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DESIGN IS FUN! – EXPERIENCES FROM A STUDENT DESIGN CONTEST AT DARMSTADT UNIVERSITY OF TECHNOLOGY

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Abstract

The national qualifying of the International Design Contest (IDC) is an interdisciplinary competition for students at Darmstadt University of Technology. The students have to plan and build a remote-controlled robot that is able to fulfil a given task using identical construction kits. The participants compete with their robots against each other in a public event. The winning teams are qualified for the international finals.

The paper in hand reports on a survey that was conducted to determine if and to what extent the educational objectives of the competition are attained.

Keywords: design education, design competition, creative education, student teams, experiential learning

1 The International Design Contest at Darmstadt University of Technology

In the twelfth year of its existence at Darmstadt the International Design Contest continues to be a highlight of the academic year. Over the years, the number of students that want to take part in the contest has constantly risen. But popularity alone does not furnish proof for the quality of an educational concept. This is why we decided to examine closely – together with our students – the advantages they see in this form of design education.

1.1 The task

In the competition the students are projected in real-life product development situations. They have to deal with requirements and restrictions that determine the complex function and parts structure of their robots. The overall function for the robots can be formulated as “pick-transport-place items”. The table adds various other functional and geometric constraints. The supply the students can access for building the robots is limited to the content of identical construction kits.

Collecting items

100 commercially available squash balls, 22.5 grams of weight each, with a diameter of 40.6 mm form the centre of interest for the collecting machines. Compared to table tennis balls which have often been used as collecting items in previous contests, squash balls are relatively heavy. But the most critical point for the students seemed to be the friction of the rubber balls.

Table

This year's table consisted of two levels: a big basic level and two smaller upper levels. The levels are connected with two ramps, one on either side. On the basic level the starting positions for the robots are located. This is also where the 100 balls fall onto right at the outset of the game. For scoring, the balls have to be taken somehow or other to the upper level. From the canted upper level the balls roll towards the centre of the table onto the blades of an impeller wheel (diameter approx. 500 mm) and let it turn round. Two flags visualize the score. Note that the elevation of a flag is proportional to the angle of rotation of the wheel and not to the number of balls! The main dimensions of the table are approx. 5 meters (width) x 3.5 meters (depth) x 2.5 meters (height).

