

HOW INDUSTRIAL DESIGN KNOWLEDGE DIFFERS FROM ENGINEERING DESIGN KNOWLEDGE

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ABSTRACT

That knowledge plays a meaningful role in product development is largely undisputed. There is, however, no agreement about which kinds of knowledge are relevant for the disciplines involved. Obviously, there are differences between the knowledge required by industrial designers and by engineering designers. This paper aims to describe knowledge which is needed in the early stages of design processes. Driven by an educational problem referred to in the paper, several aspects of design knowledge are discussed in contrast to engineering design knowledge. This paper does not develop a cohesive model of design knowledge. But the aspects help developing a method for easier knowledge evaluation in early stages of the industrial design process.

Keywords: design knowledge, design methodology, industrial vs. engineering design

1 INTRODUCTION

That knowledge plays a meaningful role in product development is largely undisputed. There is, however, no agreement about which kinds of knowledge are relevant for the disciplines involved. Obviously, there are differences between the knowledge required by industrial designers and by engineering designers at the start of a design process. This has been observed by analysing design projects completed by students whose design education is preceded by an engineering curriculum [1]. The observation has shown that some students have difficulties accessing and activating knowledge at the start of the design process.

The source of the larger part of knowledge used in the design process is the designer himself [2]. He must however be able to activate and use this source. Due to the strong impression created by the preceding engineering education, the observed students dedicate their efforts primarily to technical and functional (objective) aspects and rarely to emotional, subjective aspects. The latter are equally indispensable for the creation of successful products.

Awareness about this problem leads us to consider facilitating methods. What can one do to foster the activation of the “right” knowledge for the industrial design process?

In order to develop methods to this end, we will address differences between industrial design knowledge and other kinds of knowledge, in particular engineering design knowledge.

2.1 Different understandings of the term *design knowledge*

The term design knowledge has many interpretations from a number of disciplines. As a result there are many intersections and some contradictions in terminology and content. This makes the definition of a cohesive model of design knowledge quite difficult.

Design knowledge is not the same as design knowledge. There are various understandings of the term design knowledge, e. g.

- The knowledge one person uses when experiencing a design object
- The knowledge which is in a design object itself
- The knowledge which one needs to be able to designing objects

One helpful categorization of design knowledge has been described by van Aken [3]. His taxonomy is concerned about “knowledge that can be used to produce designs” [3: 387], which is what we are interested in. He divides *general design knowledge* into *object knowledge*, *realization knowledge* and *process knowledge*. These categories are further divided into *prescriptive* and *descriptive* knowledge. However, we do not follow his strict distinction between *evidence-based* and *experience-based* knowledge at this stage of our research.

We can ascertain from the categorisation of design knowledge according to van Aken that the above-mentioned activation problem deals primarily with *prescriptive object knowledge*. In this paper the term design knowledge will be used to mean this subset.

As described above, there are several design disciplines which differ in terms of goals, methods, processes and knowledge. Also there are different scientific disciplines investigating into design and into designers such as psychology, sociology, economic or engineering sciences. These disciplines apply their specific research methods and use their specific terminology when making statements about design knowledge. On the other hand, there are studies which do not explicitly mention design knowledge but contribute to the debate. The facets of design knowledge specified below originate from different scientific disciplines and thus are quite diverse.

In the following paragraphs, (prescriptive object industrial) design knowledge will be characterised. Distinctions to the (prescriptive object) knowledge in engineering will be outlined.

2.2 Design knowledge is *not-knowing*

Design knowledge is *not-knowing* [4]. At the start of a design process, the designer knows almost nothing about the goal. He knows just as little about the path leading to it. Notions about the process, the environment and implementation of the design object do exist, but these are neither precise nor verifiable [5]. This is the case for both industrial and engineering design, when the task is about designing objects which do not exist in any form yet (new design). In practice, engineering design is often concerned about adaptive design and detail design, whereas industrial design focuses on new designs. Therefore the problem of not-knowing is tends to be more present in industrial design.

Not-knowing is also linked to uncertainty and decision-making. In engineering design, decisions are mainly concerned about function and fit, they are made objectively. In industrial design, often only subjective decisions can be made [6]. We have observed that inexperienced designers (i. e. students) feel inconvenient when there is no objective rule for making decisions especially in the early stages of the design process. This is also a facet of not-knowing.

In practice, industrial designers more often may be confronted with not-knowing than engineering designers, but this is widely caused by their tasks.

