SUMMARY

Every year thousands of new products are being put into a material world that is already cluttered with an enormous amount of existing products. Product designers thus face the challenge to create new products which will fit into the space as defined by these design precedents, in order to make them identifiable by consumers as possible solutions, yet at the same time will extent it into novel directions, in order make to their products stand out from the crowd. What role then do these existing product forms play in the generation and development of new product forms? How can this role be influenced by means of new design techniques? And how can these techniques be supported by means of a design support tool? These three questions have directed the research in this thesis. They were addressed using various methods and means, such as literature reviews, contextual interviews and experimental studies as well as user interface design and software prototyping.

To create new product forms the designer has to translate an abstract functional description of the product, which reflects no decisions regarding a possible form, into a structure that represents a materialized solution (Chapter 1). In this form-creation phase designers still very much rely on traditional tools and media, such as felt pens, paper, markers, foam, cutters etc. Although these lack processing capabilities, they score high in terms of flexibility, agility and expressiveness, thus not hampering the fluidness of the thought process of the designer. Computer tools, on the other hand, although potentially offering tremendous possibilities for generating and manipulating design representations, tend to slow down the designer in his creative process through their emphasis on rigid rules and often unnecessary precision.

This observation led to the belief that a better understanding of the form-creation phase, with it's characteristic techniques, tools and physical environment, was needed to identify the requirements computer tools should fulfill to successfully support the designer in this phase. Using the method of Contextual Inquiry, two series of interviews with designers at their work place were conducted (Chapter 2). In the first study it was decided to look first at the form-creation phase from a broad perspective, to acquire a better grasp of the common factors underlying it in any design domain. Therefore creative professionals from various disciplines other than industrial design were interviewed in their own design studios or offices. The statements, observations and remarks acquired in these interviews were interpreted and processed into several areas of interest, which, in turn, then structured and focused the second series of interviews, which involved only professional industrial designers and concentrated more specifically on the actual, visual creation of product concepts. Clustering and interpreting the data from these interviews resulted in a set of considerations regarding cognitive, perceptual-motor and methodological aspects for designing a computer environment to support conceptualizing.

In both series of interviews the role of existing designs in the generation of new concepts was identified as ubiquitous and important, yet not very well understood and supported. Being solutions to previous problems, these precedents provide designers with important frames of reference in the generation and development of new product forms. Reflecting certain elements of convention, which have been developed in a society in the relation between function, form and use of a product, these precedents embody design knowledge which can be applied by the designer in new design situations. However, because of the unique and specific character of these situations in an ill-structured problem domain such as design, the designer can not simply 'copy' such knowledge from existing designs and 'paste' it into the design task at hand. Thus successful transfer of design knowledge from precedents would require some form of active adaptation by the designer. How, then, does this adaptation process proceed, how can it be influenced and in what way should a design support tool be organized to augment it?

As a first step in answering these questions, a framework to describe the role of existing products in the generation and development of new form concepts was constructed through a theoretical exposé on the formation of new ideas (Chapter 3). It was argued that these come about through a 'displacement of concepts', a process in which old concepts do not literally get transferred to new situations, but are to be restructured in response to the characteristics of the new situation. By projecting the old concept onto the new situation, the old would become a program for the exploration of the new, through which aspects and qualities of new concepts can be envisioned and evaluated. Classification plays a key role in this process, in that possible candidates for displacement would manifest themselves as basic-level concepts that can be distinguished in the existing structure of the new situation. Projection of these basic-level concepts to either a more general or more specific level of knowledge organization would then induce the formation of new concepts.

This general framework was then made more specific for the form-creation phase of the product design process. A special form of classification, 'Typification', was presented as a means to identify and structure the design knowledge which products embody. By grouping together products on their shared typicality regarding function, form or meaning, product types are formed, in which the product-specific knowledge of the individual instances is organized on a problem-independent level. This specific character then affords the projection of these types to new design situations. Three product typologies were developed each representing a body of design knowledge on a different level of organization. Throughout the form-creation phase the designer then alternates between these levels, to identify relations between forms, materials and functions of products, or between forms, materials and socially and culturally determined uses of products.

This theoretical framework was then brought into the realm of an actual design situation (Chapter 4). In a design experiment the effects of providing designers with precedent designs as reference material, while working on a design task, were studied. Two ways of organizing the provided precedents, random vs. typological, were compared. The subjects, all senior students of Industrial Design Engineering in Delft, were given the task to design a 'mobile

telephone for a female executive'. During this task the subjects could draw reference to a collection of product examples. For half of the subjects these examples were organized into five product types, while the other half was given the same examples as an unorganized collection.

It was hypothesized that providing subjects with product examples which were organized in product types would results in design concepts, that in their appearance reflected, to a greater extent, the features of the provided types. This turned out to be true for those types that were in line with the given design brief. In these cases the products that make up for the type were used as confirming examples, forming a positive frame of reference. When a product type was not in line with the brief, it seemed to function in just the opposite way, with the products in them acting as contrasting examples, resulting in design concepts in which the features of the type were much less present. It was also expected that through their problem-independent nature the product types would reduce the effect of fixation, being a designer's adherence to his preconceived ideas regarding the product form as represented by his pre-concept. The subjects who received the product types showed much more development in their design process, in a direction that was expected considering the design brief, than the subjects who were provided with the unorganized product examples.

