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DESIGNING AESTHETIC FREEFORM OBJECTS: A COURSE FOR INDUSTRIAL DESIGN ENGINEERING STUDENTS

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ABSTRACT
Retaining basic sculptural education within an industrial design curriculum may seem a bit odd. A design theory focussed on creating objects might also be considered old-fashioned. But it obtains its right to exist from future generations, who will still be surrounded by objects. And these objects will have to be designed.
An education in design basics includes instruction in drawing, graphics, colour, and three-dimensional form with one common goal: teaching a basic design methodology and equipping students with sensitivity for fundamental aesthetic, syntactic and semantic qualities of products. This is of great importance when students with an engineering design background are taught in industrial design, where two significant differences to usual design curricula can be found: first, there is less time available to teach these students in product design; second, these students are marked by technical-functional problem solving and used to getting precise instructions.
Within a three-year design curriculum, which supplements two years of mechanical engineering education, we offer a coherent education in design fundamentals.
In this paper we will describe the Two-Step Method, which is used as a fundamental design method in our education program. Furthermore we will show how this method is applied to educating industrial design students in creating aesthetic three-dimensional forms.

Keywords: industrial design education, design action, aesthetic freeform

1 INTRODUCTION

Retaining basic sculptural education within an industrial design curriculum may seem a bit odd. A design theory focussed on creating objects might also be considered old-fashioned. But it obtains its right to exist from future generations, who will still be surrounded by objects. And these objects will have to be designed.
At the Technische Universität Dresden practical industrial design fundamentals have been offered to engineers since the late 1950s [1]. Even then basic design methods were taught in special subjects on the basis of abstract sculptural objects and students gained sensibility for syntactic and semantic qualities of form and colour [2].
The initially rather supplementary education of engineers in industrial design has developed into independent education programs in several places around the world. This also happened at the Technische Universität Dresden. Students who have passed a two year mechanical engineering course, can choose an industrial design engineering programme. In this programme, more than just information about industrial design is

taught [3]. Students in this programme have less time to train aesthetic sensibility and fundamental design methods than their “competitors”, whose only focus is design, e.g. at schools of art and design. This led to a well-organised set of courses on design fundamentals within the narrow time-frame of three years of industrial design education programme at the Technische Universität Dresden.
In order to prepare students for complex design projects, theoretical background about the industrial design process must be explained. Design methods are taught in fundamental design lectures such as drawing, sculptural design, graphic design, colour and CAD. These subjects follow a consistent principle. According to this principle, the common goal of all of these subjects is sensibility and aptitude, including design action in all of its facets. Design action can be systematically understood, applied and internalised with the help of the Two-Step Method, which is explained further below.

2 EXPLAINING DESIGN ACTION

Design is based on the simultaneous occurrence of thought and visualisation processes [4]. A design activity directed towards objects is called representational design [5]. Representational design action is a permanent interaction between thought and its externalisation. The result of each operation is recycled through the sensory organs and leads to further thinking [6]. This sequential relationship between representational design actions makes up the totality of representational design activity.
Aptitude and proficiency in representational design must be readily available in order to be used routinely and automatically. Visualisation should require very little mental capacity during a representational design act.
For the education of industrial design engineers an explanatory model that is easily understood was selected. This model consists of an iterative loop of anticipation, application and feedback, which is divided into five steps [5]:

1. Evaluation of an input status with regard to correctness and appeal. This input usually is the output of the previous design action.
2. Mental anticipation of a new status based on the previous evaluation and of operations that could invoke this new status
3. Decision about the possible operations and anticipated result
4. Execution of selected operations
5. Review results – has the intended result regarding correctness and appeal been achieved?

These five steps have been combined to only two steps for practical application in education (See fig. 1). This method describes design action in a way which can be understood by students at the start of the product design education program. The *Two-Step Method* is a basic design method, taught within the courses on design fundamentals.
Figure 2 shows the method intuitively applied on the determination of the car body of a luxury limousine. Here a tape plan is being aesthetically optimized. The use of the input as a reference as well as the gained sensibility can be seen.

