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PRODUCT DEVELOPMENT SEMINARS – KEY FACTORS FOR SUCCESSFUL PRODUCT DEVELOPMENT IN STUDENT TEAMS

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ABSTRACT

This paper focuses on how to successfully run a cooperative student seminar on product development. The setup of a recent seminar is described in detail, showing important constraints and conditions. Two teams were monitored closely and examined in detail as to their different ways to proceed and how this contributes to the overall results. For means of evaluation, success factors for each step of the design process were determined with regard to the overall motivation. From this, recommendations for the supervision of following product development seminars are deduced.

Keywords: teamwork, seminar, methodical design, success factors, design process

1 INTRODUCTION

Nowadays, concurrent design can be considered state of the art in industry [3]. Characterized by an important division of labor and distinct competences necessary to develop a product, working in a concurrent design environment demands particular skills. Among these are teamwork, social skills and the ability to cope with shared goals in particular. Thus, engineering education must strive to qualify students to be able to work under such conditions efficiently. Seminars, during which students cooperatively work on a design problem, are a well accepted means to do so, often addressed as project-based learning [4].

2 PRODUCT DEVELOPMENT SEMINARS AND PROBLEM TREATED

The Institute for Product Development at the TU München, Germany, offers seminars on product development. Every semester, at least one is offered to four to six students who work on a distinct design task in close collaboration with an industrial partner.

The goal of these seminars is twofold: For students, the seminars offer a detailed insight into up-to-date product development in an industrial context, for companies a chance to create innovative and often unorthodox solutions methodically. Often, the seminars result in patents being filed.

The students are closely supervised and put into application a suitable range of methods and methodologies across all stages of the design process. The seminars are linked to a series of lectures offered by the institute so that the students get the chance to deepen and apply the theoretical knowledge they already gained.

The seminar presented here was run in cooperation with Bosch und Siemens Hausgeräte GmbH (BSH), one of the largest producers of whiteware appliances worldwide.

The industrial partner confronted the students with two distinct tasks which are part of an overall new product design for a fuel stove operated on vegetable oils. The stove is to be marketed in third world countries to counteract deforestation. It consists of a reservoir that is connected to the stove's coil by a hose. Within the coil, the oil is heated by the stove's flame and thus transferred into gas phase to be burned. The coil is mounted inside a baffle on a tripod. Figure 1 shows the prototype of the stove.

Figure 1. The fuel stove (coil not visible inside tripod)

Team A was asked to work out four different solutions to generate a pressure of about two bars in the oil reservoir. Team B was scheduled to design four different methods to clean the coil of combustion and gasification residues. Each team consisted of four graduate students (in their third or fourth year of study, having little experience in design) and two supervisors (PhD students). Originally, both tasks were considered well-defined and approximately equal in difficulty and complexity.

3 PLANNING AND TASK SEQUENCE

The overall action was geared to the Munich Procedural Model [6], which is the key element in lecturing methods in the mechanical engineering curriculum at the Technische Universität München. The sequence of tasks followed is shown in figure 2, section 1. The seminar was held on a weekly basis throughout the semester with the teams working separately. Due to limitations of an ongoing experiment on success factors for innovative design [10], they did not exchange any information.

At three points of time, the industrial partner was directly integrated into the seminar; for the kick-off, for an intermediate selection of the four designs to be followed by each team, and for the final presentation. The students also interacted with engineers and project management from BSH on an individual basis to retrieve the information needed. At the beginning, a research facility on combustion was visited to better understand how the stove worked. This close cooperation was highly purposeful, above all the workup of the problems in the beginning proved useful later in the process. The understanding was further supported by the intense use of functional modelling (activity-diagram, function-structure, function chain [9]); this was not appreciated by the students for being rather long and meticulous work. Yet, it supported the later phases emphatically by raising common understanding within each team. From these models, the requirements specification was generated, including those specifications that were – as the original design task – handed to the students only textually and as slides. The requirements were used for all later decisions.

