

ENGINEERING STUDENTS AND ROBOT CONTESTS: LEARN LIFE TO THE MAX!

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Abstract

The paper describes the IDEC, Industrial Design Engineering Contest. IDEC is a design-build-and-contest event at the Faculty of Industrial Design Engineering of Delft University. The paper describes similarities and differences with robot contests from literature. It shows IDEC is a relative extreme short workshop and although IDEC can not be seen as a robot-contest according the definition of a robot, the students' learning experience show many similarities with larger, longer and more complicated events.

Keywords: robot contest, engineering contest, experiential learning

1. History of the IDEC

Design-build-and-test projects, mouse trap driven cars and specifically the ME 2.70 design contest by Harry West at MIT all formed the elements of an initiative started by Philips in 1993. Philips then started the 'Qreatech' (later called 'Inventech', 'Philips Design Competition' and 'Createch'), a robot contest between teams of the three Dutch Universities of Technology (Twente, Eindhoven and Delft). This was also the start of the IDEC (Industrial Design Engineering Contest), in Dutch "io-Techniek Workshop". The main motives for Philips to start such an initiative were to enlarge the group of possible Philips employees and even more to stimulate the hands-on experience of academic engineers with the integration of mechanical and electronic design (mechatronics). Philips has steadily reduced her organizational and financial input into the contest so now the three Universities of technology in The Netherlands are responsible for this an annual event. From each university three multidisciplinary teams of five to six students are delegated consisting of students in mechanical engineering, electrical engineering and IDE (Industrial Design Engineering) (recently also management and health science students are involved in the contest). The robot contest is now called 'Createch' and forms a spectacular annual event. The three universities each take there turn in hosting the event.

The IDEC is a qualifying round for the Createch, the winning teams from IDEC merge with students in electrical and mechanical engineering into three Delft University Createch teams. Since 1994, the IDEC has been organized for eight times.

When starting the IDEC, we set out to make a robot contest that would have a number of unique features within the IDE-curriculum; no 'large report writing', no 'postponing of due dates' and a closing event that would appeal to a large audience.

The challenge for students would consist of a combination of three aspects:

- make it work in a short period of time
- only use the materials you are allowed
- defeat the competition

These three aspects can be seen in the daily life of industrial design engineers as well, in this respect, the IDEC forms a simulation of the future of IDE students. Aforementioned features have evolved into a set of specific IDEC criteria for the planning, the contents of the toolkit, lay-out of the playing field, powering and controlling the robots, the assignment and the organization. The next chapter will present and discuss these features in detail.

2 IDEC features

2.1 The basics

- The contest is based on a series of one-to-one matches. The winner (out of 16 participating teams of five students each) is selected in three rounds of games and a set of (cross) finals. Round one; from 16 to 8 teams, round two; from 8 to four teams; round three from 4 to 2 teams. Losing one game means you're out. This proves especially hard for the team losing the first match. They have been working on their robot for an entire weekend and are out of the contest within three to five minutes.
- You are not allowed to demolish your opponents' robot. Obstruction is allowed but should not be the soul purpose of your robot.
- The IDEC winner is determined by the results of the matches. There is also a so-called jury prize; the jury itself determines the criteria for this prize.
- The robot should be made from components from the toolkit and additional fasteners from a specified range only. Buying components or trading them with other teams and the use of workshop scrap is prohibited. The robots sizes at the start are limited; in the majority of the contests we allowed a 50 by 50 centimeter foot-print and a maximum height of 1 to 1,5 meter (depending on the nature of the assignment). Teams are not allowed to alter the surface of the playing field (i.e. attach something to it).
- The jury decides. In the week following the announcement of the assignment and rules (see 2.2 planning), and also during the weekend, the teams have lots of questions concerning the assignment, almost in a juridical way. The organizing committee answers these questions during the week. The jury is in charge right from the start of the contest. It consists of CEO's from related industries, professors from associated faculties, etc. Busy as they usually are, they take ample time to read the assignment and rules. During the contest they act upon their interpretation of the rules, which not always matches the students' interpretation. In some cases this leads to spectacular discussions between jury and competitors and sometimes even intervention of the audience.

