Design of Machines and Structures, Vol. 6, No. 1 (2016) pp. 21–38.
https://doi.org/10.32972/dms.2016.003

INDUSTRIAL DESIGN IN ENGINEERING PROGRAMS: ABOUT THE SUCCESS OF AN INTEGRATED DEGREE PROGRAM MODEL

THOMAS GATZKY

Prof. h.c. HD Dipl.-Formgestalter, Dipl.-Ing.
Otto-von-Guericke-University of Magdeburg
Faculty of Mechanical Engineering
Research and Teaching Area Industrial Design
thomas.gatzky@gmail.com

Abstract: Product development is an interdisciplinary and dynamic process. Especially in its early stages, engineers and industrial designers, among others, have a substantial say in the cost-intensive decisions being prepared and made.

The Master's program in Integrated Design Engineering (IDE) is based on the Magdeburg model of integrated product development and aims at preparing future engineers to apply human-centred, integrated product development methods. It also offers opportunities to integrate industrial design into the engineering program.

Creating products for people means to design all future product characteristics in a way that helps people handle the product, eases its use, and makes it safe and emotionally attractive for the user. The industrial design curriculum focuses on analysing aesthetic and ergonomic product requirements.

Design tasks focus on the use scenario of the product to be designed and its perceptually adequate form as key challenges of the design process.
In IDE development projects, students can practice a holistic and integrated approach to designing. These projects present an ideal experimenting ground where engineers and designers learn to work together.

Keywords: *integrated product development, industrial design specialty in an engineering program, aesthetic and ergonomic product requirements, use scenario and perceptually adequate designing, Master's program in Integrated Design Engineering (IDE)*

INTRODUCTION

Product development is a dynamic, interdisciplinary process that involves cost-determining decisions, especially in the early stages, to which engineers and industrial designers contribute significantly. However, it is a well-known phenomenon that engineers and industrial designers have "difficulties" in communicating with each other. Where do these problems come from? Do they have an objective base and if so, is it possible to mitigate them or even use them productively?

This paper asks a number of hypothetical questions about ways to ease conflicts between engineers and designers. The industrial design courses within the engineering program offered at the University of Magdeburg provides some answers to how to ease potential conflicts. The overall goal, however, is to make the product development process more efficient, and for students to learn to design products according to holistic quality standards.

1. OPPORTUNITIES AND CONFLICTS – AN ATTEMPT TO DEFINE THE SITUATION

Since the 17th and 18th century, product development has increasingly become a team effort. By devising subject-specific approaches and development methods (methodological research in engineering design) and related design tools, individual specialty fields have made tremendous progress. The engineering disciplines have advanced in a co-ordinated manner in contrast to the relationship between industrial design and engineering design. Numberless attempts undertaken in the 1970s and 1980s to depict the industrial design process in much the same manner as the engineering design process were understandable but did not resonate in everyday design practice. Especially computer-aided design tools developed in different directions. The initial incompatibility of CAD and CAID programs was an expensive nuisance.

There are many reasons to explain the situation but the decisive factor is the different approach design engineers and industrial designers pursue. As shown in *Figure 1,* both approaches differ fundamentally with regard to the time the geometrical-physical and functional product design is created in its entirety.

1.1. Causes of conflict

Industrial designers and design engineers are both designers. Both disciplines aim at contributing to the development of a physical product. Both disciplines are mainly responsible for creating a geometrical-material product. Design engineering and technological requirements such as adequate load, material and production specifications have a direct impact on the embodiment of structural parts, components, sub-assemblies, and entire products.

What both disciplines have in common is designing a geometrical-physical product according to technical *and* aesthetic product specifications, but this objective also creates problems since both disciplines approach the common development objective from very different angles. Differing discipline-related goals, approaches, development methods, and design tools have led to a distinctive division of labor in the early phases of product development. The differing approaches to industrial design and engineering design, which are reasonable from a content-related perspective, have often created communication problems in practice. In this context, the point in time matters when to integrate design activities, communication and comprehension problems as well as issues of linking organizational and structural aspects.

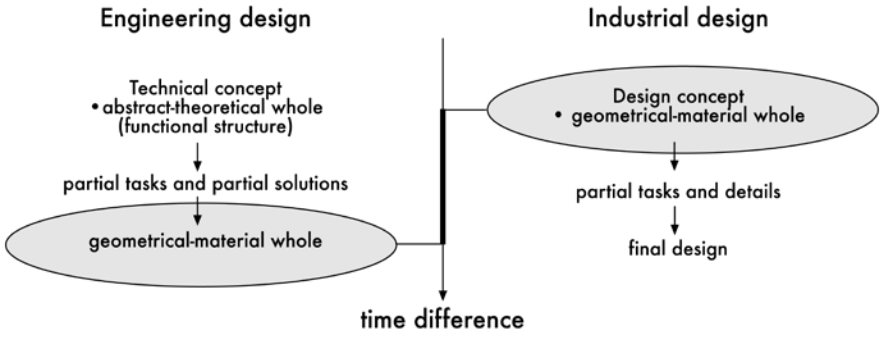


Figure 1. Different points in time at which the geometrical-material entity is created [1]

