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INTERFERENCES OF INDUSTRIAL DESIGN AND ENGINEERING IN FUTURE DESIGN EDUCATION

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ABSTRACT

During the last years, the differences between industrial design and engineering design have become increasingly blurred. The two disciplines show interferences regarding their methods, problems and ideas. Fundamentally, they also share the term 'design' which addresses industrial design as well as engineering design. This is visible particularly in contemporary product development processes where a holistic understanding of the word design forms the base of successful communication and collaboration between designers and engineers [1]. Radical changes in industry regarding speed, cost efficiency and quantity influence the design process and thus design education. An acceleration of product life cycles requires the parallel development of product parts and systems. Customized industrial goods have to meet the specific needs of a small target group. Users need to be involved in their development. Within these complex systems digital and analogue design overlaps.

With our contribution to the E&PDE conference 2017, we will present our education concept as an ongoing research project. It has a focus on product design education at tertiary – and thus university – level. We want to discuss interferences of industrial design and engineering and we will have a closer look at particular examples from our process, for instance at our newly established makerspace and virtual reality lab.

Keywords: Industrial design engineering education, practice, process, innovation and industrial experience. Topics: Design education practice, creativity and innovation in design education

1 INTRODUCTION

Designers and Engineers have a lot in common. Not only do they share the word 'design'. The two disciplines also show interferences regarding their methods, problems and ideas. This becomes obvious particularly in Herbert Simons 1969 book *The Sciences of the Artificial* where he defines design as a wide-ranging activity dedicated to shaping the artificial world. Following Simon, the activity of designing can be characterized as a process of *synthesis.* Within this process, all kinds of artificial objects are being shaped: "The engineer, and more generally the designer, is concerned with how things ought to be […]" [2]. These objects do not exist yet; they need to be developed in a process of design.

Despite this fundamental consensus, the two fields of industrial design and engineering design remain separate in design education itself. Whereas engineering is dedicated to the institutional contexts of technical universities, industrial design is rather associated with art and thus taught at schools of art and design [3]. In this respect, the designer seems to be a genius creating new ideas for daily objects that are somehow functional and useful. The paradigm of engineering on the other side is to follow a standardized and rational pattern. This distinction caused a communicative gap between designers and engineers.

The communicative gap has always been an issue, but it becomes even more significant when considering radical changes in our contemporary forms of communication and production. Today's product development processes highly depend on a successful collaboration and communication between industrial designers and engineers. The acceleration in our digital forms of communication enables us to manage many steps of product development simultaneously. Our educational concept relates to the particular part of product development where design and engineering overlap. The industrial design program at our university combines design methodology with engineering basics (Figure 1).

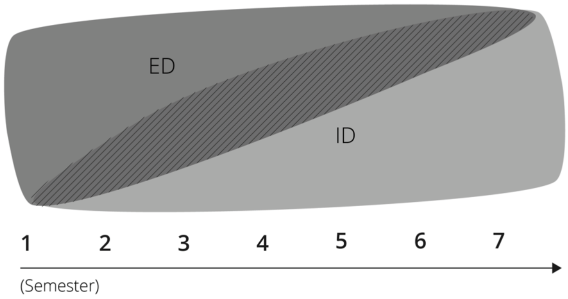

Figure 1. In contemporary product development processes methods, skills and practices of engineering and design overlap. Our program implies a holistic approach to design education and to design as a discipline. (ED: Engineering Design; ID: Industrial Design)

Our university is located in the industrial south of Germany, which is well known for its long tradition in engineering and design. The famous Ulm school of design, founded in 1953, is just around the corner. In contrast to the artistic approach at Bauhaus, HfG Ulm connected design, science and engineering [4]. The idea was to develop functional products in close collaboration with industrial partners. Mathematics, construction and planning methodology were applied to design problems. Further, early concepts of cybernetics and artificial intelligence were envisioned to be part of future design processes [5]. Ever since HfG Ulm was closed in 1968, German design education has tried to re-accomplish the intensity of discussion, experimentation and skill that could be found in Ulm. This larger historical background has influenced our design practice as well as our understanding of design education. Due to the close interlinking of scientific-technical and formal-creative spheres we are filling a gap between design and technique.

