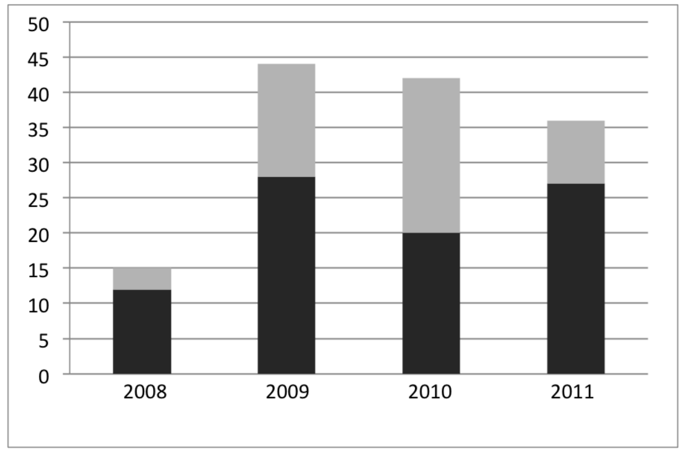



Fig. 2. In light gray, the number of teams that subscribed at the beginning of the semester to our competition. In black, the number of teams that actually participated in the competition (eg had a working robot at the end of the semester).

weeks of the first semester. Students attend the workshops on a voluntary basis. They cannot earn any credits for participating.

In 2008, the idea rose to organize a robot competition for “intelligent” robots, accompanied with some introductory workshops on robotics. Since then, four competitions have been organized: (1) a light eating contest, (2) a sumo robot competition, (3) an autonomous navigation contest and (4) again a sumo robot competition. A visual overview of these competitions is shown in Figure 1. In what follows we give a short description of the setup and guidelines of the four competitions:

- In 2008, *light eating contest*, the goal was to build a robot that can drive autonomously towards a source of light, while avoiding obstacles on their way. The obstacle course gradually became more difficult towards the end of the competition with obstacles that for example tried to trap the robot or block the light. The robots were limited in size and weight: the maximum width, length and height of the robot was 20 cm and the total weight was limited to 1500 grammes. In order to track the light, and to detect obstacles, light sensitive sensors and short range reflective distance sensors could be used. For the transmission, only electric (DC) motors were allowed. The “brain” of the robots in all competitions is a microcontroller board, which will be explained further.
- In the *sumo robot competition* of 2009, the goal was to build a robot that could push other robots out of a circular shaped arena. Robots were limited to a width and length of 25 cm and could be infinitely high. The weight had to be lower than 1250 grammes. Robots could use electrical (DC) motors for driving the wheels, and optionally additional motors or RC-servos for driving levers or expanding pieces to distract other robots. For the sensors, long range distance sensors could be used to find other robots, and reflective sensors to detect the edge of the arena.
- In 2010, an *autonomous robot navigation* contest was organized. The goal was to autonomously navigate through an obstacle course and reach the other side of the course. In contrast to the competition of 2008, there was no navigation light, instead robots could use a compass sensor to keep track of their orientation. Of course, also long and short range distance sensors could be used to detect obstacles. Robot were limited to a width and length of 25 cm and a height of 50 cm. The weight was limited to 2000 grammes. Only electrical (DC) motors and RC-servo motors were allowed.
- In 2011 we organized a second edition of the popular *sumo robot competition* with the only difference being an increase of the weight limit to 1500 grammes.

At the beginning of the second semester the students register to the competition individually, or in teams with two or tree members. During the semester they can attend evening sessions to work on their robots. More than ten sessions are organized during the course of the semester. Two of the sessions are organized as lectures where the basics of robot building are explained, but in most of the sessions the students just use the lab infrastructure of the university and our guidance to build their robots. Apart from the sessions, students often work at home on their robot during their free-time. About two months after the first session, the competition itself is organized. The students bring their friends and family to support them in the battle for some very nice prices.