Figure 1 illustrates this fundamental problem. During the design process, the designer creates a gestalt (form or shape) or a geometrical-material entity in the early design phases because it is the only way to analyse, evaluate, and further develop the overall impact of the design concept. Normally, engineering design concepts for the overall appearance of the future product (structural design, housing) do not exist at this point in time. Agreeing on the shape or form of the product (aesthetic design) and the design of individual components (engineering design) may become a problem with a high conflict potential.
In general, conflicts may arise from the following circumstances:

- increasing division of labor during design processes since the time of the industrial revolution until today;
- development of engineering design methods that disregard people's expectations as users of technical products and thus do not reflect human-related product requirements sufficiently;
- development of design tools geared to a strict division of labor;
- engineering degree programs in line with the model of the division of labor which paid little attention to user requirements (human machine interface);
- different degree or training programs for engineers and industrial designers.

Traditional engineering programs still comprise a number of fields of study that do not focus on the bigger picture (i.e. creating an overall design). In the case of architectural engineering, it is the architect who takes on the role of gestalt designer. The architect envisions the shape or form of a building. In engineering programs, industrial design should play this part. The different approaches to engineering design and industrial design are perceived as normal when they are explained in engineering and industrial design programs in view of their specific tasks. Once the foundations have been laid as described in [1] and [2], it is possible to create an understanding and readiness to follow an integrated approach in all phases of the design process.

Practitioners are all too familiar with the problem. The ideation of a form (gestalt), often in the shape of a final model of the future product, has increasingly become an important strategic and methodological instrument of the development philosophy. Design engineers and industrial designers who are only familiar with the approaches linked to "their" own methods are prone to conflicts. Finding common ground will take more time and incur costs if they do not recognize or accept this difference in order to overcome it.

1.2. Harmonization and collaboration requirements

There are a number of ways to help ease the relationship between design engineers and industrial designers during the early stages of product development. They include:

- raising understanding and providing information about training and qualifications of each discipline,
- synchronizing development steps with many iterations,
- providing an integrated development environment (forms of organization, structural allocations, communication),
- providing a common data basis and efficient interfaces between digital tools (CAD, CAID, RP, model making).

Current product development philosophies accept the different points in time mentioned and describe a development environment encouraging collaboration between engineers and industrial designers.

The *Magdeburg Model of Integrated Product Development* [3] created the prerequisites for the integration of industrial design courses into an engineering degree program. It has been implemented successfully as part of the Integrated Design Engineering (IDE) master's program.

2. TEACHING AND STUDYING IN AN INTEGRATED ENVIRONMENT

In 2000 the Faculty of Mechanical Engineering at Otto-von-Guericke-University in Magdeburg introduced the Integrated Product Development (IPD) area of specialization within the graduate program in General Mechanical Engineering. The way was paved by new design engineering research and university teachers who were open to an integrated approach to the product development process.

Until then the field of industrial design had played an isolated role. Now possibilities opened up to truly link the technical and the design-oriented development process as a study and research task.

2.1. Scientific foundations of Integrated Product Development (IPD)

Olsson was the first to publish the basics of IPD at the University of Lund (Sweden) in 1969. Since then, IPD has been further advanced in many ways. The Magdeburg approach to IPD was described in detail by BURCHARDT and

VAJNA [4]. It paved the way for an integrated approach to engineering studies at the University of Magdeburg.

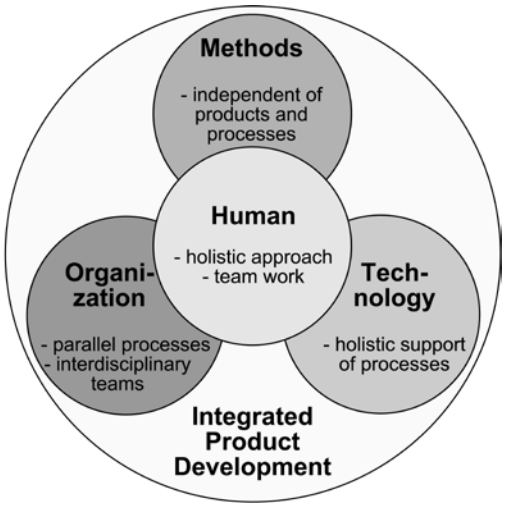


Figure 2. The Magdeburg model of Integrated Product Development (according to [3])

VAJNA describes the following characteristics:

Human focus: All considerations are based on the assumption that human beings are creative problem-solvers. They come up with holistic solutions, acquire the necessary knowledge, use it to solve problems, and pass it on after finishing the task. Depending on the problem to be solved, a person can either work alone or in a team. During work, people communicate with internal and external partners in line with a holistic communication approach.

