Appendix D

Reviews

This appendix reviews the books that form an important foundation to the work in this thesis.

Creative Cognition: Theory, Research, and Applications

Ronald A. Finke, Thomas B. Ward, and Steven M. Smith.
Published by Bradford, The MIT Press, paper 1996 (hard 1992).

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9. General Implications and Applications

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> *Creative Cognition combines original experiments with existing work in cognitive psychology to provide the first explicit account of the cognitive processes and structures that contribute to creative thinking and discovery. In separate chapters, the authors discuss visualization, concept formation, categorization, memory retrieval, and problem solving. They describe novel experimental methods for studying creative cognitive processes under controlled laboratory conditions, along with techniques that can be used to generate many different types of inventions.*

The review by John Richardson in the Times Higher Education Supplement praises the book for tackling a particularly difficult area of psychology:

> Original and well articulated ... [A] benchmark for psychologists who are concerned to understand and explain one of the less tractable areas of human cognition. It can also be recommended as a rich source of practical ideas to anyone responsible for education and training in professions that depend on the regular exercise of creative thinking (cited in [FWS92]).

It is this practical aspect of Creative Cognition that made it a suitable basis for investigating the link between creativity and SD in this thesis. The book was used as a rich source of practical ideas by the author of this thesis whose aim was to investigate how the development of software might be construed as one of the professions "that depends on the regular exercise of creative thinking".

The review by Stuart Sutherland of the Laboratory of Experimental Psychology, University of Sussex in NATURE begins with a general criticism of the research into creativity:

> Creativity, whether in science, literature, music, painting or everyday life remains a mystery, despite the fact that psychologists are increasingly turning their attention to the topic. Creative Cognition is not

> unrepresentative of their efforts. Too often they put old ideas together in imprecise ways, call the result a new theory (or model) and give it a high-sounding name - in the present case "Geneplore", which competes with previous expressions as "Concept Specialization Model" and "Structure Mapping Theory". The outcome is usually too commonplace to be new and too vague to be a theory [Sut93].

Sutherland clearly views Creative Cognition as neither particularly better nor particularly worse than other research into creativity, in his view, research into creativity typically results in findings that are common sense and imprecise.

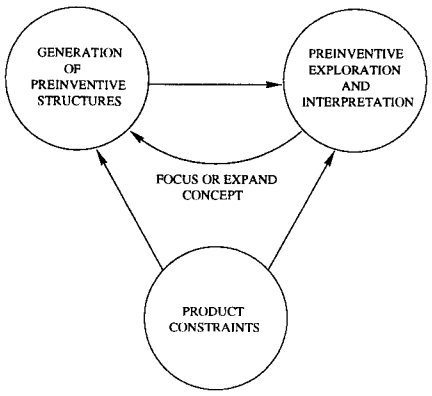

Figure D.1: Geneplore Model.

Figure D.1 shows the basic structure of the Geneplore model criticized by Sutherland. In the generative phase, one constructs mental representations called preinventive structures. These structures have various emergent properties that are exploited for creative purposes in the explanatory phase. The resulting creative cognitions can be focused or expanded according to task requirements or individual needs by modifying the preinventive structures and repeating the cycle. Constraints on the final product can be imposed at any time during the generative or exploratory phase [FWS92].

Sutherland criticizes particular aspects of the Geneplore generative phase rather than the general principle of such a phase. In particular, he does not single out the six creative properties for criticism identified in the book as being important for creative discovery or the six generative processes described in the book. It is these properties and processes that are made extensive use of in this thesis. What

Sutherland does criticize is the idea that restricted choice during the generative phase leads to increased creativity, arguing that surely this just leads to increasingly "bizarre interpretations of the restricted structures." This particular idea of restricting choice is not pursued in connection with SD in this thesis.

As with the generative phase, Sutherland seems to have no problem with the exploratory phase and exploratory processes in principle. However, he does comment that it is not entirely clear from the book whether the exploratory phase takes place at a conscious or unconscious level. This is rather unjust since the authors state that exploration would typically occur in a "deliberate and controlled manner" and "in an organized and systematic way" which clearly suggests a conscious process. Certainly the exploratory actions described in this thesis, corresponding to the generative processes of creative cognition, are meant to be applied at a conscious level.

Sutherland returns to his theme of vagueness: "Nothing in this book is sufficiently precise to suggest a working program. The best parts of it are those concerned with well-worn findings." Perhaps this is true, but creativity is a very difficult subject in which to be precise as recognized by Richardson. The authors clearly state their intention is to reach a balance between the "demystification of creativity" on the one hand whilst not wanting to "define creativity out of existence, or minimize it conceptually, because there really is something special about the creative mind - something that will always be surprising and innovative." This subtle approach suited investigating the essence of EM in this thesis.

Sutherland concludes his review by saying that "one cannot help feeling that there is more to creativity than meets the authors' eyes." This is no doubt true because of the apparently unfathomable complexity of creativity. What the authors do manage to establish, about the structures and processes of creativity, has been used in this thesis to investigate the link between creativity and SD.

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Total Design: Integrated Methods for Successful Product Engineering

Stuart Pugh.