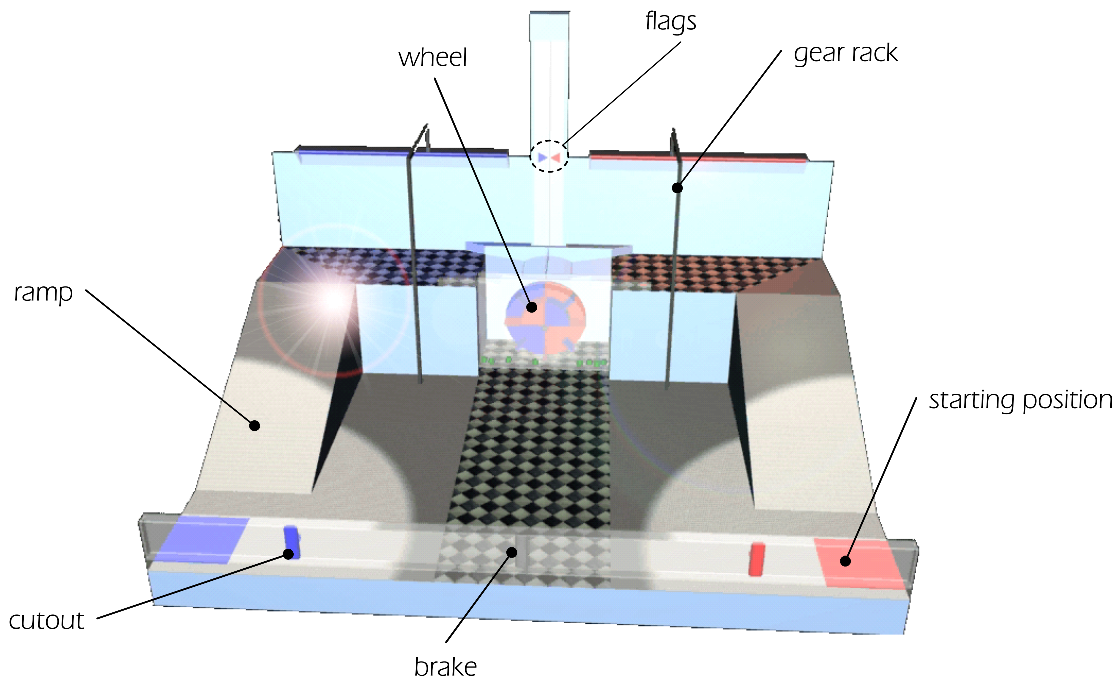

Figure 1. The table, source of lost sleep for the participants.

For those who like tactical variety the table is equipped with three buttons inserted in the front panel. Two buttons allow cutting out the adversary's electricity for 5 seconds. Another button applies a brake that stops the wheel for 5 seconds. The balls that are situated in the wheel mostly fall off without transferring its impulse to the wheel. For pressing the buttons the teams have to manoeuvre their robots into the right position.

Construction kit

For building the robots the students dispose of a cardboard box full of parts. Taken all in all, the contents of this construction kit (shown in Figure 2) can be divided up into three main groups: machine elements (motors, pneumatic cylinders), construction materials (wooden boards, aluminium profiles), and gadgets (CDs, nylons).

Figure 2. The construction kit contains more than 90 different parts.

1.2 Public reaction

The 16 teams compete with their robots in a public event with relatively wide appeal. The competition is held in the second largest auditorium at Darmstadt University of Technology which is regularly filled to capacity. In 2002, the event was attended by more than 500 spectators. Local and national coverage of the event by print and online media, radio, and television certify the popularity of this design course.

Figure 3. … and off to competition!

1.3 International Framework

Two months after the national qualifying, the winning teams of the Darmstadt competition met fellow students from all over the world. Apart from Massachusetts Institute of Technology (USA) that hosted the international final, delegates from Tokyo Institute of Technology (Japan), University of Cambridge (UK), University of São Paulo (Brazil), Seoul National University (South Korea), and the winners of a nationwide robotics contest from France gathered for 14 days in Boston. Heidemann, Heinz, and Birkhofer [1] have analysed in detail the dynamic learning situation of internationally mixed up-groups at a former IDC meeting.

1.4 Educational objectives

Since the resources for developing and manufacturing the robots are limited in time and by the assigned construction kit, the students are stimulated to produce innovative solutions. The participation in the contest is fully voluntary for the students. The IDC is meant to be a sort of counterbalance to the strongly analytic parts of engineering education. In the competition students should find an outlet for creativity while they are given the opportunity to develop so called soft skills. The contest should encourage the students to transfer theoretical knowledge. If these objectives are met, a competition can be a valuable complement for "traditional" education (cf. [2]).

2 The survey

2.1 Research Design

Typification and Measurement Method

The survey has been effected in written form through self-administered questionnaires. This has been done with the intention to exclude an influence on the survey owing to the presence of faculty staff. By refraining from "deadline pressure" we expected to create well-thought out answers. Nevertheless, a questionnaire return within seven days with an acceptable response rate (eight nonresponses out of 32 distributed questionnaires) has been obtained.

A special interest of this study has been to point out if our design contest has got a formative influence on the participants. Thus, the research design has been oriented towards comparing the situation before and after the contest. The research design we chose is based on a pretest-posttest-concept (see Figure 4). We asked half of the participants – one student per team – to answer a questionnaire when they were working for the first week in the workshop, just after having finished the robot design concepts. In the pretest, 16 students took part. The second half of the students (16 students) was asked to fill in similar questionnaires in the last week of their practical activities in the workshop, shortly before competition day. In other words, this longitudinal study gathered data at two points in time from two different samples, whereas the total number of respondents corresponds to the entirety of the population (32 students).

Limitations

Empirical studies in social sciences proceed in a similar way when the effect of a certain treatment (e.g. a new therapy) is to be examined (cf. [2]). In order to predicate the effect, an experimental group is exposed to that treatment. In our case, the "treatment" we exposed our students to is the robot realisation phase of the design contest. Differing from these studies that intend to verify the effectiveness of a treatment by comparing the experimental group to an untreated control group, our study – as a matter of fact – permits to analyse trends.