Field integration: All fields involved in product development are integrated in the product development process. These fields include sales and marketing, *industrial design*, development and engineering design, work preparation, manufacturing, assembly, shipping, maintenance, customer service, and product return. This makes it possible to largely take into consideration the impact of subsequent phases of the product's life cycle at a very early stage and make decisions at the earliest possible moment.

Product integration: In terms of product development, a product's shape, function, handling, product efficiency, sustainability, and good price performance ratio all have the same importance and impact since they influence each other.

Process integration: Making sure that all necessary steps are taken together and simultaneously in order to ensure the complete development and manufacturing of

the product. Processes can be understood as complex networks. If needed and appropriate, elements of such processes can be synchronized to a large extent.

Integration of methods: A number of flexible and efficient problem-solving methods as well as creativity and learning techniques are available for IPD and can be used depending on the context.

Knowledge integration: Providing comprehensive knowledge about the product, related development, manufacturing and usage processes and related methods and technologies in a knowledge base with such knowledge being acquired and transferred by holistic means of internal and external communication.

Application integration: Use of computer-aided technologies for (almost) every step of the development process within a jointly used user interface to dynamically model, simulate, and optimize the product's shape, features, behavior and its manufacturing and usage processes.

Information integration: Uniform, complete, consistent, and permanent information base for redundant-free storage and the avoidance of overlaps to the extent possible.

Generalization: IPD can be used for creating any kind of object (physical products, services, software etc.).

2.2. Integrated Design Engineering – an interdisciplinary course of study

The Chair of Information Technologies in Mechanical Engineering at the Institute of Mechanical Engineering is the driving force and main supporter of the IDE program platform. Current design engineering research, collective, practical experience in design engineering, industrial design related project work, and the introduction of the IDE master program manifest the transition from IPD to IDE.

Currently, two qualified industrial designers take responsibility for the study and research field of industrial design. The integrated study program focuses on development projects carried out by students. It links all theoretical knowledge taught in lectures with concrete assignments that companies provide in order to have a product newly developed or further advanced. The search for and selection of project partners focus on small and medium-sized companies from Saxony-Anhalt. The IDE projects help companies with product ideation, creating aesthetic, technical and ergonomic designs and obtaining intellectual property rights. In order to reach marketability, initial IPD product developments receive government subsidies. But contractors also include market leaders looking for fresh ideas and alternative concepts to in-house developments. Whereas IPD was only available to mechanical engineering students in the past, it has gradually become a highly accepted cross-departmental and interdisciplinary study program [2].

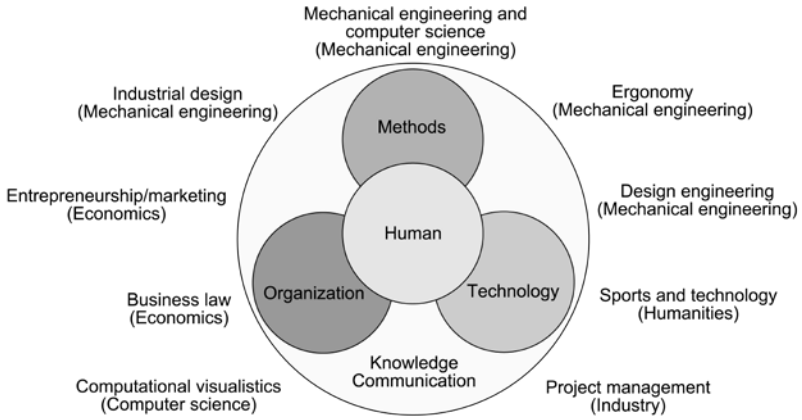


Figure 3. Where teachers and students of the IDE master program come from (according to [5])

In summary, the following characteristics make this study program special:

Heterogeneity: IDE teachers represent various disciplines and faculties. Coursework includes special design seminars where students can learn to apply a multitude of different design methods and tools.

Project work: Students from participating faculties work together in heterogeneous teams. Typically, assignments for developing a new product or modifying an existing one come from companies. Market analyses, intellectual property rights and usage analyses, drafting, designing a preferred option, and building a model or functioning prototype are important steps in the drafting and design process. The results must be defended in front of an expert jury after having reached different milestones.

Coaching: Each student project is coached both by research assistants from various fields and an industrial designer.

Internationalization: In some cases, projects are organized together with student teams from foreign universities. We had international project teams with students from the University of Miskolc and the Technical and Economic University of Budapest (both in Hungary), the FONTYS Hogeschool in Eindhoven (Netherlands), Lehigh University of Bethlehem, PA, USA, INGP Grenoble, ECP Paris (both in France), the University of Malta, and Carnegie Mellon University of Pittsburgh, PA, USA.

With the publication of the book *Integrated Design Engineering – ein interdisziplinäres Modell für die ganzheitliche Produktentwicklung* [1] there is now also a textbook available for Integrated Design Engineering.

3. DESIGN SPECIALTY WITHIN AN ENGINEERING PROGRAM

What is possible, what makes sense?