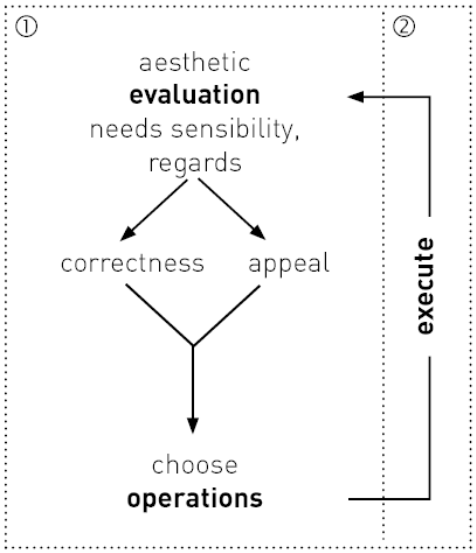

Figure 1 Explanatory model: Two-Step-Method

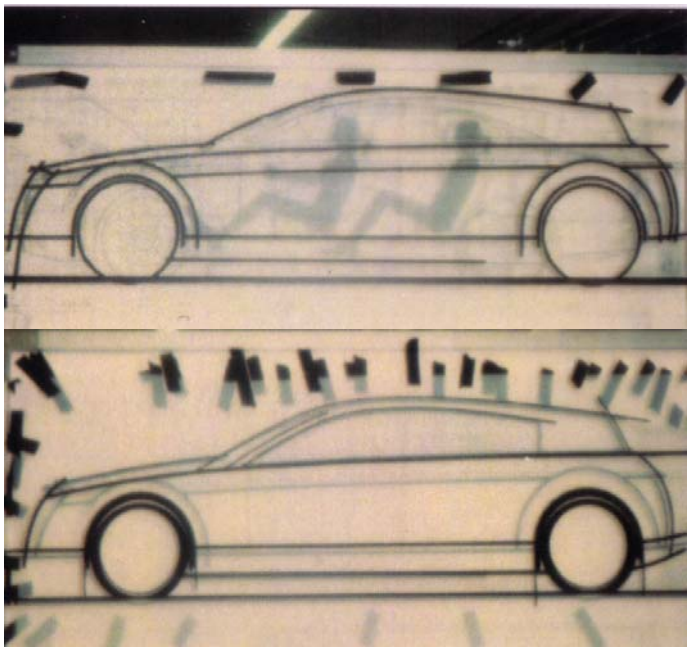

Figure 2a,b Application of the design method (excerpt)

3 TRAINING SENSIBILITY

Within the fundamental design education students train their sensibility for elementary design qualities. This sensibility is trained in both receptive and productive ways, which means by evaluating and by doing. Evaluation of aesthetic objects must pay regard to correctness and appeal. Both criteria have been derived from the aesthetic judgement of taste [7], whereas correctness regards all objective qualities and appeal regards all subjective qualities.

4 DESCRIBING AESTHETIC GEOMETRY

In the lecture Sculptural Design, aesthetic geometry is described by using the terminology of semiotics and geometry.

Semiotics is the science of signs and symbols. It differentiates between syntactics, semantics and pragmatics. *Syntactics* describe geometric objects and elements and their objective relations to each other. *Semantics* regard the meaning and characteristics of the object and its elements on its own (e. g. light, slow, floating). *Pragmatics* is the meaning of an object in the context of its environment (e. g. pencil, drill press, car). It is the meaning of the object in its technical, functional and socio-cultural context.

Elements can be points, lines, radiuses, directions, surfaces etc. What is seen as an element depends on useful geometric relations. Relations of these elements can be for example: relation of locations, relation of directions or relation of quantity.

5 THE LECTURE SCULPTURAL DESIGN

The teaching and application of the Two-Step Method described above will be illustrated with the example sculptural design. The aim of this lecture is the systematic development of an aesthetically optimised object with simple tools. An input status, the sequence of steps and the two-Step method are given (see Fig. 1).

The input status is to be developed by purposeful systematic variation, which is done by permanently determining elements to be changed and by selecting and executing necessary operations. One constantly repeats two steps and continues until a final status, determined by the designer himself.

Step 1: evaluating the input status
using individual cognitive and emotional knowledge

Step 2: selecting and executing operations

The ability to evaluate an input depends on the complexity of the object and the aesthetic sensibility of the student. This sensibility cannot be expected at the beginning of the design education but will be developed. Therefore it is necessary to keep the complexity of the tasks at the beginning low. As a certain sensibility is gained, complexity can be raised gradually from task to task until the students are a finally capable of shaping a 3D freeform object. In this series of tasks the past output is used as the input of the subsequent task. Different levels of complexity correspond to the tasks as shown in Figure 3.