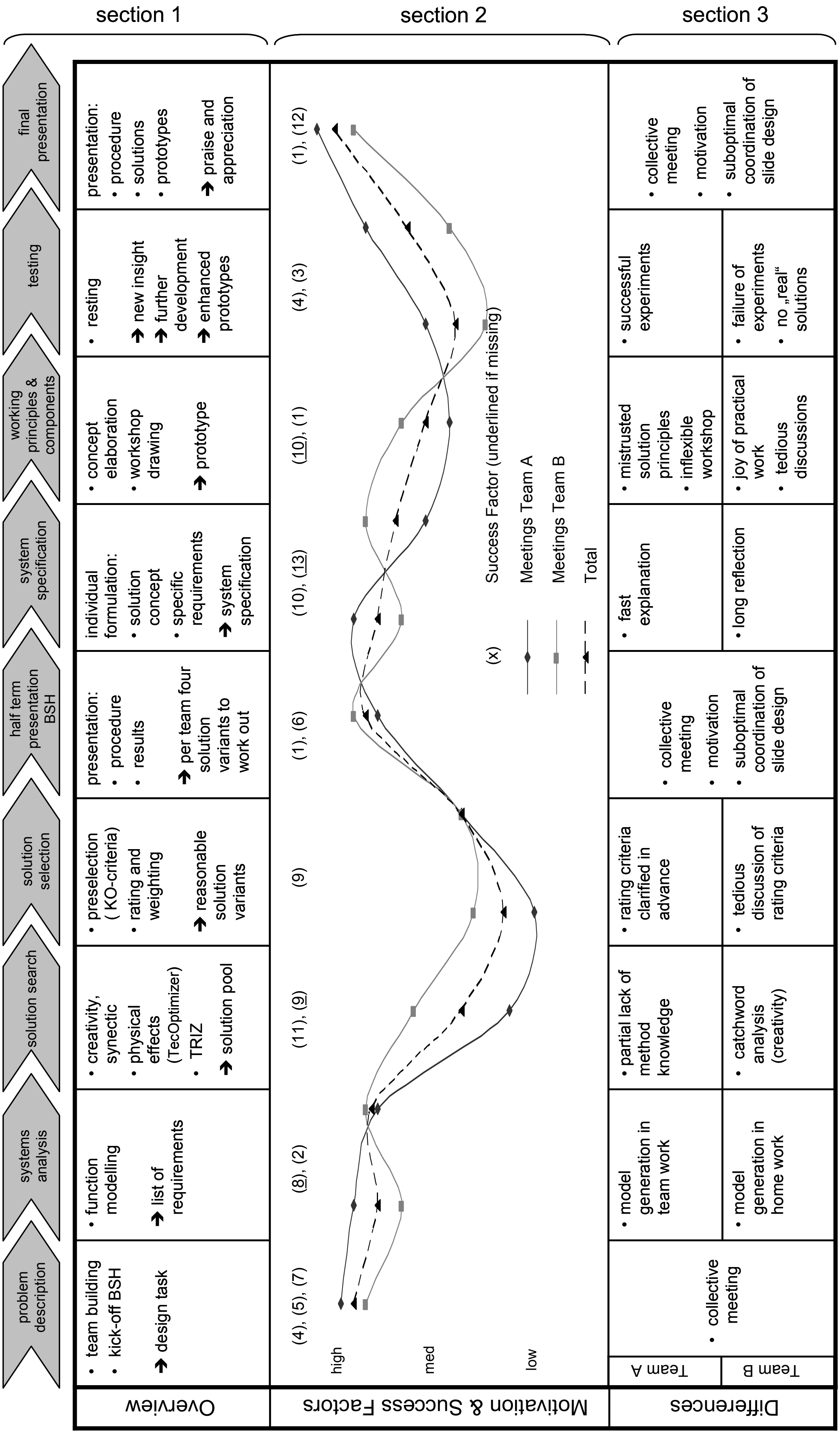

Figure 2. Task sequence, motivation of team members and important influences on motivation

Within three weeks, a multitude of possible solutions was generated by each team using creativity methods; for building up pressure 20 possible solutions were found, for cleaning the coil 43 of over 100 ideas were taken into closer consideration. Using exclusion criteria and a rating reflecting the importance of different requirements, the ultimate solutions were preselected by the students and confirmed by the industrial partner. After the intermediate session with the project partner, every student developed an individual functional model (design and prototype) of a concept agreed upon with the partner company. During this time, team B co-worked more loosely with each student presenting his concept weekly to the others and advancing it as homework, whereas team A ran through all four designs as one team. During the last weeks before the final presentation, intensive trials were carried out to test the prototypes and fine-tune them. While team A first doubted the functional capability of their designs and was surprised to see them work, team B had to discover that the problem could not be solved as expected. Yet, ultimately each student came up with one final working solution, though not all could fulfil all set requirements.