Time constraints in design coursework, the study intentions of the students and their individual prerequisites are conditions that may limit possibilities but also present opportunities for trying something new.

3.1. Objectives and focal points

From the many approaches implemented since 1984 within the degree program at the University of Magdeburg, a relatively fixed curriculum offering more than 10 different mandatory classes and electives has emerged and become a staple of the Magdeburg engineering program.

Put in a nutshell, objectives and focal points include:

- introductory knowledge about industrial design,
- creating awareness of design challenges in product and environmental design,
- exploring design philosophies, quality standards and positions on contemporary product and environmental design,
- presenting justifiable positions to counter an anything-goes-approach to industrial design,
- acquiring knowledge to be able to consider and to integrate design challenges in the context of engineering decisions,
- touch-point issues between industrial design, design engineering, manufacturing, ergonomics, marketing, and ecology,
- analysing and designing usage processes (in terms of the perception of action and object perception) as an especially important aspect of the design process and source of decisive gestalt requirements,
- the specificity of the design challenge: creating perceptually adequate designs,
- creating awareness of aesthetic design with an understanding of perceptual adequateness to complement technical design requirements such as adequate load, material and production requirements,
- design exercises: training the eye and the hand,
- concrete and applicable advice for designing products with design theory in mind,
- real experience in applying integrated approaches by participating in interdisciplinary and cross-departmental projects,
- practical training through participation in corporate product development projects.

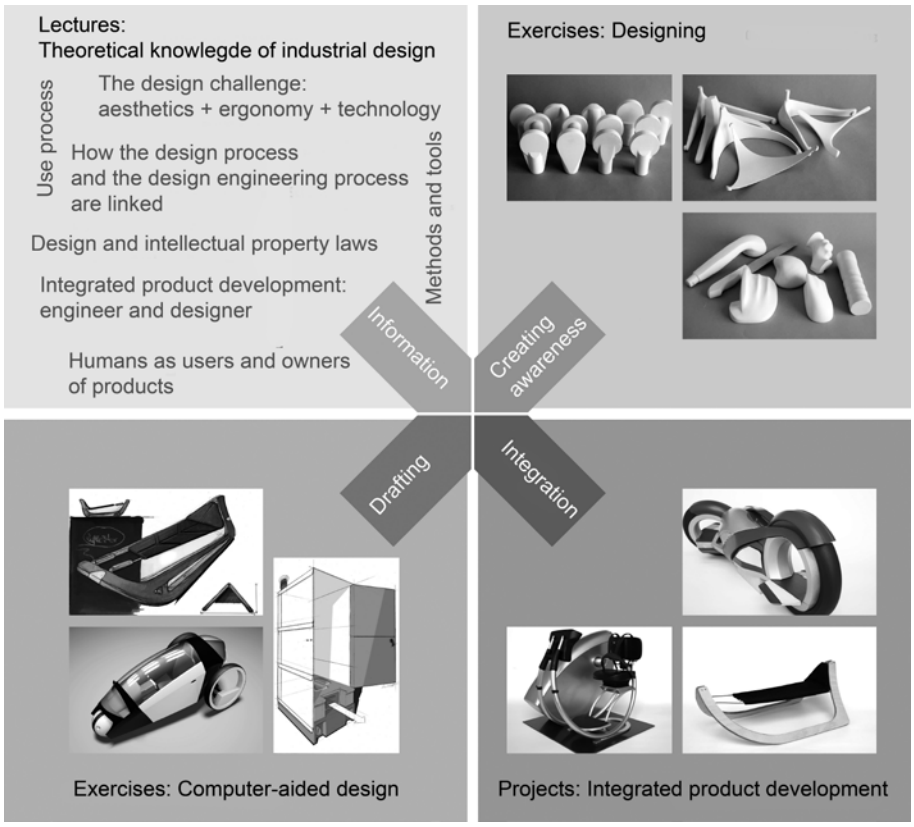


Figure 4. The four elements of design coursework [8]

A design specialty integrated into an engineering program requires a specific selection of topics geared to the requirements of the engineering program. Touching points between industrial design and design engineering are defined by their object and process-related nature.

The product design coursework aims at four aspects shown in *Figure 4.*

1. Providing knowledge about industrial design during lectures.
2. Creating awareness of design qualities in practical exercises.
3. Practicing drafting techniques such as sketching, drawing, computer-aided visualizing and model making.
4. Learning to develop products in an interdisciplinary team.

Over the years, three main topics have emerged forming the core of the current curriculum:

- considering the use scenario as a design challenge,
- creating perceptually adequate designs, and
- pursuing an integrated approach.

These three topics are barely touched or not taught at all in traditional engineering programs. Since they all focus on people as users of products, industrial design can make a valuable contribution to engineering programs.

3.2. The use scenario as a design challenge

Engineering studies approach technical objects such as machines and devices in view of their hardware performance, thus neglecting the human-machine interface. Increasing automation and electronification (miniaturizing and digitalizing) obscure questions of user-friendly design. However, it is possible to counter trends towards so-called black box design (standardization and anonymization) by thoroughly analysing all human-related product requirements. If both design engineers and industrial designers concentrate on this aspect, there is a chance of finding consistent gestalt concepts. Schürer aptly describes this phase as "from the digitalized function to analogue action" [7].