2.2 Planning

The contest is planned during one of the last weeks of the semester in which the students have little classes to attend and just before the start of the exams. About three weeks before the IDEC start, student can enroll in teams. The planning just before and during the contest is best presented in the following scheme:

Table 1. IDEC planning

Monday	Hand out the assignment (strictly confidential till then)
Tuesday to Friday	Teams go through the assignment and make plans (both strategy and engineering) during the day, no IDEC-obligations are scheduled
Friday 13h30	Toolkit containing a set of materials is handed out, teams start building
Saturday	Building and testing (09h00 to 22h00) lunch and dinner included
Sunday	Building and testing until 16h30; impoundment of the robots, drinks and dinner
Sunday 19h00	IDEC event followed by informal drinks

The planning shows IDEC is a very short and intensive contest, hardly interfering with other classes or courses. In this way the workload of students can be balanced quite well. Due to the high level of group commitment and motivation during such contests, contests lasting longer might easily disrupt normal studying behavior [1].

2.3 The toolkit

Teams are allowed to use materials from the toolkit only to build their robot. The toolkit consists of a wide variety of electrical, mechanical and pneumatic components. The nature and amount of material can be adjusted to the specific assignment. Standard toolkit components are: electric motors (4), a set of gearwheels, a single-action pneumatic valve, a servo, drinking straws, rubber bands, plastic cups, some wood/aluminum, lots of Meccano components (strip, wheels, etc), rope, a refuse bag, plastic tube, etc.

2.4 Powering and controlling the robots

The robots are powered by an umbilical cord, it delivers power for the electric motors (2 main 6V, 2 small 3 V motors with modular gearbox) , the servo and the pneumatic cylinder. Due to the length of the umbilical cord (6m), the system has a power-and-sense configuration. This system is tailor made for the IDEC. See figure 1 for a system lay-out.

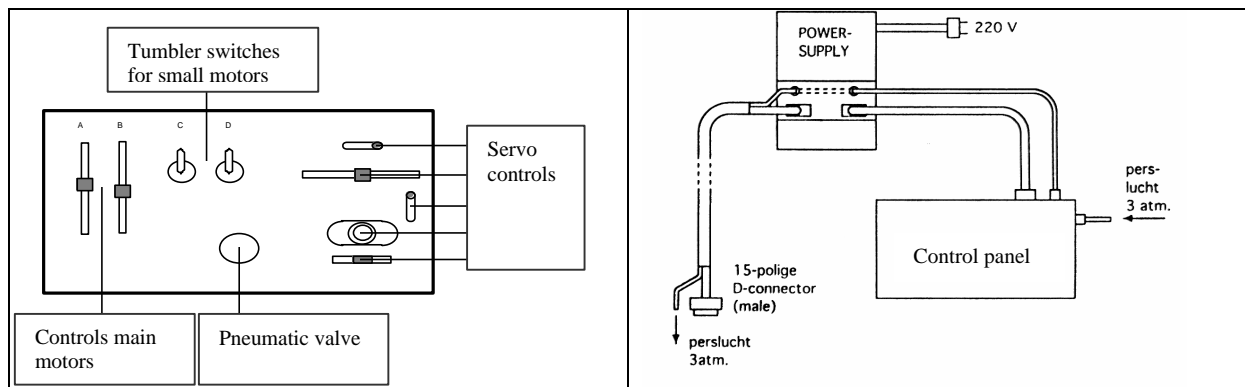


Figure 1. Lay-out of control panel and power system

2.5 Lay-out of the playing field

The playing field (or sometimes ‘battle field’) consists in most versions of the IDEC of a rectangular platform on a level of 80 to 90 cm off the floor, measuring approximately 2 ½ by 4 meters. This ‘table’ allows both jury and audience to have a good view over the contest (see figure 2).



Figure 2. the playing field during the 1998 ‘roborope pulling’ contest (the two ends of the rope protruded from a hole in the middle of the table, the robots first had to get hold of it and then reel it in)

2.6 Assignments criteria

In the nine years we organized IDEC, the most valuable learning experience from the organizers point of view was ‘how to design an assignment’. When we started in 1995 only a fraction of this knowledge was available [2]. It has proven to be a dominant criterion in determining whether a contest would be successful. In 1998 we defined the following set of criteria for a successful assignment.