Over the years, more than 200 students participated in one or more of the robot competitions. The level of graduation of the participants is distributed uniformly, ranging from freshman to senior students. Most students are studying or are intending to study computer science or electronics, with a participation of 32% and 23%, respectively. Others have various backgrounds ranging from mechanical engineering to bio-engineering and

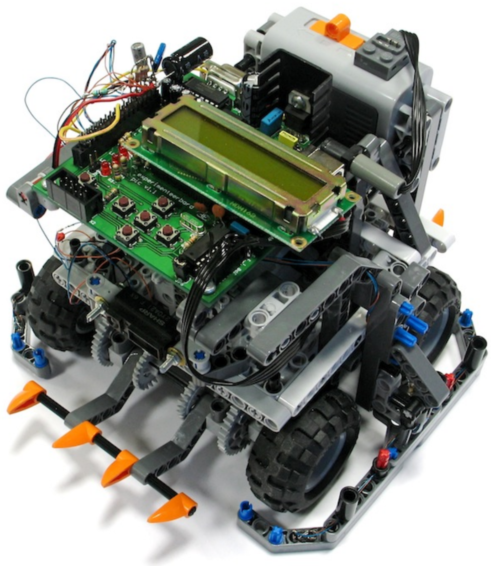


Fig. 3. A typical example of a robot build by the students. One can identify the microcontroller board, a set of motors, battery back and sensors.

even geography. The grey bars in Figure 2 we show the number of teams[2] that subscribed to the competitions. In 2008, the number of participants was rather limited, but the competition quickly grew to about forty teams. The black bars in Figure 2 show the number of teams that actually competed on the final day. While most of the teams manage to build a working robot by the day of the competition, some teams quit because of limited time due to other (mandatory) projects in their education program.

In Section IV we describe our approach to (1) make our workshops and robot competition doable for everybody, and (2) make sure that as many teams as possible finish their robot.

## III. A cheap robot platform

A part of getting students motivated to participate in a robot competition is providing them with cheap and easy-to-understand components. A robot has three major parts: (1) the mechanical part, consisting of a robot chassis and motors, (2) the brain of the robot, i.e. a microcontroller board and (3) the sensors. From our experience, we know that students have no difficulty in finding a robot chassis and motors. Most of them recycle Lego™parts from their childhood, others are more creative and use metal plates and fetch some motors elsewhere. The electronics, both the processing unit and the sensors, are regarded more difficult since most of the students have little or no experience with microcontrollers and sensors. Therefore, WELEK provides a microcontroller board and proposes a number of sensors that can be used, depending on the type of competition. Typical sensors that have been proposed include phototransistors, short and long range distance sensors and in case of the autonomous robot navigation contest a compass sensor.

The microcontroller board WELEK proposes is the Dwengo board[3] [6], a good priced platform with a PIC18F4550 and a wide range of onboard peripheral which can be used to easily build a robot without the need of additional electronics. The board comes with a display, some generally applicable buttons and LEDs, a quad-bridge motor driver, a USB and serial port and an expansion connector that enables easy integration with different sensors. In order to make the programming of the robot's intelligence easier, we provide a framework in C which makes all the needed functionality easily accessible so that the participants only have to focus on how they implement the robot's behavior. A battery pack of six or eight AA batteries can be attached easily to power the robot.

For students it is very important that building a robot does not take up too much of their limited budget. In our experience, students can build a robot from scratch for less than EUR 100. This includes the microcontroller platform, two motors and a set of sensors. Thanks to sponsoring, we can even significantly lower the actual price the students have to pay for the robot. Additionally, they have the opportunity to spread the cost by working in teams and by recycling components used in previous competitions. Making sure participating is cheap motivates students because they still have money left to buy some beers.