The use scenario as a basis for analysis and design ties together aesthetic, ergonomic and perception-related psychological aspects. By analysing the use scenario during the design phase, it is also possible to overcome the separation between design and ergonomics.

"In this sense, ergonomics can be understood as a design component, and aesthetics, in turn, as a component of ergonomics. However, in this context the aesthetics of an object must not be understood as associative aesthetics or pretty design but as an aesthetic related to and guiding action. It has not only an impact on how we experience the object but also on how we behave in the light of these aspects and, last but not least, on how we take targeted action. Experiencing, behaving and taking action are basic human experiences. It does not suffice to satisfy these basic needs by designing adequate artefacts for use that means ergonomically adequate devices. Instead these needs are essentially influenced by the creation of action-guiding elements, so to say in terms of their software ergonomics, that appeal to the senses [7]."

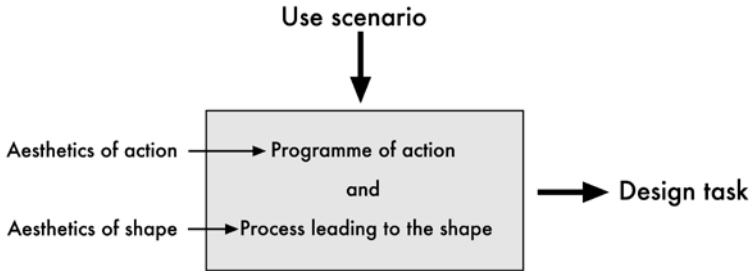


Figure 5. Use scenario as a design challenge [6]

The design task focuses on the user's holistic perception and experience during use. The logic, sequence and understandability of usage and resulting behaviours as well as the search for the shape, colour, material, surface, and appearance of the

physical manifestation of the human-product interface must be taken into consideration.

A design assignment described as such would be too narrow for a university design program, but has proven to be useful for a design specialty within an engineering program in my experience.

If we want to develop actions and forms that are usable, we need to ask ourselves how we "use" a product. During the development process, all prerequisites and requirements are planned so that the user can later experience what it means to "see" and "operate" the object. Perceiving and sensing harmony, pleasant feelings and grace but also to experience contrasts and tension stimulates the senses leading to a unique user experience.

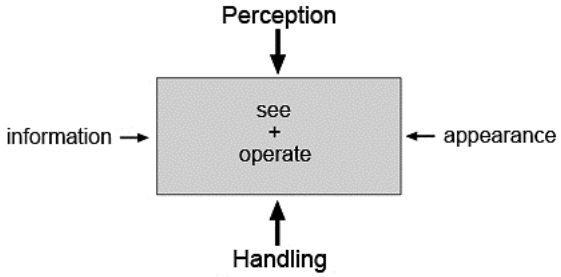


Figure 6. Relation between use-related action and design field [6]

To implement this approach, it is necessary to describe design objectives and quality standards based on questions such as:

- What is perceptually adequate?
- What satisfies appearance requirements?
- What satisfies information requirements?
- And what eases handling?

The didactic approach illustrated up to this point raises the students' awareness of all questions related to the product's future use.

It is not difficult to teach engineering students that understanding a technical product's future use is important because engineers can typically emphasize with the role of the user if asked to. Industrial designers will continue to be experts for such questions. Projects have shown that designing a use scenario together is an interdisciplinary effort and can therefore have a highly integrative effect.

3.3. Functional AND usable form as an objective

Design engineers design technically defined forms. A substantial part of engineering coursework deals with design engineering and technical design requirements. Defining adequate loads and meeting material and production specifications are requirements that directly manifest themselves in the embodiment of components, assembly groups, and holistic product forms. A form developed in such a way may be referred to as a functional form.

A functional form is not a usable form yet, especially not if products with distinctive human-product interfaces are concerned. In case of many technical objects, form and content do no longer correspond. There is a tendency towards an arbitrariness of form. To counter this trend, we need to formulate well-reasoned positions for a clear design responsibility. The objective must not be black box designs but forms that stand the usability test and touch the user's senses.

To reach this goal and understanding within the study program, students are introduced to the theory of form. Based on this way of perceiving forms and their impact on human beings, they are challenged to analyse, draft, and reify design ideas.

At a theoretical level, students study how shapes develop and are created, they are introduced to form methodology (form features), form systematics, and quality criteria of perceptually adequate designs.
Based on this knowledge, it is possible to formulate and solve very practical design challenges in the context of creating perceptually adequate designs.

To what degree is it possible to explore the depths of aesthetic design within an engineering program? It is useful to be aware of these connections but it does not suffice to come up with a creative solution to complex design challenges. A professional design competence will develop only based on virtually available design knowledge, personal sensory-creative prerequisites, and a wide range of technical skills (design tools).