1. The assignment and rules should provoke a wide variety of solutions. There should not be one best alternative. The teams should be able to combine different technical solutions with both defensive and offensive strategies. The rules should prohibit destructive or purely defensive behavior. The teams should not be able to win the contest just by obstructing the actions of the opponent.
2. Interaction by robots during the games should challenge the teams to react to the opponents actions and adapt their strategy at the spot, static game situations should be avoided. One of the elements to evoke interaction is to introduce ‘scarce resources’, i.e. a limited set of building elements, only one bridge to cross an obstacle, etc. Static situation will be omitted due to robot interaction. In order to do this, the robots have to be controlled by the team members (vs. autonomous robots). This human factor makes it worthwhile for the audience (see figure 3).

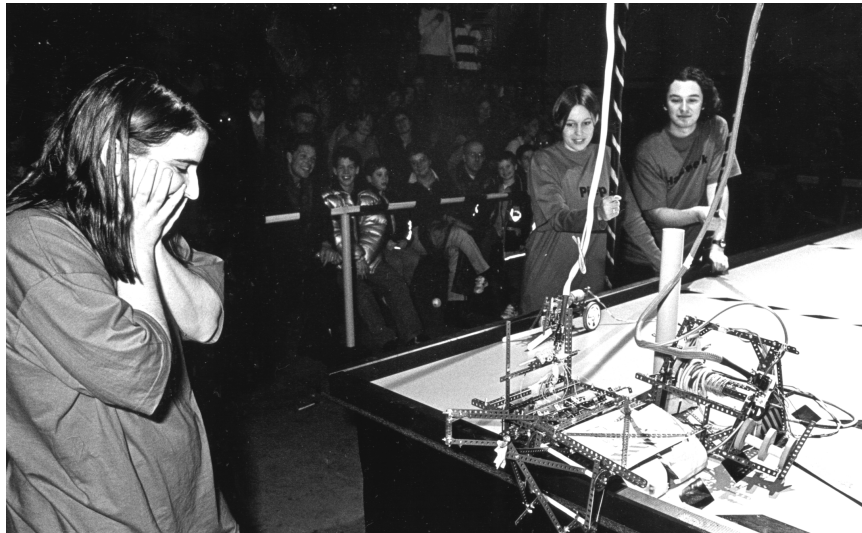


Figure 3. Human error plays a role, the motor was reversed and the entire construction fell apart (roborope 1998)

3. Solutions to the assignment should ask for a mechatronic approach. I.e. pure mechanic or electronic devises should not be able to achieve the goal.
4. The results (score) should be clearly visible for participants and audience anytime during the match without the intervention of measurement devices or calculations. In the case more tasks are possible; the score should be related to the difficulty of the task. A zero-score is considered very demotivating; a minimal score should be realizable if only by driving around over the playing field.
5. The assignment should trigger the imagination of potential participants, possible visitors and the press. This can be realized by using metaphors for the assignment like the 'volcano fighters' (assignment 2001, see figure 4) or 'operation black sheep' (assignment 1997, see figure 5).

