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DESIGN 2004

ACHIEVING FIRST DESIGN EXPERIENCES

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1. Introduction

Designing greatly depends on the education and experiences of the designers. Design students often do not have the chance to make their first project experiences at university. They learn about design methods, project management and many other engineering subjects. However, they rarely get the chance to bring together all that knowledge in a first design project. In order to support this linking process, the department product development and machine elements (pmd) at Darmstadt University of Technology conducts an International Design Contest (IDC). During this contest students get the chance to work in teams on a complete design task, from the initial idea to the real product.

2. The International Design Contest (IDC) in Darmstadt

2.1 The aims of the IDC

With the IDC, the department pmd seeks to enhance the students' education with three aims. The first aim of the IDC is to give students a holistic view of a design project and let them find through their experiences that designing is more than doing sketches, calculating, etc. The second aim is to let them discover more about team work, time constraints, unforeseeable incidences, etc. The third aim is to give them the chance to improve their practical skills in a workshop.

In order to meet these aims, the IDC is organized as follows: The terms are published in the internet. The design task is to build a remote-controlled robot with a limited component-kit which must be able to perform a certain task. All university students, irrespective of their major, can apply for participation in the IDC.

2.2 The exercise and the organization of the IDC

The task of the IDC 2003 in Darmstadt was to build a remote-controlled collecting machine, which could pick up, transport and place squash balls and rubber rings on a table. For scoring during the competition, the balls have to be placed into a box on one side of the seesaw. Beside the box, there was a stick on which the rubber rings were placed. The seesaw visualizes the score. To balance a rubber ring, it was necessary to place 10 squash balls into the box. It was allowed to take away the adversaries rubber rings, but not the squash balls. For tactical variety, the front panel of the table was equipped with two buttons. These buttons allowed teams to cut the adversary's electricity for 5 seconds.

For building the robots, all teams received the same construction kits. The contents of the kit can be divided into three groups:

- Machine elements: motors, pneumatic cylinders, etc.
- Construction materials: wooden boards, aluminum profiles, tubes, etc.
- Miscellaneous gadgets: PET-bottle, rubber-glove, etc.