In all, the results of the experiment showed that providing designers with typologically organized design knowledge in the form of product types has a beneficial effect on the results of their design process. Extending these results to the development of computer support tools led to the concept of a visual database of design precedents that are organized into types according to the three product typologies. Such a database would provide the designer with a valuable body of design knowledge to consult during the design process. However, rather than developing a database that is presented to designers as a complete collection of pre-organized product types, it was argued that a database that is essentially organized, maintained and extended by designers themselves, would have an important additional value. Further, it would force designers to attentively observe and compare products on different levels of detail and abstraction, thus enhancing their sensitivity for design details and nuances.

To explore the feasibility of this approach a better understanding of how designers actually organize design precedents was acquired (Chapter 5). An organizing task, in which a collection of product examples had to be arranged, grouped and named, was designed and evaluated as a possible procedure for indexing products into a database. Two groups of senior students of Industrial Design Engineering from Delft performed the task with four different classes of products, with one group receiving additional information in the form of a design brief. This condition was added to determine if such a design brief would lead to more similar organizations, induced by the abstract features which were listed in the brief.

The results of the experiment showed organizing products to be a natural and meaningful activity for designers, even though it did concern arranging, grouping and naming products on levels different from the common basic level. The names given to the groups could be easily assigned to the three product typologies, which indicated that these typologies together sufficiently span the space used by designers for organizing and describing products. The extra freedom given in the arranging task, in which grouping was not explicitly required, did not lead to readily interpreted information above that obtained in the grouping task. A two-step indexing procedure, consisting of a grouping task and a naming task, therefore seemed to be a suitable approach for entering products into the database.

The specific characteristics of a product class, such as telephones or sunglasses, did not seem to influence the organizing behavior of the subjects. The way(s) in which they arranged, grouped and named the products appeared to be consistent across all four product classes. Contrary to what was expected the design brief did not result into more similar organizations. This was attributed to the fact that the features listed in the brief were probably given less importance by the subjects in their assessments than the features of the products themselves, which were much more prominently and visually present during the experiment.

The next step then involved designing the user interface of the proposed database (Chapter 6). Several design support systems that make use of precedent designs were first reviewed. From this, a list of design criteria was

compiled, which was supplemented with the design considerations that resulted from the previously conducted contextual inquiry. Using these criteria as guidelines in the design process, attention was first concentrated on how to retrieve and present the design knowledge, which is organized in the database, in a way meaningful to and applicable for designers.

A review of current information visualization systems showed them to be rigid in their presentation, to be lacking overview and to be limited in depicting the actual meaning of the information. To overcome these shortcomings a new interaction technique, called MDS-Interactive, was developed. Using this technique the user browses a large database of objects by interacting with a small set of samples, which are shown in a layout which expresses the similarities between these samples. This layout is dynamically created using a Multi-Dimensional Scaling (MDS) algorithm, which arranges the samples in such a way that the distances between pairs of samples express their (dis)similarities according to a similarity criterion. The main interactions are removing samples that have little meaning for the user, adjusting the weight of the similarity criterion, and calling up new samples from the database. While performing these actions, the layout is continuously adjusted to best reflect the similarity relations in the sample set. Using the 'research through design' approach several prototypes, all rich in both design quality and user experience, were built to test this new query technique. Evaluations with potential users showed it to have a high potential as an interaction method for accessing large information collections.

The two-step indexing procedure, which was established through the organizing experiment, was then integrated with the MDS-Interactive technique into a new tool named ProductWorld. Again, a fully functional prototype was built. In ProductWorld the designer enters product samples into the database by positioning them into a two-dimensional area in such a way that their relative positions express their perceived similarities regarding a specific criterion. Thus product types are being established consisting of samples that share certain features. Subsequently, the designer can identify product types with a textual label that typifies the characteristics of the type without having to attach keywords to each sample individually.

Retrieving samples from ProductWorld proceeds through a dialogue similar to that of MDS-Interactive. A query starts with retrieving three random samples from the collection to create an initial selection, from which a designer can start his exploration. Samples can be added to or removed from the selection, the scale with which the samples are positioned relative to each other can be increased or decreased, a selection can be temporarily stored, and the names attached to the samples can be shown or hidden.

To determine the value of ProductWorld as a design support tool it was evaluated within the setting of a design course. In this course a group of Industrial Design Engineering students, who were working on the design of a portable MP3 player, used the ProductWorld prototype to index and explore a collection of existing MP3 players. Their experiences clearly indicated the potential value of the tool. Organizing products through its interface, which was done with enthusiasm and dedication, was considered to be insightful and valuable to their own design process, while the exploration of these organizations was perceived as engaging and stimulating. Although the results of querying the organized collection were found to be difficult to interpret, they did provide the students with a better understanding of the relationships between the products, as well as between the used similarity criteria. The specific design character of the program, with its emphasis on interactivity, aesthetics and usability, was highly appreciated, contributing to its acceptance as a design tool.

Possible applications and implications of the research in this thesis are discussed for four areas of interest: design education, design practice, design methodology and design support systems (Chapter 7). It is suggested that the typological approach and its implementation in a tool like ProductWorld might help students to overcome their reluctance towards studying existing products and integrating elements from them into their own designs. It is further advocated that research in design has to concentrate more of its attention to the development of the physical product, and that the ideas brought forward in this thesis could provide directions for this. Finally, building high quality prototypes that are based on a thorough understanding of the context of design is promoted as a valuable design-driven research approach.