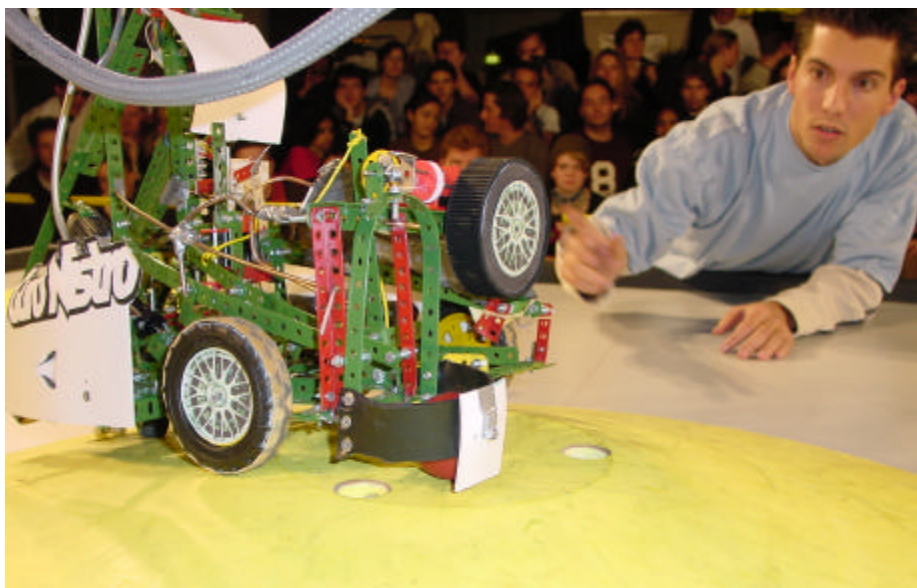


Figure 4. 'Fighting the volcano' (IDEC 2001) The team should close four smoke spitting holes using balls originally placed on the adversaries volcano

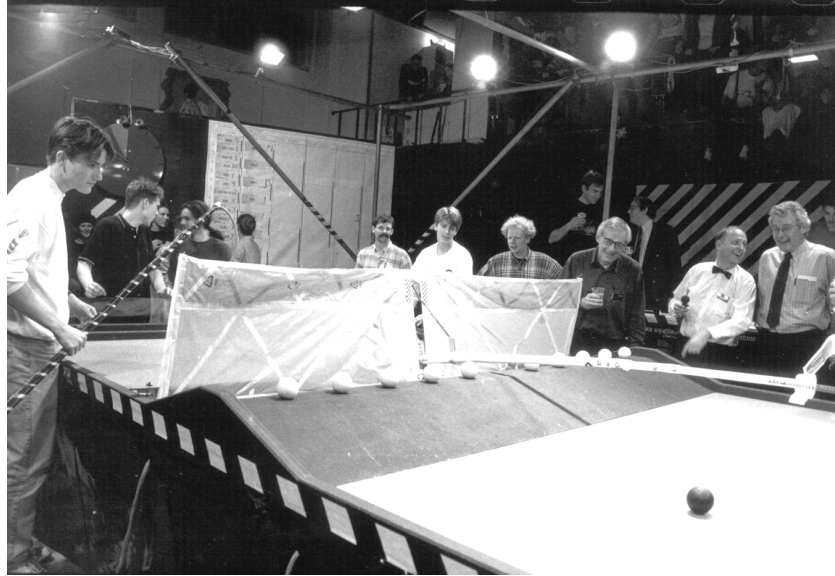


Figure 5. The 1997 assignment; ‘Operation black sheep’, one of the teams designed a large folding screen that would slam into the table when released (the robots should have as little balls on their side of the dike, the position of the black ball would be decisive in case of a draw)

2.7 The IDEC organization

The IDEC is organized by one faculty member and one teaching assistant. The teaching assistant is in many cases a former competitor, an advantage seen in literature as well [3]. There also is a lot of help from colleagues and workshop assistants. Recurring aspect can be done fast due to a matured scenario for the organizational tasks. Designing the assignment combined with rules and getting the toolkit content complete are the most time consuming tasks.

In the weekend we provide lunch and dinner for the contestants, students have tasks in this as well. On Sunday, two hours before the start of the contest, the robots are impounded in order to have a drink and good meal before things really get going. This is very helpful in taking a large amount of the pre-contest stress away from the students, this strategy can be seen in other contests as well [3]. Although this might seem trivial, it offers an atmosphere in which informal exchange of plans, problems and ideas is possible. According to the students’ evaluations, it definitely adds to the IDEC experience.

During the event we have a professional speaker to introduce the teams and comment during the games, a floor manager to keep to the tight contest schedule and keep things going and two floor hands to take down the score and rebuild or clean the playing field. All printed matter is according to a predefined lay-out style. Our faculty is in the fortunate position to be able to host the event in the main workshop hall (30 by 60 meters!). Two large stands for the audience close to the playing field and heavy spotlights provide a boxing match-like atmosphere. Students are surprised by the magnitude and slick performance of the event at Sunday night. “I felt almost ashamed to put my simple robot into that professional arena...”[student evaluation form, 1997]

The cost of the event are moderate, students pay €25,= each to enter the contest. They earn one study point (40 hours) as an elective course. The main costs consist of hiring the teaching assistant, buying toolkit components, buying lunch and dinner and hiring the stands and light/PA equipment. The input from faculty staff is in between 40 and 60 hours in total a year.