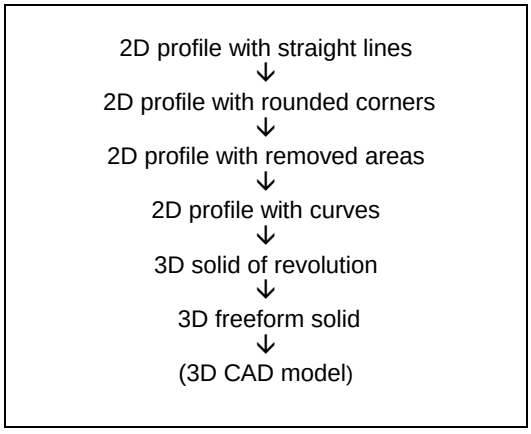

Figure 3 Series of tasks representing different levels of complexity

The first task is to compose several straight lines within a certain area to an aesthetic profile. Complexity at this stage should be avoided. Because demands on aesthetic sensibility are kept relatively low, there is enough mental capacity available to (consciously) implement the Two-Step Method. Figure 4 depicts an early extract from the systematic optimisation of such a profile with this method. It shows how the analysis of syntactic and semantic properties of the profile leads to changes made to the width of the vertical columns. In the further optimization process, the Two-Step Method is applied again and again until the contour has attained satisfactory aesthetic quality.

Figure 4 Systematic optimisation of a profile with straight lines (excerpt)

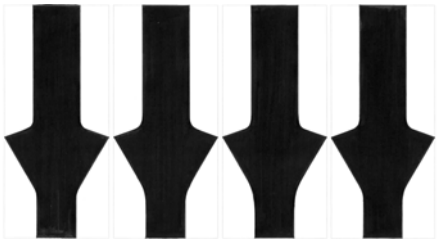

Figure 5 Differently rounded corners added to the optimized profile (excerpt)

The subsequent task is the smoothing of the profile's corner points. Figure 5 shows that the changes made to the profile are much smaller compared to earlier stages shown in figure 4, which can be interpreted as more sensible acting. The character of the profile then possibly changes and needs to be optimized again. Using the Two-Step Method now requires less mental capacity because it is somewhat familiar. At the same time the demands on aesthetic sensibility increase.

The Two-Step Method has largely been internalised during the remaining steps at higher levels of complexity, so that the available mental capacity is predominantly used for the profile.

Regardless of the rounded corner points, area is then removed from the optimised profile (Figure 6). The straight lines systematically become curves, which are used to generate solids of revolution. Always by means of the Two-Step Method, this solid is then gradually and systematically developed to an aesthetic freeform solid. This can be developed from the extrusion (Figure 7) or the revolution of the profile (Figure 8). The results of this course are used in the subsequent Freeform CAD lecture.

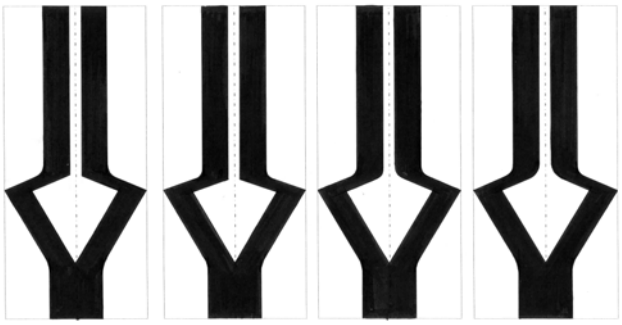

Figure 6 Profiles with removed areas and differently rounded corners (excerpt)

Figure 7 An aesthetic freeform object developed from the extrusion of the profile

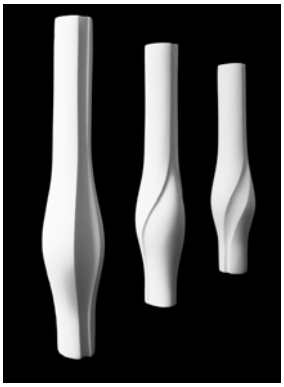

Figure 8 Three different 3D freeform solids developed from one revolved profile

6 SUMMARY

In the class Fundamentals of Sculptural Design, students learn and internalise a fundamental design method using the Two-Step Method and attain sensibility for syntactic and semantic qualities of shapes. A strongly simplified object is developed at the beginning. Subsequently, the complexity increases from task to task leading to a complex freeform solid.

In this way, students are able to implement fundamental design methods intuitively in later design projects and can devote their mental capacity entirely to the specific problem at hand. This effect justifies maintaining education in design basics including drawing, graphics, colour, and three-dimensional form within industrial design curriculums.

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