INTERDISCIPLINARITY IS A KEY TO ENHANCE THE PRODUCT DEVELOPMENT PROCESS - HOW STUDENTS DEAL WITH IT AND HOW THEY EVOLVE WITH IT

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ABSTRACT
Interdisciplinary work is gaining attention not only in the academic landscape. Even at University where many different disciplines coexist in a minimum amount of space, the interdisciplinary work was used too seldom in the past.
In order to teach the graduates the required competences regarding teamwork and project work, but also to fulfil interdisciplinarity needs, the collaborative Advanced Design Project (cADP) was integrated into the curriculum at Technische Universität Darmstadt. The cADP is based on a mandatory group work for mechanical engineering students, where engineering problems must be solved together according to the principle of minimal help. The focus of this mandatory project is not only on the problem solving process, but also in training and reflection of group processes. This project has been extended in such a way, that interdisciplinary teams of students of mechanical engineering with a focus on product development, ergonomics and computer aided techniques work on a product development project task together with students of psychology and industrial design. This new form of interdisciplinary team work of students was called cADP.
The cADP focuses on the early stages of the computer aided development of ergonomic- and design-oriented products from the very first idea to building a virtual prototype up to a design and functional prototype and evaluating this one. Products should be designed using discipline typical methods, but with the use of synergy effects of the interdisciplinary team.
In the following the experiences of students in the cADP project will be described; what are the main challenges of working together with other disciplines and how can there found a way to deal with it. For this purpose student questionnaires were analyzed.
Furthermore it will be shown how the quality of the products increases through interdisciplinary cooperation. For this purpose classic group work results are compared with the results of cADP groups.

Keywords: Interdisciplinarity, student teams, engineering, ergonomics, design, psychology

1 THE COLLABARATIVE ADVANCED DESIGN PROJECT

To comply the necessary competencies of graduates regarding teamwork and project work on the one hand and interdisciplinarity on the other hand, the collaborative Advanced Design Project (cADP) was integrated into the curriculum at Technische Universität Darmstadt. This is based on an obligatory group work for engineering students for solving design problems together supported by the principle of minimal help. In this project, the focus is not only on solving the problem, but also in training and reflection of group processes. The extension of this obligatory group work is the cADP, where interdisciplinary teams of students in mechanical engineering with a focus on product development, ergonomics and computer support work together with students of psychology and industrial design. During the studies students of mechanical engineering, industrial design and psychology learn more about discipline typical methods for the design of products. Priorities and methods of engineering are focused on the systematic and methodical analysis and solution of problems of technical implementations. The reasonable construction of individual components of the final product and the matching of component solutions to the development of a useful and well-engineered product are particularly important. Design students generate creative ideas in a more conceptual and intuitive way by using supportive methods such as mood boards or mind maps. Psychology students consider how people deal with technology and derive the requirements for new products in accordance to the human capabilities, like physical strength and cognitive information processing, and human needs like safety, self-fulfillment or relatedness. They also have extensive knowledge about empirical methods to evaluate the designing process as well as the different kinds of prototypes

Often the confrontation with the methodology and the knowledge of other disciplines arises with the entry into professional life. The cADP already allows students during their studies to experience working in interdisciplinary teams to develop products and to gain experience in dealing with other professionals. The focus of the cADPs lies on the early stages of computer-aided development of ergonomic and design-oriented products from the first idea to a virtual prototype to a functional and design prototype. Products should be designed using typical methods of the disciplines. Each student team is made up of three engineering students, one psychology student and one student of industrial design. The students create a schedule for the upcoming independent project work and distribute specialized roles, consisting of specialists in ergonomics, computing, design, project management, and a team leader. The task of cADPs is formulated openly and allows the students a lot of space for developing their own ideas. The free working style is only limited by the approval of four milestones to help structuring the project. At the end of the semester after three months of work, a final presentation takes place, where the development process and the results are presented. At this point the described functional and design prototypes or models are already existing.

2 CHALLENGES OF WORKING WITH OTHER DISCIPLINES

In particular, the increased cooperation requirements for working together in interdisciplinary teams have already been investigated in the past. It turned out that the extra effort to communicate increased enormously and therefore interdisciplinary projects were considered to be much more time-intensive compared to single-discipline projects (see [1] or studies summarized by [2]). Simultaneously interdisciplinary projects lead to higher motivation and to a higher innovative potential [1]. Within an evaluation of cADP it was investigated whether these observations can be applied to students' interdisciplinary projects. [3]

It was confirmed that it is more common that more tenseness arises in interdisciplinary teams than in single-discipline teams. The participants ascribed that to the divergent approach each member of a single discipline uses, but also to the dependence on the other team members. However, this tenseness had rarely negative impact on the group work. In fact it emerged that differences between team members due to technical differences do not have a negative impact on the cooperation within the interdisciplinary teams. The teamwork seemed to be more influenced by personal differences between team members than by methodical differences. For successful collaboration, it is important to consider the team climate. Methodical differences lead to difficulties, but they don´t affect it negatively and instead promote cooperation. Furthermore, it could be proved that non-specialist methods of team members are learned in interdisciplinary teams and used independently. Through the variety of disciplines and methods this leads to a higher use of methods in interdisciplinary teams. This could also be a reason for the increased expenditure of time in interdisciplinary projects. [3]

Although the time required for the interdisciplinary project is higher, 100% of the surveyed students of the cADP course wish to have more interdisciplinary projects. 89% of the participants on the actual cADP acknowledged to the fact, that through the cADP they have learned the great benefit of interdisciplinary teamwork ($M = 4.27$; $SD = 1.09$ on a five point likert-scale with 1 = totally disagree and 5 = totally agree).