Engineering programs do not offer this combination. It is also not the goal of the curriculum. So what is possible and makes sense?

Typically, an engineer is familiar with her/his design requirements that ideally help her/him to come up with a functional form. S/he should understand that the human being is the measure of all things and s/he should have an idea of cause-form/effect aesthetics. Additionally, s/he should also know how a design engineer can influence a user-oriented design.

Following this approach, students are introduced to a multitude of criteria, information, and recommendations available in texts and images on perceptually adequate design. Central topics include:

- recommendations on gestalt creation with regard to an entire object or elements of an object,
- recommendations on gestalt structuring,
- recommendations on organizing forms.

Such an approach as described above follows the vision of understanding functional form, usable form, and formal-aesthetic form as a sensory entirety and links it with the requirements of a technically determined design during the design process.

Subsequent design exercises produce results on a sensory level that can be evaluated. What impact has an edge, a surface, or a transition of forms? How do I find out the correct gripping volume? Does it feel organized or too complex? How can I

organize a form? These are all questions that an object raises, which students can see and describe.

Making and working on an object is already a way of generating understanding. Students can experience what it means to "think with your hand". They learn to understand their eyes and hands as sensory tools. These exercises do not suffice to teach design competences on a degree level but they are ideal for illustrating the sensory-aesthetic challenge by giving students a chance to learn by experience. In addition to creating sensory experiences, e.g. by touching a well-designed handle, students also learn to verbally describe their work since the right terminology is necessary to be able to describe and evaluate designs.

3.3.1. Design exercises

On a didactic level, exercises focus on making, perceiving and evaluating objects. Methodologically, they are based on the theory of form. *Figure 9* illustrates the design categories applied to a model.
The methodology follows the principle of simplicity to complexity.

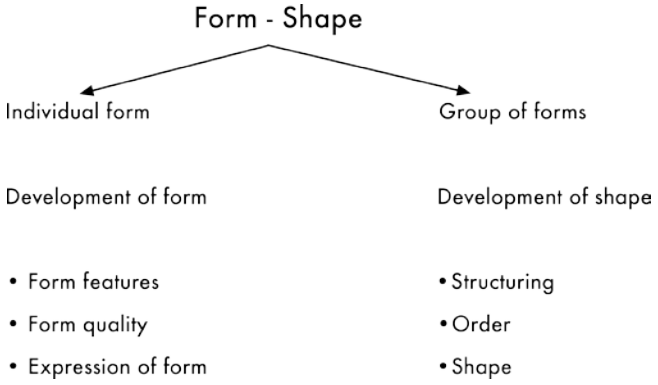


Figure 7. Methodological approach: design exercises [6]

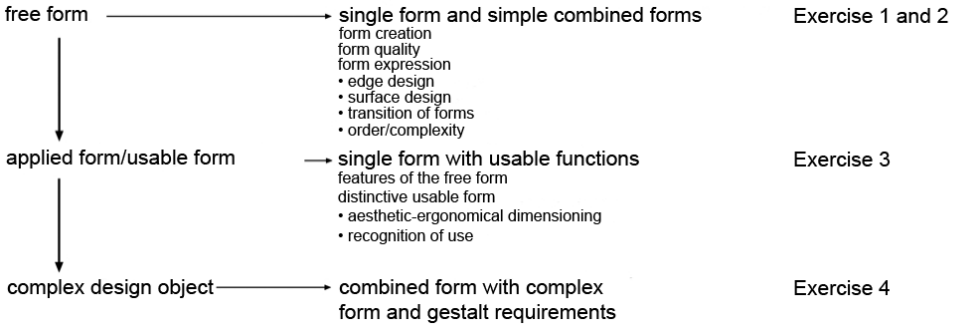


Figure 8. Topics related to the theory of form [1]

The following images illustrate the results. The complexity of the design assignment increases from left to right.