2 CHANGES IN DESIGN AND ENGINEERING PRACTICE

Our project of teaching interferences of industrial design and engineering relates to interdisciplinary practices we observed in industry. The necessity for this approach to industrial design education becomes visible in particular when looking at three types of contemporary industrial design projects that can be named as follows: platforms and services (1), connective products (2) and the shift from products to processes (3). What are the inherent challenges in these new tasks compared to former design projects?

2.1 Platforms and services

In modernism, the idea of industrial design was centred on the idea of seriality. Here, the industrial designer was able to focus on the singular product and its shape. The main challenge of design was to reach "fitness between context and form" [6], as Christopher Alexander described it. But today's design can't be reduced to a finite shape or to a single machine or application. As contemporary industrial goods become more and more part of a system or a platform, designers have to handle skills from relating disciplines such as computer sciences.

The designer's tasks are embedded in larger systems, which can only be developed by people from various disciplines. Users, for instance, will take influence on the design. The complexity of the system will require their participation by adapting the system to their specific context and needs in a process of Open Innovation.[1]

2.2 Connective Products

Another challenge for design deriving from the emergence of semi-digital products can be described by using the term connectivity. As design theoretician Klaus Krippendorff notes, due to digitization design products "[…] have become immaterial, informational, and entertaining" [7]. Connectivity means that a product can be coupled with other products and applications to enhance its functionality.

[1] Open Innovation is a process of collaboration between companies and external experts as well as customers and users particularly in early phases of the innovation process. Involving users help to approach ideas and characteristics of a future product.

Although connectivity here is often associated with playful accessories such as the Apple Watch or the Nike fuel band, other industrial goods are becoming connective, too. German electricity provider Yello and design agency IDEO for instance have developed an electric meter that records and visualizes the consumption of electricity and enables the user to better manage their use of energy within their home.

What we can observe particularly in the case of connective products is a merging of digital and analogue design. As the formerly separate spheres of digital and analogue design overlap, they form a “new materiality” [8] bridging the gap between the digital experience and the material and formal quality of the ‘real’ product.

The process of design leading to those products requires interdisciplinary approaches, since designers need to bridge the gap between coding and design, for instance.

2.3 Traditional industrial design becomes process-design

Of course, this does not mean that traditional industrial design is obsolete. But what has been changed in the context of ‘typical’ industrial products? First of all, industrial products and systems became more and more complex. In order to realize such a complex product, design and engineering processes were parallelized and closely interlocked. The industrial designers and engineers have to work together within the same PLM / CAD system in order to constantly use the latest design standards.

What does this mean for the designer? In order to avoid iterative loops, the designer must be able to communicate with the engineer. He needs to understand technical boundaries that influence the structure of technical components. He must be able to connect digital with analogue elements and think of design as a whole system and not only a singular, self-contained object.

However, communication is crucial to successfully connect the various actors in such a design process. Design here has to be understood as a process of mediation between different disciplines. A number of different stakeholders form a network in which products and processes are designed. They all have different requirements considering their different backgrounds, languages and targets.

But communication here is not limited to language. Stakeholders can communicate via different visual and organizational tools. Digital prototyping is a very important way to visualize various design concepts in an early stage of the project, in combination with agile organization methods such as Scrum. In his context, the designer will become a process designer and will therefore gain more influence within a design project.

3 OUR TEACHING CONCEPT: APPLYING INDUSTRIAL PRACTICES OF INTERDISCIPLINARITY TO DESIGN EDUCATION

In contrast to the potentials of the new technologies and the newly shaped products, platforms, applications and services, many educational concepts still restrict formal and conceptual innovation. They separate design and technology as technical and mechanical skills are taught at engineering schools whereas formal and conceptual skills are taught at schools of art and design. This causes a communicative gap hindering innovation. Designers and engineers use different tools of visualization (for instance different CAD-systems) they are educated in different institutional contexts and furthermore use a different terminology. They also relate themselves to different social and cultural contexts. To sum it up: Designers and engineers are trained differently and within different cultures of design.

As shown in figure 2 we combine in our educational concept industrial design and engineering skills on different levels very closely. On the operative level, we combine sketching, design methods and aesthetical fundamentals with engineering skills like CAD, PDM and the methodological approach of engineering. The students work on a common project using all aspects of both disciplines learning how they influence each other and which kind of dependencies exist. Here they learn something about dead-line oriented team-work and longer project run times even beyond several semesters. The tactical level shows how a complex project has to be managed and the students get into a deeper touch with the communication efforts they need to collaborate with other disciplines in a fast and effective way. We also discuss the efficiency of a multi-discipline collaboration and the limits we can reach in a project-based work.