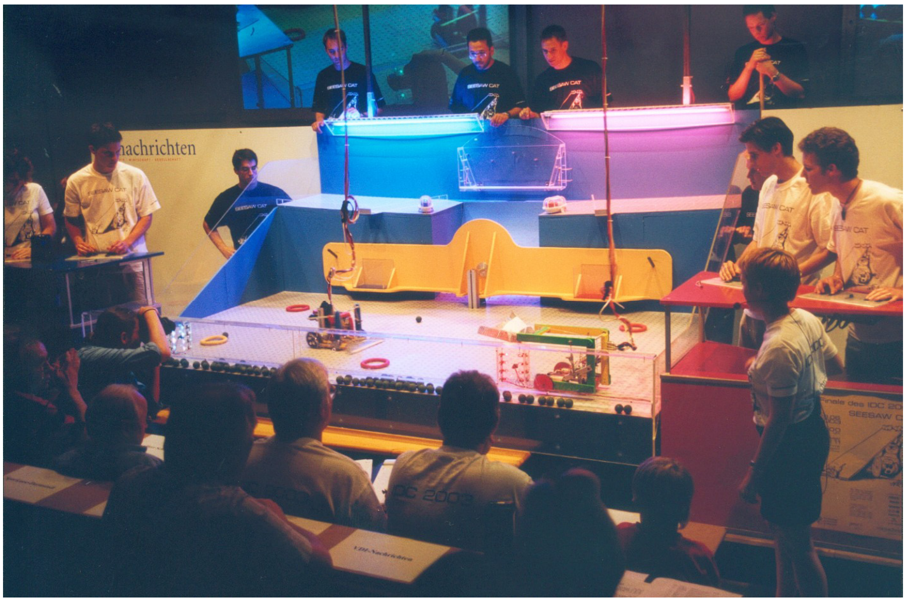

Figure 1. IDC 2003-table

The teams apply with a preliminary concept of how to build a robot which can fulfill the tasks. Each team of two students then has 10 minutes to present their concept and ideas to a jury. The jury judges the ideas according to creativity, functionality and design. The best sixteen teams are selected and receive a toolbox and the construction-kit. Then they are left to their own devices. Two instructors are always available to answer questions or discuss problems. After four weeks the students are ranked. For this, they have to present their robot at the current stage of development. The prerequisite for attending the ranking is that the robots must be fully motorized at that point. The ranking provides the students with a first deadline. The second and last deadline is the final contest four weeks later. At this point the robots have to be fully functional. The teams compete with their robots at a public event which is attended by more than 400 spectators.
Four weeks after the contest, the winning teams meet other competing students from all over the world at the Chubu-University in Nagoya (Japan). In international teams consisted of one student from each country. Six countries participated and each team consisted of four students. They vie for first place in the final contest, which is similar to the one in Darmstadt. In only two weeks, the students must design and build remote-controlled robots using identical kits. Therefore, they have the additional tasks of overcoming differences in language, culture and design education. Heidemann, Heinz and Birkhofer have analyzed the dynamic learning situations of internationally mixed groups at a former IDC meeting [2].
The aim of this paper is to find out how students act within such a project with almost no didactic guidelines and how they learn from this experience. It is interesting to see how they manage to adhere to the schedule, how they handle design problems and how they overcome conflicts within the team.

3. Design of investigation

Two questionnaires provide insights into the students' actions and thoughts during the IDC. The first questionnaire was filled out right at the beginning of the project, when they received the components-kits. It focused on their planning, their expectations of the teamwork and their self-assessment regarding their knowledge and skills. The students estimated the weekly working time from the start to the end of the project, and delegated tasks within the team. In the self-assessment part, they arrange the engineering subjects according to their estimated usability within the project. The second questionnaire was filled out after they finished the robot. The questions aim to verify the answers from the first questionnaire. In addition, the students were asked if they formulated requirements and functions for the robot. These questions aim to gain insights into methodical work within the project.

4. Results

4.1 Project management

A basic result of this questionnaire is that the students make very strict time schedules with milestones and task-sharing. It is obvious that they do not expect unforeseen incidences. Also, a high self-assurance is noticeable. Regarding the planning, most students must admit that they ran out of time due to unforeseen incidences: mechanisms did not work, functions could not be controlled, etc. Only very few students already had experience in project management, which they gained in voluntary projects next to their studies.

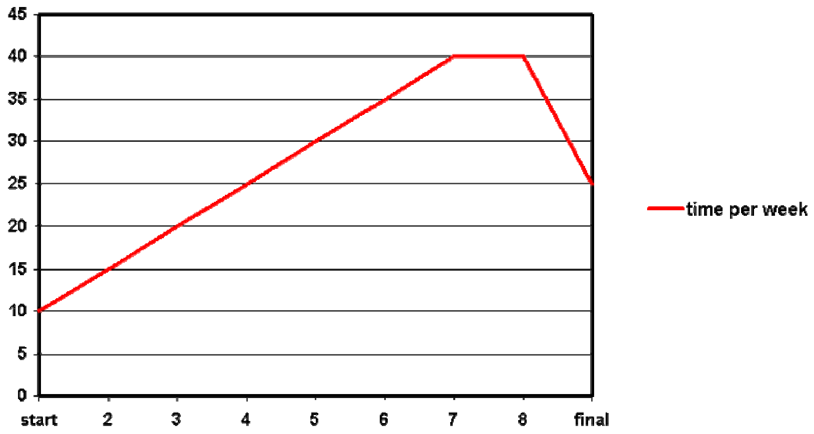

Figure 2. Time involved

In the first questionnaire, an effort curve was asked of the students. Ninety-five percent of the students drew the curve shown in the following figure:

- They expected a constantly increasing work schedule per week. Most of the work was concentrated in the last two weeks. This curve was confirmed in the second questionnaire when they were asked how much time they spent on construction. In the last weeks, they spent most of their time in the workshop practicing handling the robots, and improving and fixing the last few things.
- They did not plan to do task sharing in the construction time. Some answered with this statement: What the one does not know, the other one does. This plan was also confirmed in the second questionnaire. They did not have tasks delegated to different people during the construction time.