Discipline	Description	Uncertainty	Degree of detail	Distance to goal	Decision making
Sales and marketing	High-level product characteristics	Company capability, market, world events	Low	Known	Selection of alternatives
Management	Tasks, deadlines, budgets	Resources, technical risk	Low	Known	Constraint resolution
Engineering design	Sketches, drawings, CAD systems	Technical, missing information	High	Not known	Function and fit
Applied mathematics	Formulae, simulation models	Underlying specifications	High	Known	Objective evaluation
Materials science	Formulae, empirical models	Physical performance	High	Known	Physical evaluation
Systems engineering	High-level diagrams	Influencing factors	Low	Not known	Weighting
Product design	Sketches, models, mood boards	Context, emergent properties	Low, high	Not known	Subjective
Manufacturing and logistics	CAM systems, MRP systems	Known types	Very high	Known	Potentially objective

Figure 1 Differences between disciplines [...] that may be involved in the design of a complex product [6]

2.3 Design knowledge is *prior knowledge*

Phases of systematic and opportunistic behaviour alternate while designing. During opportunistic phases, the designer recalls previous tasks or problems that he has solved in a certain manner and applies them to the problem at hand, even in cases in which a systematic approach might lead to another, possibly better solution [7]. (Unconscious) use of prior knowledge can be observed in many disciplines [8], and studies show that it is inevitable [9]. In contrast to the field of engineering, design cultivates this behaviour [10, 11 and others]

2.4 Design knowledge is *tacit knowledge*

Design knowledge, for a large part, is knowledge that exists but cannot be expressed in words. According to Polanyi [12] this tacit knowledge cannot be converted into explicit knowledge. Nonaka and Takeuchi presented the S-E-C-I model (Socialization, Externalization, Combination, Internalization) [13], which describes how explicit (design) knowledge can be internalized to implicit (design) knowledge and vice versa. There has been some discussion whether tacit knowledge can be directly converted into explicit knowledge. However, tacit (design) knowledge can serve as the basis for generating explicit (design) knowledge [14]. This is the case in both industrial and engineering design.

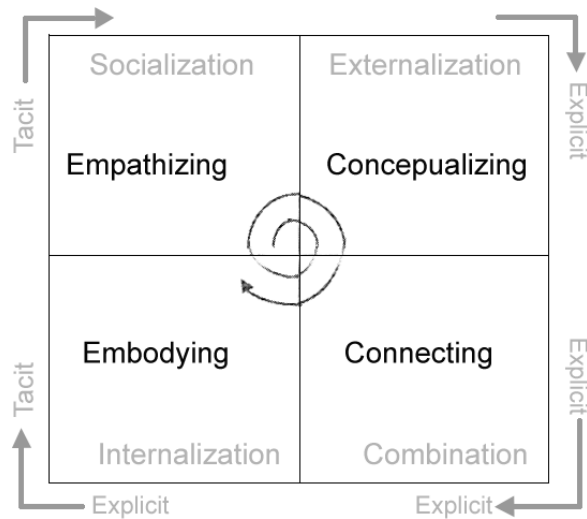


Figure 2: The S-E-C-I process [13]

2.5 Design knowledge is *episodic knowledge*

The knowledge used by designers can be described by the use of neuro-scientific knowledge categories [15]. During the design process each of these categories of knowledge is used, but at the start the focus lies on declarative knowledge, including its factual and episodic knowledge. In industrial design, episodic knowledge plays a very important role [11, 15 and others]. The same has been proven for engineering disciplines [16, 17], despite it is rarely or not taken into account in academic engineering design methodology [18].

2.6 Design knowledge is *everyday knowledge*

Many studies suggest that design knowledge is *everyday knowledge* [11, 19, 15 and others], i.e. it is not solely the knowledge gained from schooling or work, but knowledge from the entire day-to-day life of the designer. Many tangible and intangible socio-cultural references contribute to the industrial design process [20]. Studies have shown that the extensive use of everyday knowledge in the sense of socio-cultural references have a positive influence on students' design processes [21]. There is a strong connection between episodic knowledge and everyday knowledge, so it can be concluded that everyday knowledge has also impact on engineering design, though to a lesser extent.

2.7 Design knowledge is *objective, subjective and emotional knowledge*

Design knowledge is about experiencing. In contrast to design engineering, design focuses on the experiential relationship between the design object and the user. This experience is an individual one, and the evaluation of the object tends to be holistic. These judgements include objective as well as subjective and emotional criteria, even for the object's technical functions. Experiencing, under its many names, traditionally belongs to research about design methodology and has recently been given more attention [22, 23, 24 and others].

2.8 Summary: a possible definition of design knowledge

From the descriptions and definitions listed above, we conclude the following attributes of design knowledge:

- It is not known at the very beginning of the design process
- It must be acquired from the
 - prior (and experiential) knowledge,
 - episodic and factual knowledge,
 - socio-cultural and everyday knowledge
- It is implicit and tacit
- It is objective, subjective and emotional.

These attributes are quite diverse, but together they are a suitable fundament for further research.

3 FURTHER RESEARCH

The outlined characterisation of design knowledge can be used to develop suitable methods to facilitate the gaining of design knowledge at the beginning of the design process. Further requirements for such a method have been set. With the help of these requirements, appropriate methods for activating design knowledge at the start of the design process can be identified among the immense span of published techniques to gain knowledge.

A pre-selection of suitable methods has been tested in qualitative individual studies. These studies examined a number of student projects under field conditions.

One result of these preliminary studies is the focus on narrative methods and its ability to bring forth implicit knowledge [25, 26].

A set of methods for the development of narrative scenarios has been developed and tested in qualitative field studies. These narrative scenarios concern about the user and usage of the objects to be designed. First results are encouraging. However, final results can not be given at this moment. Currently we are evaluating our chosen research methods for measuring the impact of the narrative scenarios in industrial design projects. This is discussed in detail somewhere else [27].

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