On the strategic level we teach how to set up a concept out of the first ideas in the very early stages of a design process. Furthermore the students learn how to plan the whole product lifecycle with a holistic view. In order to set up a collaborative environment right from the start we build teams, in which professors and students work very closely together. There are no hierarchies in the teams and the students get direct feed-back at every stage of their work.

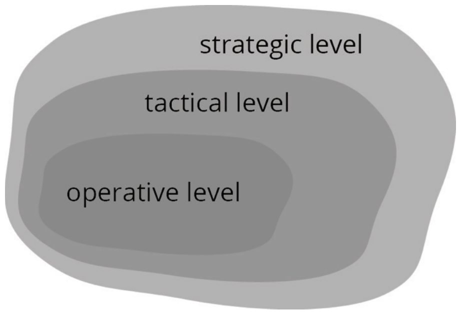

Figure 2. The three levels of combined ID and ED education

So how can we transfer industry's interdisciplinary practice and the idea of an interference of design and engineering into a contemporary concept of design education? In the following, we will outline the framework of our design program, but also give a more detailed idea by presenting three particular examples from our educational practice.

3.1 Basic structure

Students first pass a basic education in engineering, whereas topics related to industrial design are already implemented, but further developed in the second part of the program (Figure 1). More precisely, we offer a bachelor of engineering containing the basic content of a mechanical engineering program and we combine it with design methodology and skills. After the first two semesters students have to make a choice if they would like to specialize in industrial design and engineering, but they continue to collaborate with fellow students from the other disciplines and they will most likely gain practical experience in companies which are focused on engineering and design.
By teaching basics of both disciplines we can ensure that the content fits into the frame of a bachelor program. Subsequently, our graduates can do a master in related disciplines and even gain a doctoral degree.

3.2 Interdisciplinary skill: Freehand sketching

Although digitization is the paradigm of contemporary product development processes, sketchings are still of fundamental importance for engineering and at the same time for industrial design. Sketching can be used and understood by people with different backgrounds, languages or horizons of experience. They are used as a means of thinking, evaluation or activation and furthermore for information storage and communication [9].
These design sketches include additional information about the object – several views, hidden lines and cross sections make the sketch more detailed so it can be 'read' like a text. In contrast to drawing lessons at art schools, students learn how to develop the object in a process of synthesis similar to Herbert Simon's idea of design we have mentioned above. They don't copy real objects but they need to draw and at the same time design an object in order to fully understand its spatial and formal properties. Drawing then is the base of learning CAD, for instance.

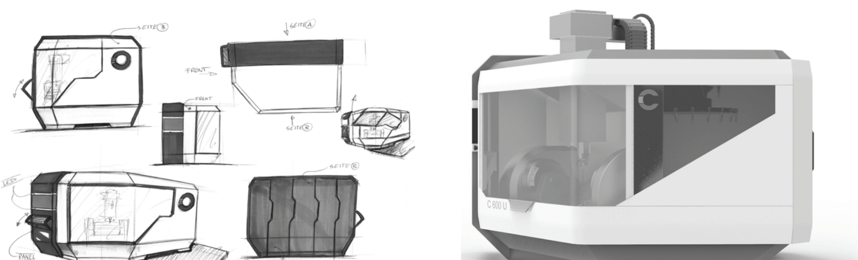

Figure 3 (left): A conceptual sketch for the design of a digital manufacturing centre.
Figure 4 (right): Rendering of a digital manufacturing centre. The cognitive process leading to the design is completely different from the classical way of designing a tooling machine.

3.3 Industrial design project: manufacturing in the context of digitization

Following training in skills such as drawing, our students work on projects in the fields of user centred and technology-based platforms and services.

One of our projects started with the question how digitization changes the manufacturing industry (the so-called 'Industry 4.0'). Assignments in engineering often ask students to follow a list of requirements when working on a new product. Instead, we asked students to approach the problem differently by thinking of possibilities how digitization could improve the whole process of manufacturing and not only a single product (see Figure 3 and 4).