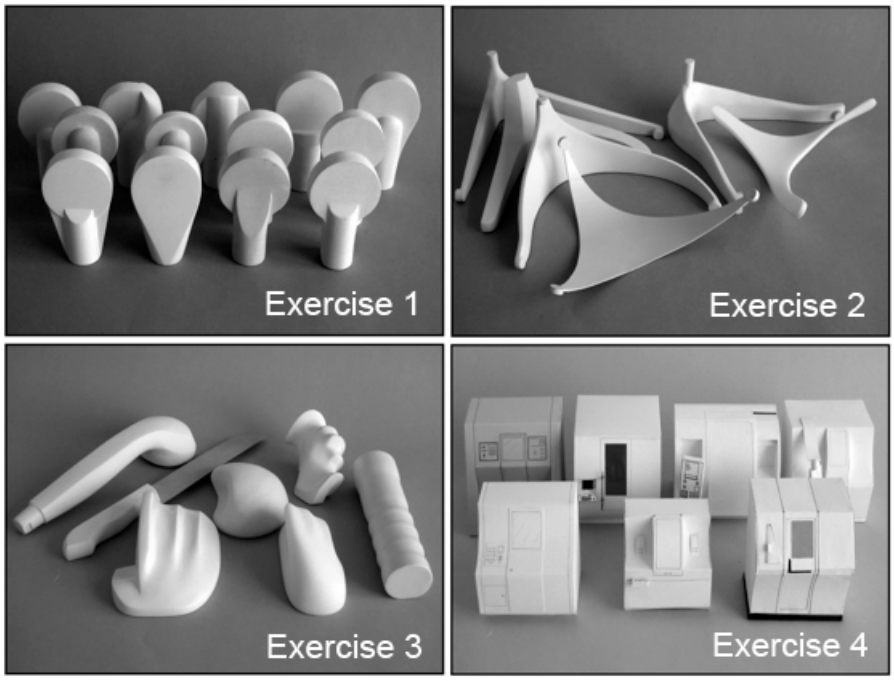


Figure 9. Design exercises – Models made of plaster and paper [6]

3.4. Sustainable design

In recent years, interest in sustainable product development has increased tremendously. Development objectives related to the use, manufacture, trading, repair, and disposal of a product must be integrated into the early phases of product development. This raises questions directly related to product design.
Sustainability aspects such as:

- Compostable: Products whose organic elements are transformed into soil by living microorganisms at the end of their use.
- Long product life: Long-lasting products as an expression of the sensible use of natural resources (can be repaired, cleaned, recycled, not a fad).
- Local: Use of local material, strengthening local businesses.
- Saving energy: Low energy consumption, scaling down the carbon footprint.
- Avoiding trash: Reducing scrap, increasing recycling, useful packaging.
- Multiple use: Used several times, combined use.
- Recyclable: Products that can be used to generate new raw material once they have reached the end of their product life.

- Up-cycling: Making new products from old products.
- Renewable resources: Products made of material that replenishes naturally.

Coursework is divided into lectures and small projects on the sustainability aspects listed above.

4. IDE DEVELOPMENT PROJECTS FOR STUDENTS – LEARNING HOW ENGINEERS AND DESIGNERS CAN CO-OPERATE

In many cases, project teams are composed of students studying the disciplines shown in *Figure 3.* The core of a team is made up of students majoring in IDE, mechanical engineering, computational visualistics, sports and technology, and industrial design. Other team members may study occupational psychology, marketing and entrepreneurship.

The fact that industrial design majors studying at the Institute of Industrial Design of the University of Applied Sciences of Magdeburg/Stendal also participate in these projects is a hallmark of the model. To have future engineers and designers meet during their studies is a great way to teach students how to smoothen the product development process. Bringing together different approaches to designing, special knowledge and methodological skills and tools are both an opportunity and a risk of such co-operation.

4.1. Experiences of an integrated approach for engineering and/or design majors as illustrated by the example of the main phases of the design engineering process of an IDE project

In the weekly team meetings, students discuss the technical input by all students participating in the design process, their specific perspectives on the challenge at hand with the aim of finding a solution that they can all agree on.

Analysis phase: A division of labor largely characterizes work in the analysis phase. Design majors research forms and uses of previous products or competing products. Future engineers analyse performance parameters, technical principles, the design of individual components, and materials to be used. Together they carry out intellectual property rights analyses. Based on further analyses (market analysis, customer surveys, company research etc.) they define the assignment and present a design brief at the first milestone meeting. Typically, no conflicts arise during this phase.

Conceptual phase: During the conceptual phase, ALL students must present their ideas and first sketches during the meetings. As shown in *Figure 1,* conflicts regularly surface. Engineering majors focus on technical details. Their excessive self-censorship with regard to costs and implementation limits their creativity. Often they are not able to make convincing sketches. They turn to computer-aided designs and calculations for reassurance but these often come too early in the process. Industrial design majors typically present skilful sketches and visionary holistic de-

signs. This is the point when students, guided by an experienced facilitator, need to learn that their own (learned) approach must be harmonized with the approaches pursued by the other team members. For industrial design majors it is oftentimes hard to understand and personally painful to have their first sketches attacked by arguments they perceive as absurd and pointless. This is when it becomes obvious that they have not been prepared for such a confrontation.

Engineering majors must learn that in the early phases of product development, the search for holistic technical and aesthetic concepts takes centre stage and that questions of the product's usage characteristics for the user are more important at this point than, for instance, optimizing a component. By developing a use scenario together, students have a chance to fuse aesthetical, ergonomic, occupational, psychological, and technical requirements. The path to a usage and a gestalt vision is strewn with conflict but it is the right path leading to a feasible and acceptable integrated design process. The use scenario developed together opens the view to the problem at hand. It makes it easier to organize, structure, and evaluate the ideas and concepts the students have come up with. The step of developing one or several preferred concepts remains a challenge, however. But the use and gestalt vision presents an objective that guides the selection process. The conflict potential decreases significantly; the development process becomes more target-oriented and efficient.