Indeed, participant observation would have been a valuable alternative to a survey. But the effort for experimental methods would have surpassed disproportionately the frame of this evaluation. As a compromise on feasibility, the time interval between the two measurements also had to be kept low.

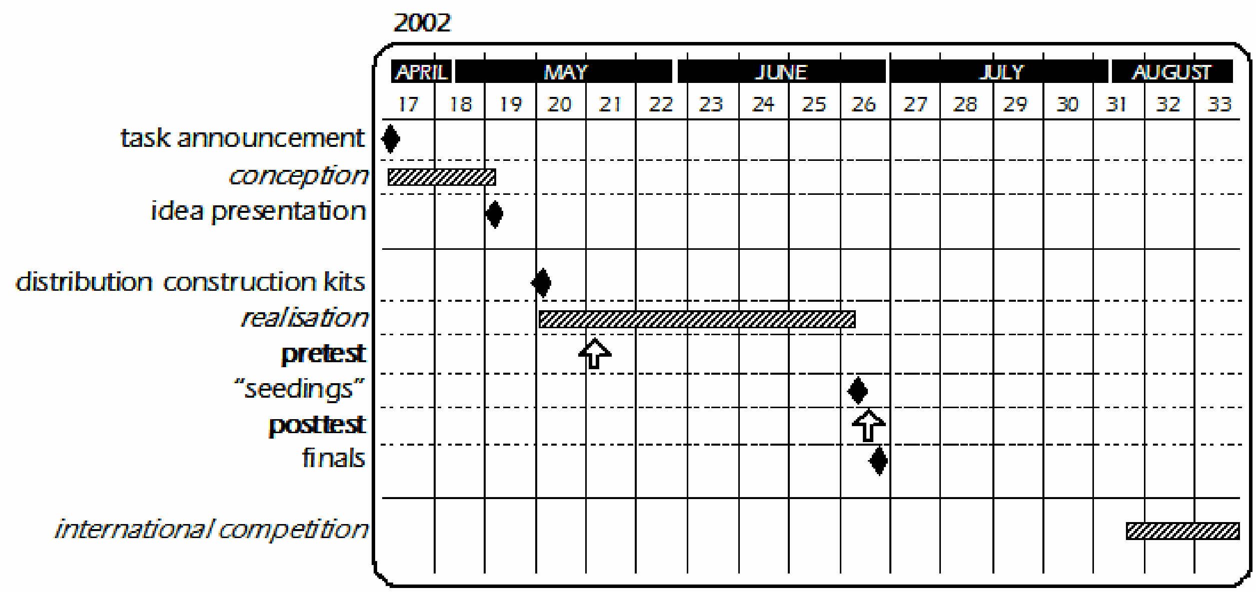

Figure 4. The survey had to fit a tight schedule.

3 Results

3.1 Project Management

By means of a graphical method the participants should assess the time they have spent on the contest weekly. Apart from one team that completely underestimated the effort, the rest of the teams has made more or less reliable time estimations. Figure 5 compares the amount of time a team actually needed (posttest) with the initial time estimations (pretest). The average workload has been 159 manhours which is very remarkable for an ex-gratia project.