3 INCREASE OF QUALITY

The first cADP project started in 2003. During the first implementation of the cADP the teams were just consisted of three engineering students and one design student. The task was much less complex and the project ended up with a concept for a product and representations. Exemplarily for these first runs of the project results are shown in Figure 1.

Figure 1. Renderings of the products created by the first cADP students

The products are characterized by a relatively low complexity. Tasks were, for example, integrating two functions in one product (Figure 1) or conventional measuring tapes combined with a separate digital display and a few buttons for easy handling (Figure 2).

Figure 2. Rendering of measuring tapes designed by cADP students

A low-complexity task was also the creation of a multi-functional lighting for prams or for a mouse and desk pad (Figure 3).

Figure 3. Rendering of multi-functional lightings design by cADP students

The technical complexity increased significantly with the task to design a product that allowed children to bake risklessly and independently. For this purpose, the students developed a concept so that children can pour the ingredients at a defined location and by actuating a simple lever the baking process can take place in well-insulated interior. (Figure 4)

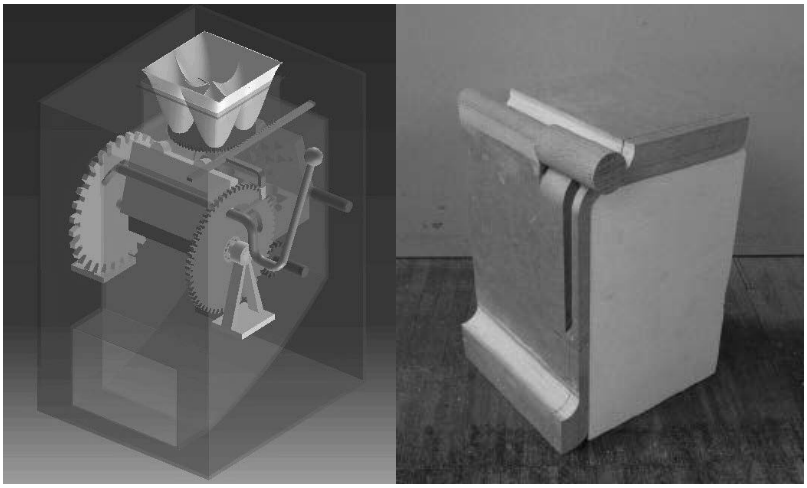

Figure 4. Waffles-bake-automat for children created by cADP students

Due to this task the question of the safety of such products arose. The potential of expanding the project and to additionally consult the Department of Psychology has been identified. The labour and engineering psychology department was highly interested about the project and has been involved in the project with full commitment for 3 years now.

By the potential of the subject-specific knowledge and methods of psychology, it is possible to work on issues of safety and appearance of a product within the cADP in a qualified way.

Since the participation of psychology, the new group composition consists of three engineering students, one design student and additionally one psychology student. With the increased group size a more complex scope of duties was handled. The task was to design an ecologically sustainable transport concept as well as a vehicle for various scenarios. Therefore the students developed a complete transport concept and created a rough design and layout of transportation vehicles. An airship for the automatic distribution of goods in traffic congested areas and an automated distribution of retail goods in a trolley for the use in snow rich regions are shown in Figure 5.

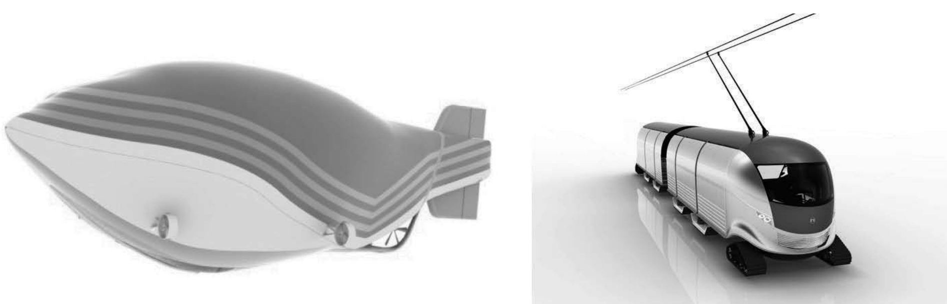

Figure 5. Renderings of future transport vehicles created by cADP students

The complexity of the task advanced with the additional task of not just building a digital visualization of the students vision, but to build a real design and function prototype. The increase was even desired by the student because the students were so convinced of their concepts, that they wanted to see them implemented.