In summary, it should be noted that the concept phase brings familiar conflict patterns to the surface. By developing the future usage scenario together, engineers and designers can come up with a mutually agreed design vision. All subsequent processes will be less prone to conflict and more efficient. This phase takes three to four weeks and ends with defending the 2nd milestone.

Design phase: Once this phase has been reached, students (should) have achieved a good balance between an integrated and a subject-specific design engineering approach. The engineers continue advancing the technical concept, dimensioning components and making calculations based on the designers' form and detailed sketches. In order to meet ergonomic requirements, the engineering design and the aesthetic design need to be adjusted and modified constantly. Production-related and economic conditions are gaining more weight and must also be taken into consideration in the engineering and aesthetic design. What is typical of this phase is the digital exchange of design data between engineers and designers (and computational visualistics/IT specialists). The students are trained to use special computer technology. The exchange of design data has become increasingly easier thanks to advanced data transfer technology but it still takes up time and resources. After about 7 to 9 weeks of integrated project work, students collaborate increasingly with regard to the drafting, selection and evaluation process. They deal with conflicts more productively, i.e., individual skills and competencies flow directly into the creative teamwork. Once the 3rd milestone is reached, a design concept agreed by all students is presented illustrating all technical and design aspects (CAID and CAD images, physical models, calculations, evaluations, selection processes).

Documentation phase: Again, a division of labor characterizes this phase. Engineering majors are responsible for making CAD drawings and a functional model. Functional models are used to prove the selected technical concept in terms of its functionality and usability. Typically, these workshop models combine the main functional components and make initial functional tests possible but they still lack an aesthetic design quality. Industrial design and computational visualistics majors prepare high-quality renderings, animations, and presentations. Often students studying design engineering and/or industrial design work together on the model. Increasingly, rapid prototyping models serve as a basis for final models.

A complete product documentation normally comprises:

- project management documentation,
- presentation and evaluation of all analyses,
- documentation of the technical and industrial design across all phases,
- functional and design models,
- final report provided by the team leader.

Presentations open to the public at the university or in R&E departments mark the highlight of the semester project work. In many projects, student teams also come up with a marketing and business concept for the same product development assignment. Since these concepts also span all milestones, students gain an excellent understanding of all phases of the product development process.

5. SUMMARY

At the beginning of the 1990s, the University of Magdeburg started to offer industrial design courses for mechanical engineering majors in addition to traditional engineering programs. Finally, in 2000 after several failed attempts of integration, IPD was introduced as a specialty within the mechanical engineering program.

After the introduction of bachelor and master's programs around 2009, the study course and research platform *Integrated Design Engineering* developed providing an ideal platform for integrating industrial design coursework into the engineering program. Graduates of the Integrated Design Engineering master's program have gained and are able to apply the skills needed to work on and advance the touch points of engineering design, industrial design, and ergonomics especially in the early phases of product development.

REFERENCES

[1] GATZKY, Thomas: Produktdesign (Section 3.2.1) und Industriedesign (Chapter 4). In: VAJNA, Sándor (Hrsg.): *Integrated Design Engineering. Interdisziplinäres Modell für die ganzheitliche Produktentwicklung.* Springer, Berlin–Heidelberg, 2014.

[2] NAUMANN, T.–GATZKY, T.–VAJNA, S.: Integrierte Produktentwicklung als Ausbildungskonzept. *CAD-CAM Report*, Jg. 23, Nr. 2, 2004.

[3] BURCHARDT, C.: *Ein erweitertes Konzept für die Integrierte Produktentwicklung.* Dissertation. Otto-von-Guericke-Universität, Magdeburg, 2000.

[4] VAJNA, S.–BURCHARDT, C.: Ein erweitertes Konzept für die Integrierte Produktentwicklung. In: VAJNA (Hrsg.): *Buchreihe Integrierte Produktentwicklung.* Band 3. Otto-von-Guericke-Universität Magdeburg, Reihe Magdeburg, 2001.

[5] VAJNA, S.–NAUMANN, T.: Implementation of the New IPD Study Course at the Otto-von-Guericke University Magdeburg. In: CULLEY, S.–DUFFY, A.–MCMAHON, C.–WALLACE, K: Design Applications in Industry and Education. *Proceedings of the 13th International Conference on Engineering Design 2001 (ICED 01)*, 277–284.

[6] GATZKY, T.: *Vorlesungs- und Übungsmaterialien zu den Lehrveranstaltungen Industriedesign.* Technisches Design für Ingenieurstudenten der Fakultät Maschinenbau an der Otto-von-Guericke-Universität Magdeburg, 2008.

[7] SCHÜRER A.: Entwicklungstendenzen im Investitionsgüter-Design. Designcenter Stuttgart (Hrsg.): *Design aktuell*, 1, 1988.

[8] GATZKY, T.–WIESNER, M.: *Dokumentation und Ausstellung zu „30 Jahre Industriedesign an der Otto-von-Guericke-Universität Magdeburg“*. 2014.

Translation by Dr. Janina Gatzky