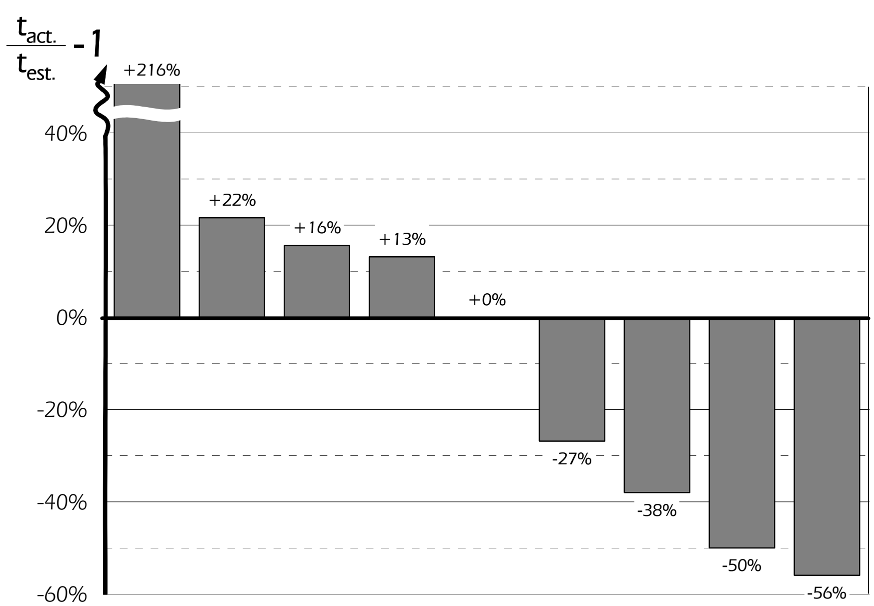

Figure 5. Comparison between estimated and actually required amount of time.

The number of teams practising work sharing has risen noticeably but not significantly during the contest. At first, no team at all planned “work sharing”. At the end of the contest, in three teams the teammates worked simultaneously on different parts of the robot. The “hidden” rate may be eventually higher but only these three teams designated different personal spheres of responsibility of each team member.

3.2 Skills

The students have been asked to self-assess their performance at university compared to the average of the year, their practical skills “at the workbench”, and their creative talent. Additionally, they should rate in how far these three instances of skills are decisive in the course of the contest.

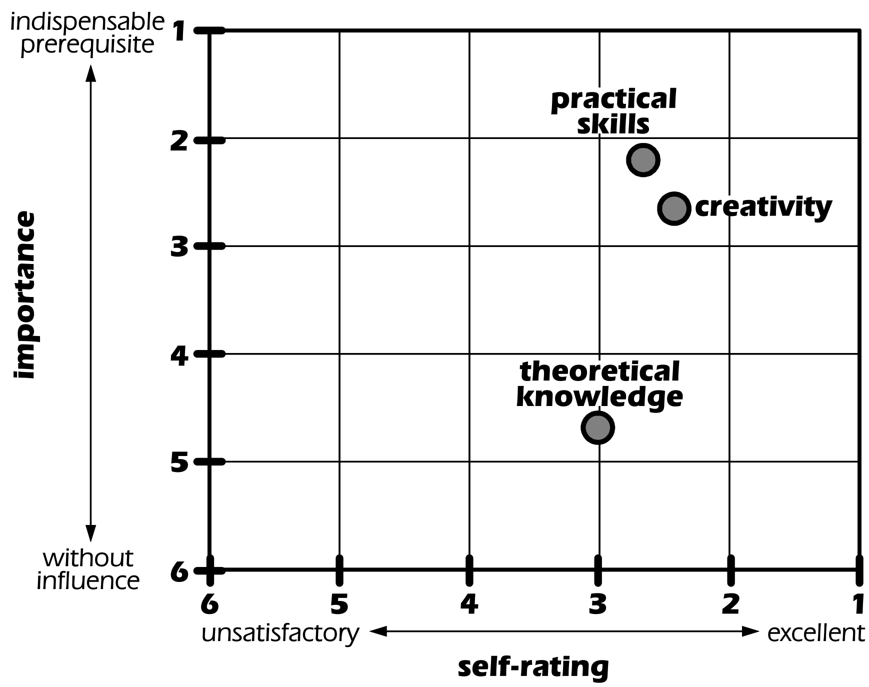

Figure 6. The students self-rated their skills and judged in how far these skills are decisive in the competition.

Figure 6 traces the assessment of the students and reveals a gap between theoretical knowledge on one side and practical skills and creativity on the other side. Both in the pretest and in the posttest the students say systematically that their theoretical knowledge is less developed than their practical skills and creativity though still better than the average. And according to the students, theoretical knowledge plays a minor role in the contest. Practical skills and creative talents are nearly seen as an indispensable prerequisite for the contest while theoretical knowledge is judged less important.

3.3 Motivation

The questionnaire also includes two open questions that aimed at exploring what motivates the students in taking part in the contest and what they think that can be learned in the competition. In the following the answers have been grouped into clusters.