## IV. Approach

Everyone who has organized a competition, especially a competition with a technical aspect such as a robot competition, has experienced the phenomenon that people subscribe to the competition but don't participate in the final event. This effect can be observed in Figure 2 which presents an overview of the number of teams that had the intention to participate (light gray) and the actual number of teams that had a working robot on the day of the competition (black). The main reason why students drop out is lack of time, they have other projects which are mandatory in their curriculum. But apart from that, two other aspects are important: (1) the difficulty of the competition, and (2) the availability of guidance.

Figure 2 shows that in the 2010 competition less than usual teams finished their robot. While the exact reason can not be derived from our questionnaire (students claim to drop out because of lack of time), we believe that the complexity of this competition is also a significant reason. In contrast to the other competitions, three types of sensors were needed to build a robot that could successfully complete the obstacle course. Additionally, students needed to come up with more advanced control strategies in order to deal with all possible obstacle configurations. In the future we plan to keep the concept of the competitions simple so that each team can at least build a working robot and compete with their peers in the final event.

[2]On average, each team contains 2.3 individuals

[3]Dwengo vzw is a non-profit organization that supports people who like to experiment with micro-controllers http://www.dwengo.org

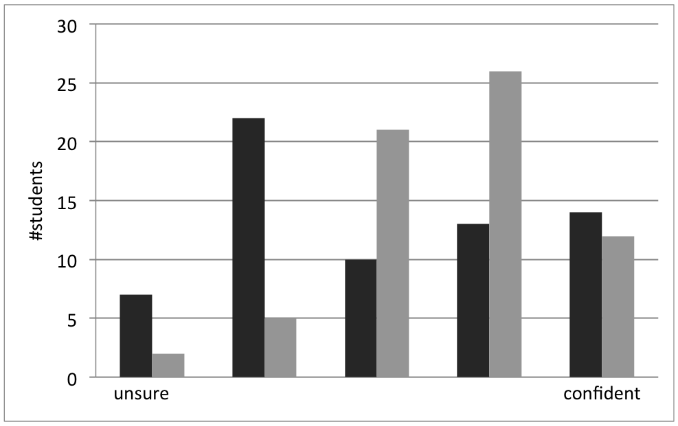



Fig. 4. Illustration of how students estimate their prior knowledge and skills to build their own robot. In black, their believe in prior knowledge before participating the robot workshops and contest. In light gray, the students' estimation of the necessity of having prior knowledge and skills after they participated in the robot competition.

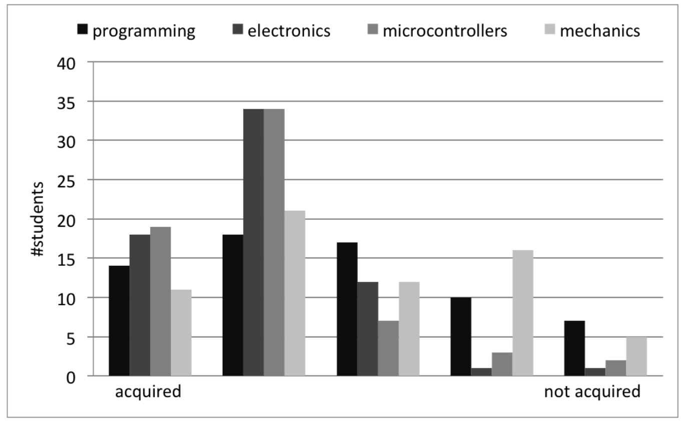



Fig. 5. Competences acquired by the students: programming skills (black), electronics (dark gray), microcontrollers (light gray) and mechanics (lightest gray).

At the same time it should be the case that creativity and hard work leads to better working robots. Sumo competitions are a good example of a simple concept with lots of room for creativity.

Despite our efforts, still a lot of students believe they don't have the knowledge to build a robot and to participate in a robot competition. The black bars in Figure 4 show how students estimate their prior knowledge and skills *before* participation. In the same Figure the grey bars show how students estimate the importance of prior knowledge and skills *after* participating. We observe that students are unsure about whether they are able to build a robot or not, but once they have done it, they see that it is not that difficult at all. We believe that an important reasons of this shift towards more confidence is the intensive guidance we provide during the robot building.