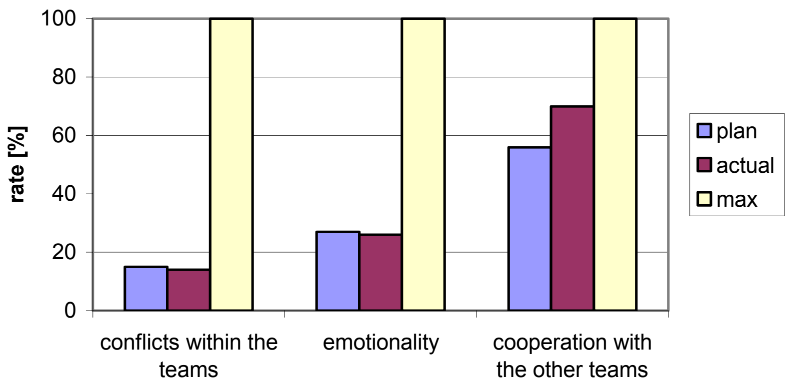

Figure 3. Team work

Furthermore, they expected a conflict-free work time during the construction phase. They also expected a non-emotional work atmosphere which does not imply that they did not have fun. These expectations were confirmed, and in some cases, outdone by the actual experience. But the expected competition between the individual teams was lower than they expected. There was more cooperation than competition.

4.2 Subject's influence

The evaluation of the knowledge part in the questionnaires showed that the students judged the theoretical foundation to be of minor importance for the competition. The most important subject for the competition was machine elements. A little less important was the subject technical mechanics followed by form production, design and project management. It is significant that the students ranked the importance of the subjects after the competition lower than they had before it.

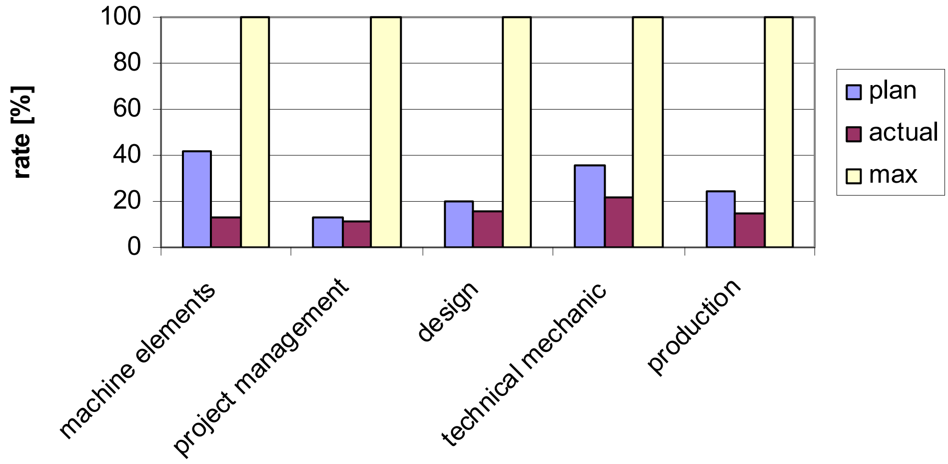

Figure 4. Subject's influence

Students expected practical knowledge and creativity to have the same influence on the competition. But they expected more of an influence then they realized while building the robots. The practical knowledge has greater importance in the contest then the creativity.