The first open question asked the participants to enumerate their reasons for taking part in the competition. The wide range of answers is condensed in Figure 7.

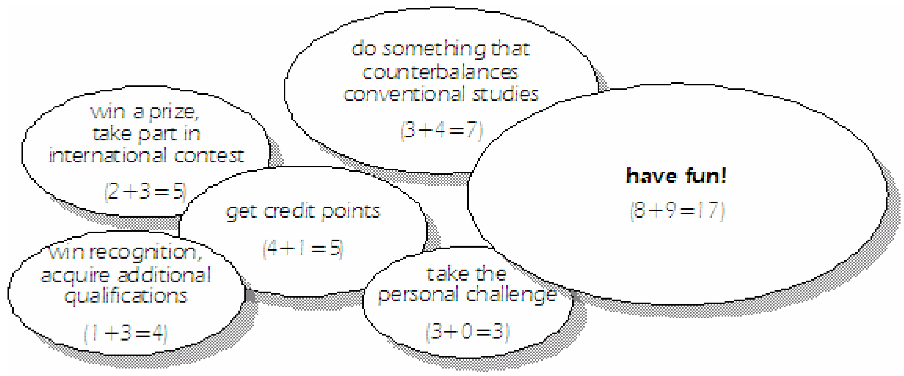

Figure 7. Motivation for participation.

Unexpected or not – one answer came like a shot: It's fun (17 mentions) ! The unanimous majority of students states that the competition complies with their personal inclinations. Considering the undisputable clearness of this result one can even speak of real passion the students show for their subject of study, i.e. engineering design. There is no evidence that time weakens the initial enthusiasm. The pre- and post-poll does not show any signs for decline (eight to nine mentions, before and after the contest). Further three students declare that – in addition – they take the competition as a personal challenge.

Although left far behind, other reasons have been cited. According to seven mentions the design competition stands for a certain counterbalance to more conventional education (quotation from a questionnaire: "I really needed a change! I was bored of all that 'combat arithmetic!'")

Five students were – among other things – interested in credit points. At Darmstadt University of Technology the International Design Contest under certain conditions is equivalent to seminars and tutorials. But for the most part, the participation remains completely voluntary and the success of the competition depends mostly on personal commitment.

Highly motivated through a qualification for the international finals another five participants declared without a moment's hesitation to win the national qualifying in Darmstadt. Still four students wanted to profit from the competition willing to win public recognition and acquire extracurricular qualifications.

Beelich and Schwede [4] distinguish *pertinent* and *extraneous* motivation. *Pertinent* or *primary* motivation that involves personal interest in problem solving is supposed to have a better learning effect since reaching the learning objectives satisfies a personal need. Learning with *extraneous* or *secondary* motivation is more problematic because the learning target is only a means to an end. Referring to the IDC, the survey indicates a high level of primary learning motivation. This is a particular good starting point for reaching the educational objectives.

3.4 Learning Objectives

The second open question takes a closer look at what the students expect to learn initially, respectively what they finally think to have learned during the contest. The impression they had remains relatively stable throughout the considered period of time.

The given answers (see Figure 8) are more balanced-out than in the first open question. In other words: there is no prevailing factor. In the opinion of seven students, practical experience expressly plays a deciding role in the learning process. Another seven participants understand that it is possible to go through an entire product development process by means of which a connexion between product development and product realisation can be established. According to seven mentions the ability to cooperate with others is trained as well. This contains the cooperation with teammates. The same positive assessment applies to the cooperation in interdisciplinary teams.