As a first step they had to investigate the users' needs and search for upcoming new technologies in the specific environment of the manufacturing industry. Acting rather as coaches than as teachers, we suggested methods from industrial design as well as engineering. We further discussed methods from market research, marketing or other fields. As a second step the students developed initial visual concepts with drawings and mock-ups. These were the base of discussion and testing. In this phase of the process, design methods like 'Lean Start-up Method' (LSM), persona, user journey and storytelling were combined with engineering methods like morphological matrix, binary comparison and rating box. During the last phase of the project we produced detailed visualizations while all aspects of the concepts were realized using CAD. We use CAD software as late as possible in the process so we can ensure the concept is not depending on software. Nevertheless, CAD is essential in order to test designs in the virtual space and optimize it also on the level of engineering (respecting the formal aspects).

More precisely, we work on CAD-models that can be used both by engineers and industrial designers. This 'one-virtual-model' - principle is a central aspect of our design education. The model then refers to all aspects of a project, for instance 3d-printing, rendering or tooling and even marketing. With this 'one-virtual-model'-workflow we are mapping the daily industrial practice into a design education on university level.

3.4 Merging the digital and analogue: the makerspace as a new type of workshop

Engineering and industrial design as well as digital and analogue design particularly overlap in our newly established 'makerspace', we do not only use CAD-tools but we also conduct experiments in the workshop.

Here we refer to Neil Gershenfield's concept of a FabLab. Following the principles of Open Design, it provides access to tools and the knowledge how to use them. The merging of traditional prototyping (milling, cutting, and screwing) with new manufacturing technologies such as 3D printing is a central feature of a makerspace. Neil Gershenfield suggests that design education should not be too much bothered with expertise, instead designers should use 'bricolage' and improvisation in order to produce functioning prototypes of high complexity [10] Nevertheless our makerspace also provides 'expert' equipment for product development and simulation. Students can make 'real' models and at the same time test them in a virtual space. However, we provide virtual reality tools which usually can't be found in a FabLab, but which are more common in professional product development contexts. Product data management and simulation tools from engineering can be used in a space directly next to the workshop.

In our projects, students learn to think independently from any kind of technology or discipline or context. This enables them to apply their knowledge in different contexts, particularly with unforeseeable technology-driven changes in the future, which we can't anticipate in our curriculum. Their independence enables them to adapt to different kinds of corporate structures.

3.5 First lessons learned

Both, our teaching concept and the makerspace are quite recently implemented at our university but we are able to communicate the first experiences and indications of success made in the first year of our new approach. In general, we can state that the engagement of the students working on projects increased enormously. The students' presence in the makerspace is very good and a lot of them have transferred their working place from home to the makerspace at the university. Thus the communication between students and professors improved a lot. In the ongoing projects we can feel a positive competition between the students combined with a more relaxed and creative learning environment. The students are able to work on more complex projects with less fear of failure. The shared experiences in working on a project together very tightly bring students projects up to a higher level than working more separately or even off-campus.

Another aspect is the enhanced use of both digital and analogue tools in the early phases of a design project. As professors we are able to optimize our teaching methods and the use of our infrastructure.

4 THE FUTURE INDUSTRIAL DESIGN ENGINEER

What does it mean to be an industrial designer today? As a conclusion, we would like to propose a brief answer to the question what kind of figure the future industrial design-engineer will be.

Designers still need to reflect the context, the formal possibilities and the material conditions of production. They still need to work on technical details as well as on the general concept of a product. Nevertheless, the adaptability of the products as well as highly complex machines require for additional qualifications and skills. A designer, today and even more in the future, has to be flexible; he needs the ability to conceptualize the shape and the usability as well as the functionality of technical products and industrial goods and product systems. He needs to constantly grow his skills and knowledge in every new project. He has to go deep into the details of form and technique but also keep control of the product and its context as a whole.

Digitization and the increasingly complex industrial goods to be designed ask for new design professionals who can tackle design problems as engineers, but also think of formal, aesthetic and social aspects of industrial goods.

With regard to these artefacts, the borders between design and engineering become blurred and ambiguous. Today, design as a discipline can be characterized as a very heterogeneous field including various influences from other disciplines. In order to design a machine or service that is connective, adaptable to the user's needs and that crosses borders between the digital and the analogue, we need skills from engineering as well as from design. We have to pay attention to new actors taking influence on design and we have to establish the communicative structures necessary for their collaboration.

The interdisciplinary practice characterizing today's industrial research and development processes needs to be considered when redesigning design education. Herbert Simon's holistic conception of the word 'design' as an activity dedicated to 'shaping the artificial' apart from disciplinary borders needs to replace our anachronistic idea of design as a self-contained discipline.

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