2.8 Some observations

From the year 1997 until 2000 the student filled out a short questionnaire after having completed the contest. The next observations represent parts of this questionnaire.

Not surprisingly, only little engineering knowledge on academic level is entered into the workshop. For the majority of students this is the first time they design and build an externally powered product. During the following courses students themselves recognize an improved insight in electric motors, gears etc. due to the hands-on experience during IDEC.



Figure 6. The 1996 assignment ‘robotower’ (the robots had to pick building blocks from a pile of blocks in the middle of the playing field and build the highest tower)

Many times we heard (especially female) students expressing doubt about their personal engineering skills. “Can we make it work in such short time?” In just as many occasions this evaluation ends by students then mentioning;” ...they have never learned as much in so little time as during this contest...”.

During the week, and especially during the weekend, we see a shifting approach towards the problem. In general we recognize the following phases:

- Phase 1: The easy start. Student starting of with –almost juridical- interpretation of the rules in order to discover loopholes, definition of possible strategies, plans on general layout, designing and start building, teams are relaxed (Monday – Saturday around lunch).
- Phase 2: Effective building. Testing (sub)assemblies and refining them, sometimes altering large parts of the original plan. Effective and coordinated working (from saturday around 16:00)
- Phase 3: tape and tie-rop stress. Making it work, even if this means losing (large) parts of the original functionality (“ ...if it only would steer....” [students remark, 2001]). Stress and very short design cycles. (from Sunday around 12:00 until impoundment of the robots)

3 Robot contests in literature

In literature many publications on the subject can be found, starting as early as the 1960's [4] mostly discussing the educational impact of the contests involved. The next two paragraphs will present the main similarities and differences between IDEC and contests found in literature. Differences between robot contests can also be found in [5]. The abbreviation 'crit.x' refers to the related criteria in § 2.6.

3.1 Similarities

- The important role of contest like these in public relation events (open-house) is also reflected in literature [3][6][7]. People see engineering can be fun as well. Robot interaction seems to be a 'crowd pleaser' [3]. (crit. 1)
- The strategy of appealing names (or metaphors) can be seen in many robot contest; "Escape from Alcatraz" [3], "Horse d'Oeuvres, anyone?" [8] and "Sumo wrestling" [9] (crit. 5).
- The shifting approach towards the problem. From "rule research" to "using tape in order to keep it going". Very well put into words in [8]; Tom Dean asking: "Where is the science?" answered by Jim Firby: "The science is what you do back at the lab and throw away the night before the competition." (see observation § 2.8)

3.2 Differences

- In many robot contest we see a race against the clock, the goal of the game is to perform a task in as short time as possible [3][9][12]. In these contests, robot interaction is often minimized. On the other side of the 'interaction scale' we see games like Sumo wrestling, where the interaction is goal of the game. IDEC can be seen as a 'middle of the road' solution, interaction makes it worthwhile for the audience but destructive behavior is not allowed. (crit 1 and 2)
- In IDEC, applying physics or using mechanical calculations is hardly seen. In [6] and stronger [10], (computer) modeling and simulation of the task is necessary on order to comply with the demands of the contest.
- The use of the umbilical cord vs. the use of onboard batteries, combined with the role of the operator in IDEC and the autonomous robots in many AI-robot contests. Here I would like to add a personal note: I still have to get used to people cheering for a 'deaf' autonomous robot....but ok. (crit. 2)

4 Discussion and conclusion

Mikell Groover (Robot Institute of America) defines a robot as: ... a reprogrammable, multi-functional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks...". According to this definition, being programmable is an essential feature of robots. In literature we even find it the other way around. At Wilkes University [11] the robots are used to enable and visualize software engineering. At IDEC, no programming is performed, so the term 'robots' does not seem to be appropriate, neither comparing IDEC with (AI)robot contests. Although.... the amount of similarities between robot contests and the IDEC proves otherwise. In essence students learn fast and intense from these types of courses. They think it's fun and so does the audience.

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