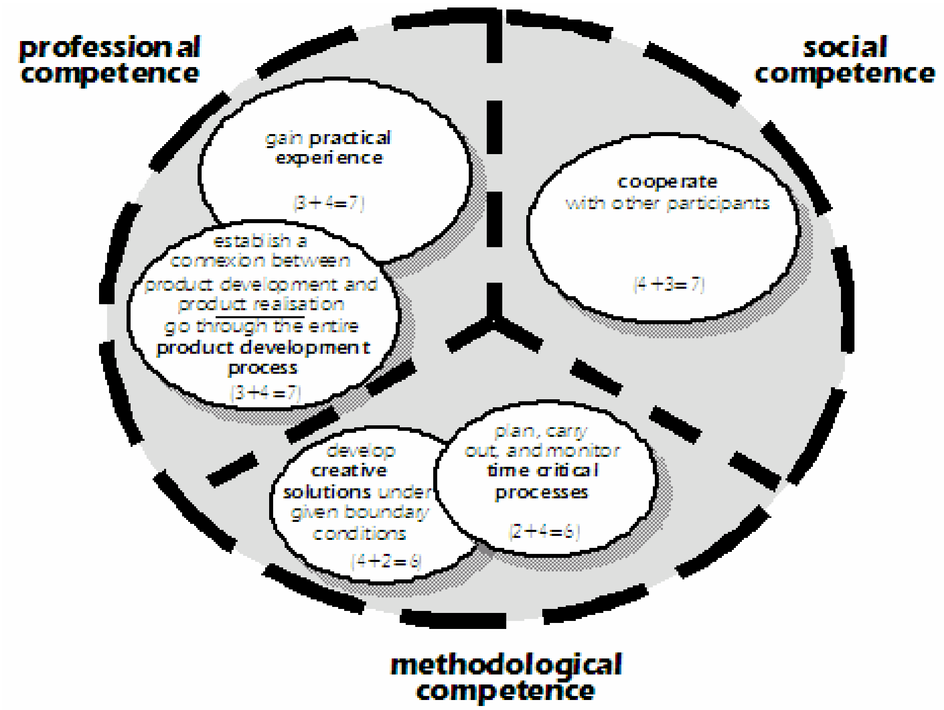

Figure 8. Learning objectives.

3.5 Cooperation

The questionnaire also contained a number of questions on cooperation. This implies as well the way teammates cooperated within the teams as cooperation between adversary teams. Cooperation within the teams has become slightly more emotional and conflict-ridden than originally estimated (see Figure 9), whereas the relationship between adversary teams has taken – despite the competitive character of the event – a more cooperative shape than initially thought.

The growth of cohesiveness and unity between adversary teams is surprising but can be perfectly explained by group dynamical effects (cf. the stages of group development in [5]).

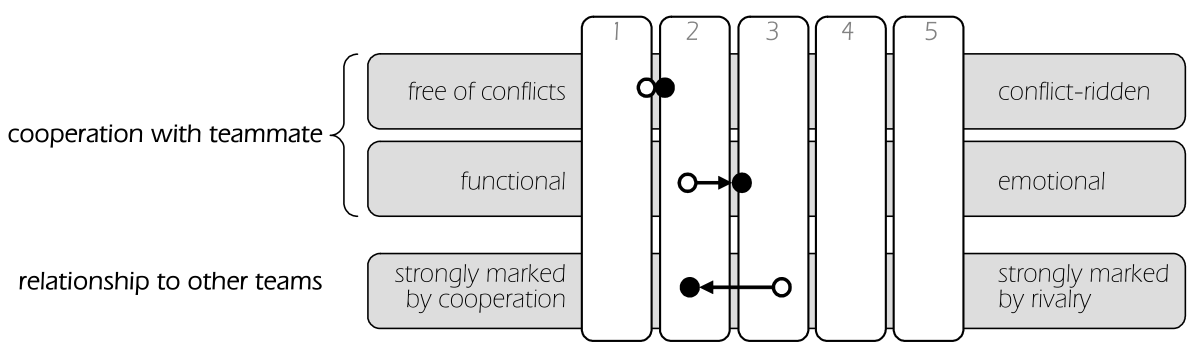

Figure 9. Cooperation profile (○ pretest / ● posttest).

4 Conclusion

For the first time, a “candid shot” of the Darmstadt design contest has been taken. The survey has helped to get a more detailed picture of how the participants perceive the competition.

Design competitions bear the stigma of playfulness. The survey could prove that students are working long and hard to reach self-imposed limits.

In particular the results concerning the questions on motivation and learning effect are very promising. These results give evidence that the personal identification of students with their subject of study can be enhanced by the given education concept. This report should show other universities how primary learning motivation can be reached through uncommon and sophisticated ex-gratia projects.

There are still many things to improve in forthcoming contests. Above all the discovered gap between theoretical knowledge and application has to be closed.

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