Typically, we start with a kick-off session at the beginning of the second semester. In this session we give an overview of the goal including the rules and a basic explanation of what a robot is and how students can start building one. After this overview, students get the opportunity to subscribe, and to buy and solder the necessary components. Next, two times two hands-on soldering sessions are organized during which the students can solder the microcontroller platform. After that, a theoretical session about sensors and how to program robots is giving. We explain which sensor types can be used, how the output of these sensors can be interpreted and what functionality is available in the programming framework. We observed that even freshman students with no electric experience and almost no programming experience are able to understand the concepts in this theoretical session and apply them to their robot. This theoretical knowledge can then be applied to the their robots in the following four (again two times two) guided sessions. Typically, students build their robot, solder and connect the sensors, and perform some tests. Right before the competition itself there is an extra session which can be used to test their robot and to fix the last few problems. During all sessions, the WELEK team is there to help the students and answer their questions. By attending the sessions, students see the work of the other teams which gives them the opportunity to compare robots and learn from the other teams. In our questionnaire, a huge part of the participants noted that the sessions motivated them in building their own robot.

## V. Learn by building robots

That robots can motivate students to learn, even in their free time has been shown before [7]. From our questionnaire we wanted to learn how students estimate the knowledge they have acquired by participating in our robot workshops and robot competition. The results are presented in Figure 5. We explicitly asked how much they feel their knowledge about programming (black bars), electronics (dark gray bars), microcontrollers (light gray bars) and mechanics (lighter gray bars) has improved. Not surprisingly, students feel that they have acquired a lot of knowledge about electronics and microcontrollers. Their programming skills and their knowledge about mechanics have also increased, but to a lesser extent.

But not only knowledge is important. We also asked the participants how much their creativity was stimulated during this competition and wether they learned to work in team or not. In Figure 6 we present the results: the black bars show wether students learned to work in teams, while the gray bars illustrate to which extend the students think their creativity was stimulated. It is clear that the students creativity was highly stimulated, but learned to work in teams to a lesser extend. The latter could be due to the fact that most teams consist of friends which knew each other beforehand and in this way already knew how to work together.

Overall, we can conclude that by participating in the robot workshops and the competition, students feel they really learned useful competences. These competences are in many cases complementary to those acquired in the standard curricu-

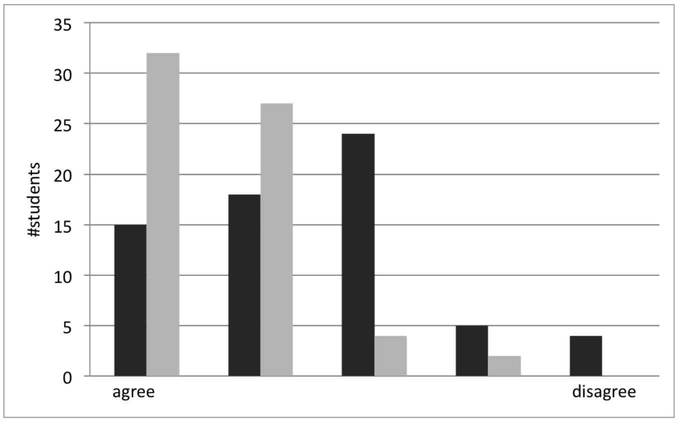



Fig. 6. Acquired soft skills: in black, how much the students feel that they have learned to work in teams, in light gray, how much students feel that their creativity was stimulated.