For the next project the topic miniaturization was pursued. Concepts for a collapsible slicer or a new ski helmet with an integrated robot have been developed. In the case of a burial in an avalanche the robot should find a way to the surface independently and will enable a faster rescue. For this purpose, the Young's modulus of snow was investigated and an electronic control concept was constructed approximately. The students thought about a way to provide feedback to the victim in order to calm the person, while the robot is looking for its way to the top. The entire technical complexity never existed in the cADP project previously. The prototypes also had a tremendous quality: the prototype slicer was able to cut all the ingredients for a sandwich during the final project presentation. Both products are shown in Figure 6 and 7.

Figure 6. Renderings of the slicer and the snowmole created by cADP students

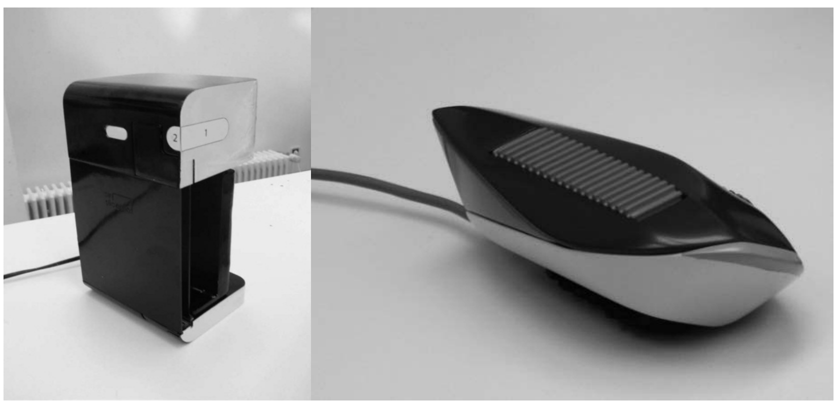

Figure 7. Prototypes of the products shown in Figure 6 created by cADP students

In the most recent cADP everyday objects were considered. The goal was to make the everyday's life more simple, pleasant, independent and/or effortless. A walking aid for older persons was designed with a mechanism on the front wheel, which makes it possible to overcome curbs easier. Furthermore, a conference table was designed and built, that can be transformed to a pause game easily by simply clicking out game play elements and cushions. Furthermore a new type of wireless ironing concept was designed that works with induction. Here the students build a fully functional prototype (Figure 8). In addition all groups used some former prototypes of lower fidelity for evaluation studies parallel to the ongoing design process. The main goal of these first prototypes was to confirm that their potential users got the same idea about the products as the designing students have.

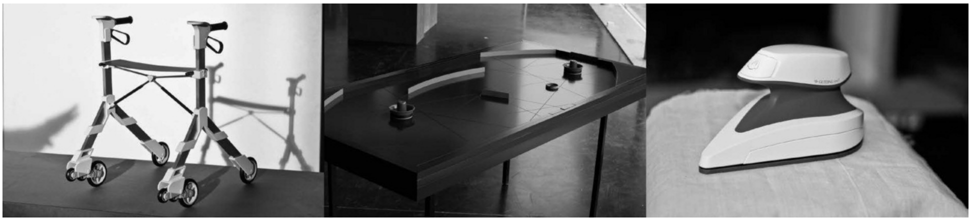

Figure 8. Prototypes of the last cADP made by cADP students

It was shown that the complexity and quality of both the solutions and the designing process of the cADP results could be significantly increased in the last few years. The interdisciplinary collaboration inspires the students to build even better solutions and prototypes and let the border between university teaching and professional product design fade out. Without the interdisciplinary composition of the teams these benefits would not be possible.

Further the students reported that they would join more projects like the cADP if there were such, because everyone involved in the interdisciplinary collaboration had such much joy and success. In addition our evaluation reveals a significant increase in the students project management skills ($F = 4,90$; $p = 0,047$) and the subjective quality of the own team working ($F = 6,60$; $p = 0,026$). Both with strong effects of a partial $\eta^2 = 0,290$ respective $\eta^2 = 0,375$. Most of the surveyed students acknowledged to the facts, that the project task was personal relevant ($M = 4.22$; $SD = 0.73$ on a five point likert-scale with 1 = totally disagree and 5 = totally agree) and that projects like cADP are relevant to the own career ($M = 4.41$; $SD = 1.06$ on a five point likert-scale with 1 = totally disagree and 5 = totally agree). Further more 14 out of 17 students affirm, that the learned contents of cADP, could be profitable transferred to their studies and to the later professional life.

4 FURTHER WORK

The project is assumed by student side very well. A limiting factor right now is the support capacity of the scientific staff of the disciplines involved. Further work has to be done here to develop a guidance plan, so that more interested students can join the cADP than before.

Further, it should also be searched for a way to reduce the time used by the students for the cADPs project without compromising the learning experience. Another way could be increasing the benefits for the student’s curriculum through combined coursework.

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