During each meeting, one student was responsible for writing the protocol; the week after, it was his/her turn to prepare the methods necessary (in cooperation with the supervisors) and both lecture and moderate the following session successfully.

All results can be considered innovative solutions. Whereas the generation of pressure turned out to be an easier design task and could be solved satisfyingly, intense tests by the students have shown that it is not possible to clean the inside of the coil with limited means. However, simple work-arounds have been developed that allow for a maximum cleaning effect with the given possibilities in a developing country.

4 MOTIVATION AND SUCCESS FACTORS

To establish the "lessons learned" from the seminar, the participants were asked to qualitatively sketch their motivation. Motivation plays a major role for personal engagement and the overall result [2] as well as the ability to learn in such a project-based learning environment [4]. Figure 2, section 2, shows each team's motivation against the 13 meetings as perceived by all participants.

Table 1. Key factors considered

1	Clearly defined interfaces between the project participants (students, tutors, …)
2	Transparency of decisions
3	Existence of collective goals
4	Good identification of every team member with the team
5	Appropriate team configuration
6	Praise and appreciation for the individual work from the other team members
7	Availability of the required knowledge
8	Knowledge of preliminary and following process steps
9	Existence of adequate method knowledge
10	Enough scope for self-determined and autonomous work
11	Insertion of personal ideas and creativity
12	Feedback to the personal style of communication and appearance
13	Collective adjustment of the objectives

Within the teams, the trends are roughly similar, although both teams do show differences in their overall behaviour. This can be linked to a) a set of success factors

and b) certain actions, achievement or set-backs. Figure 2, section 3, shows a list of how the teams proceeded differently for each phase of the development; in section 2, the individual success factors relevant for each phase are listed. They were taken from a prior project with industry judging the state of communication and collaboration [7]. Table 1 presents these factors in more detail.
Changes in motivation can be linked to the consideration of a factor or its non-observance (underlined numbers); e.g. the lack of adequate knowledge made it difficult to use TRIZ and understand each step of the procedure and its contribution to the generation of new solutions. That was true for other methods used, too. This lowered enthusiasm among the students notably and can be found in the motivational curve under the third step "solution search".
However, the teams' different approaches generated differences in the students' motivation. Whereas team A worked collectively until the end, giving the students a more secure feeling in their decisions and helping them being creative as a group, the students of team B worked rather independently. This caused a more competitive atmosphere that impeded effective group work. This is represented by factor 10 in figure 2, which is only to be linked to team B. More specifically, Team A was set back for the loss of trust in their solutions, which was, in fact, unreasonable. Team B was, at the same time, held up in tedious discussions about minor details of their solutions.
In the same way, the overall curve can be traced back to the different factors and facts lined out in Figure 2. The limited set of success factors should therefore be closely considered for such a seminar. The same is true for indications deduced from differences in team management: Close teamwork with limited homework, intense knowledge of methods, lean discussions, early practical trials and occasional direct input from the supervisors have proven most valuable, both towards learning and the technical issue.

5 RECOMMENDATIONS AND REFLECTION

Many different elements contribute to a successful seminar. The concept of a limited number of success factors and a few guidelines deduced from the overall motivation as shown by the students could be detailed much more. However, as experience from the past seminars has shown, topics vary largely and planning is highly individual. Therefore, it is difficult to transfer knowledge on how to run these seminars efficiently. The elements shown form the core to this experience.
Among the other elements an online wiki and database were used, which have proven exceptionally helpful for distributed (home)work and for the exchange and documentation of ideas during the early phases. Also, intense training in methods for moderation and presentation were essential for the students' success.
Three elements can be recommended most for this kind of seminar. First of all, the students need to understand the greater picture, i.e. the line-up of all steps of the development task. This raises their motivation during early steps of which the output is only later needed but which are of help for the overall development process. Secondly, long discussions that are not beneficial to the product developed need to be kept short. To do so, supervisors must keep some distance to the team and accelerate team process by force where necessary. Ultimately, hands-on experience is absolutely necessary to enable students gain experience with their theoretical knowledge. Hence, after a short introduction, the students need to be put into action rapidly.
The results coincide largely with observations, problems and recommendations suggested by Atman [1]. However, Atman only uses an empirical study designed to

determine the different proceedings among freshman and senior students. He does not draw conclusions on how to actually carry out design work with these students but only hints different elements in his study. Different papers summarized in [5] confirm these findings, too. The same is true in comparison to project management for distributed product development in an industrial context, to which many findings can be transferred directly (compare e.g. [8]).

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