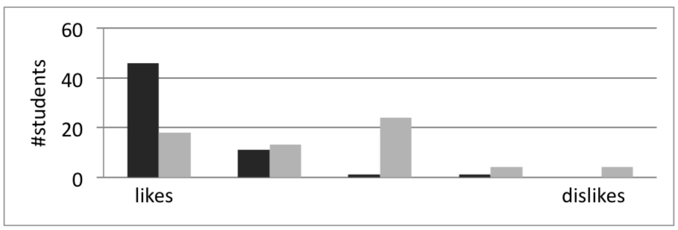



Fig. 7. Estimation of the amount of fun they had: in black, students response on the question how much they liked building a robot, in gray their intention to participate in the edition next year.

lum where the emphasis is put on theory while we emphasize the practical side of electronics.

## VI. Robot competitions are fun

We also wanted to learn how much the students liked building robots and participating in robot competitions. We get a first indication from their answer to the question how they learned about our robot workshops and competitions. One third of the students claimed to be notified by other students or friends. Apparently students like the competition so much that they pass it on to their friends. This can also be derived from Figure 2 in which it can be observed that we started small, with a few students that already participated in our standard electronic workshops, while the next year the word was spread and the robot competition became a big event with a lot of interested students.

Additionally we explicitly asked them wether they enjoyed building robots or not. The outcome of this question is presented by the black bars in Figure 7 and is very positive. This is also confirmed by the fact that the majority want to participate in next year's competition (gray bars), however, some still have doubts. A possible explanation for these doubts can be that they don't yet know the work load next years educational program.

## VII. Conclusions

In this work we presented our approach for organizing robot competitions for students. Even though these competitions are not part of the curriculum, and thus no credits can be earned for it, every year a huge number of enthusiastic students build a robot and participate in the competition. We believe that there are two reasons for this success: (1) students are fascinated by robots and they feel the urge to build one, and (2) the robot competition has been made as accessible as possible by organizing guided hands-on workshops and opening the universities infrastructure.

With this paper we want to stimulate other educational institutions to give their students the opportunity to participate in an easily accessible robot competition. This is useful because, as we learned from our questionnaire, students acquire relevant technical competences by building a robot. Moreover they learn to work as a team and are challenged to use their creativity. So, by giving students the opportunity to participate in robot competitions, they can acquire skills that are useful for their future career.

## VIII. Acknowledgments

The authors acknowledge the contributions of the other members of WELEK, specially: Tim Waegeman, Bart Coppens, Sean Rul, Guy Torfs, Tom Davidson, Dries Van Puymbroeck, Gertjan Van Droogenbroeck and Sander Dieleman. The authors would also like to thank the huge number of students that enthusiastically build their robot and participate in our competitions.

## References

[1] S. Shamlian, K. Killfoile, R. Kellogg, and F. Duvallet, "Fun with robots: A student-taught undergraduate robotics course," in *Proceedings of the International Conference on Robotics and Automation*, 2006.

[2] B. Maxwell and L. Meeden, "Integrating robotics research with undergraduate education," *IEEE Intelligent Systems Magazine*, pp. 22–27, 2000.

[3] F. Wyffels, M. Hermans, and B. Schrauwen, "Building robots as a tool to motivate students into an engineering education," *AT&P JOURNAL PLUS*, vol. 2, pp. 113–116, 2010.

[4] N. Sunderhauf, T. Krause, and P. Protzel, "Bringing robotics closer to students - a threefold approach," in *Proceedings of the IEEE Conference on Robotics and Automation*, 2006.

[5] D. Pack, R. Avanzato, D. Ahlgren, and I. Verner, "Fire-fighting mobile robotics and interdisciplinary design-comparative perspectives," *IEEE Transactions on education*, vol. 47, pp. 369–376, 2004.

[6] P. Bertels, F. Wyffels, and K. Bruneel, "Building an intelligent robot in the class room with dwengo," in *Proceedings of the National Informatics Education Conference*, 2011.

[7] J. S. Kay, "Robots in the classroom ... and the dorm room," *Journal of Computing Sciences in Colleges*, vol. 25, pp. 128–133, 2010.