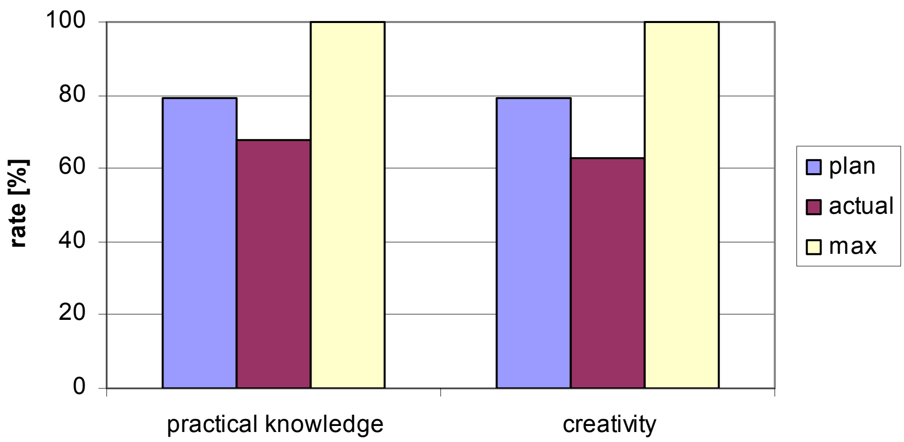

Figure 5. Influence on competition

The next questions concern the personal assessment regarding practical knowledge and creativity.

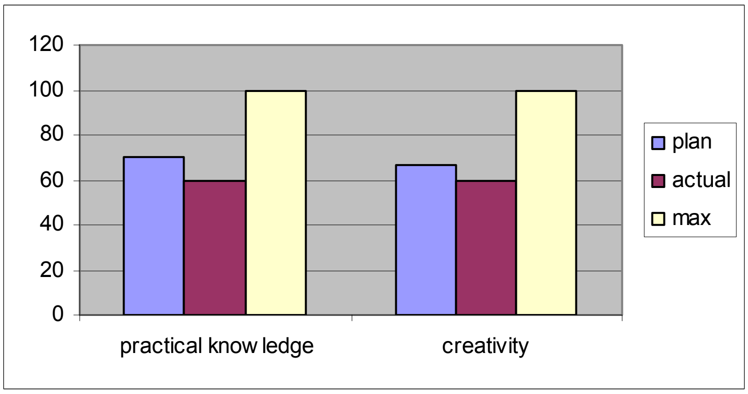

Figure 6. Personal assessment

The students tend to assess their practical knowledge and creativity higher than it really is (10%). Generally, the students are rather assured of their capabilities. Before the contest, the students assessed their practical knowledge 3% higher then their creativity. After the contest they saw their practical knowledge and their creativity as being on the same level.

4.3 Procedure

Thirty-five percent of the students made a schedule and kept to it. Sixty-seven percent of the students made a capacity plan and they all kept it. Sixty percent of the students planned to proceed by trial and error, but only 50% really did this. The other students tried to make use of design methods in designing their robots.

All of the students made a requirement collection before they started designing the robots. In the end, all the robots met the requirements. Sixty-five percent of the students developed more then one idea on how the robot could be realized and chose one. The other students had one idea right from the beginning which they tried to realize.

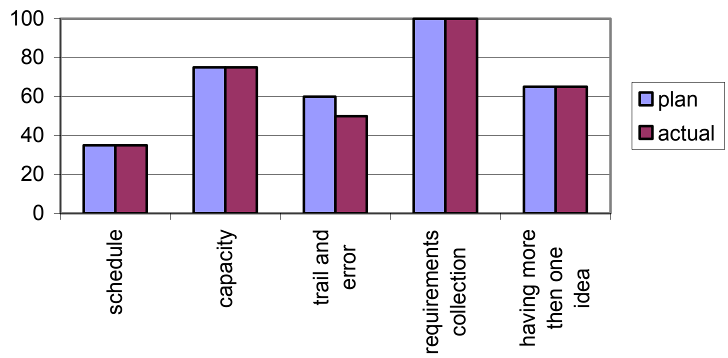

Figure 7. Procedure

5. Key conclusion

The IDC as a realistic design project helps to combine all aspects of designing (team, competition, theoretical knowledge, practical knowledge, creativity, schedules and coordination). Especially the questions about the influence of the study subjects on the contest showed that the students are often not able to transfer their theoretical knowledge into practical knowledge. Therefore, they are not able to find solutions for practice with the help of theoretical knowledge. This should serve as a hint to the design program to offer more volunteer design projects to students.

The International Design Contest at the Chubuu-University (Japan) is beneficial and highly motivating to the students. It supports learning in areas which cannot be taught in a regular design class. A design class cannot provide such a realistic environment and such an intensive team work.

Acknowledgments

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