Published by Addison-Wesley, 1991.

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> *Design is vital to a manufacturing company's goal of creating successful products. This book provides a framework for design whose overriding purpose is to create innovative products that satisfy the needs of the customer. Based around a core of design activities [shown in Figure D.2]*

design is presented as a systematic and disciplined process. Features [of the book] include:

- *a concise introduction to the total design process;*
- *a clear and simple model of design, independent of technology and discipline, allowing a structured approach to tackling design problems;*
- *numerous examples taken from a variety of fields;*
- *a chapter featuring a wide selection of design exercises.*

The book is aimed at all students in Engineering, Industrial Design, Architecture and the professional engineer and designer, for whom it is suggested will provide a useful framework to assist their design practice.

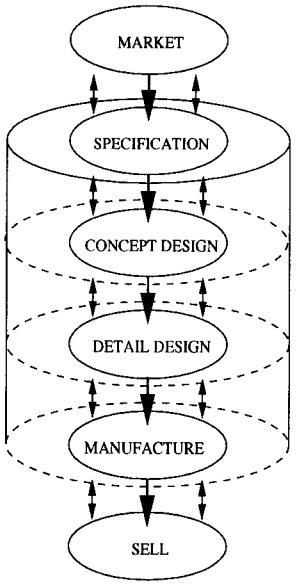

Figure D.2: Activity model for total design.

So far as I am aware, this book is unlike any other book on engineering design in that it attempts to represent the creative and analytical aspects of design and how they interrelate. Pugh states his intentions early on in the book:

> This is not a book about machine element design. Neither is it a book about finite element analysis. There are already many good books in these areas. What it sets out to be is a book that defines and takes the

> very complex jig-saw of the design process (like pieces of any artefact) and assembles it in a coherent and recognizable way, to give a uniform view of the picture on the box - jig-saws being more difficult to do without the guiding picture. Having said this, detailed analytical and technical topics are essential to the successful design of any product, and these will be considered and fitted in as the picture unfolds ([Pug91] p.vii).

This balanced view of design was used in this thesis as a model for investigating the roles of creativity and analysis in EM and how creativity might be introduced into SD.

When he wrote the book Stuart Pugh was head of the Design Division at the University of Strathclyde where he taught design to all undergraduate engineers. His career in industry included service as Chief Engineer and then Divisional Manager with the English Electric Company, as well as numerous design positions with the British Aircraft Corporation and the Marconi Company. He consulted with numerous companies in the United States, including DIGITAL and General Motors, on some of their most successful products.

Creating Innovative Products Using Total Design: The Living Legacy of Stuart Pugh

Stuart Pugh, edited by Don Clausing and Ron Andrade.
Published by Addison-Wesley, 1996.

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1. Design in Education and Industry
2. Design Process and Philosophy
3. Design Techniques and Methods
4. CAD and Knowledge-Based Engineering
5. Design Teams, Management, and Creative Work

6. Design for X

7. Design Research

8. Total Design: Summary of the whole

This book is unusual in that it was compiled by the editors from Pugh's collected works after his untimely death in October 1993. The book is essentially an organized collection of papers written by Pugh and accounts of conference presentations given by Pugh before and after the publication of his book entitled "Total Design: Integrated Methods for Successful Product Engineering" in 1990. The book provides an insight into the ideas of Pugh from the perspectives of Clausing and Andrade and how the ideas of Pugh have been adopted by the design community in general.

Clausing writes about Pugh as being neither wholly an academic nor an industrialist in the preface to his book:

> Stuart Pugh was one of the great leaders of product development (total design) methodology and practice ... Very few people have duplicated Stuart's experience of spending almost half of his career in successful industrial practice and then the remainder of his career in a university. Through this dual career Stuart developed a comprehension of and insights into total design that went far beyond those supported by the more traditional monolithic career, whether in industry or academia. These profound insights culminated in Stuart's book "Total Design" published in 1990 (Clausing [Pug96] p.xix).

Pugh's concern was that the academic teaching of design was aloof from industrial practice, while industrial practice suffered from the lack of reflective structuring that can be achieved in the university: "The symbiosis between design education in universities and design practice in industry is the foundation of Stuart Pugh's path to design success ... total design is the great integrator of the engineering curriculum ... total design is the integrator between the academy and industry" (Clausing [Pug96] p.1). A concern that is being increasingly echoed within the software industry [Lew95].

Pugh saw one of the reasons for the gap between academia and industry being the tendency of researchers to disintegrate and simplify the inherently integrated and complex design process. Pugh points out that in considering research we must make the following three distinctions:

- total design and partial design;
- static products and dynamic products;
- technology-specific methods and generic methods.

Much research into design processes and methods is primarily applicable to the partial design of static products in some specific technology set. Such methods can be useful in their particular domain. However, they are best viewed as subsets of total design, providing the right details in the context of the more important decisions that have been made by applying the generic methods that Pugh emphasized.

The formulation of the design activity model was born out of the need to give an definition of design that captured its complexity. This definition of design has been adopted by SEED (Sharing Experience in Engineering Design - a multi-disciplinary organization comprising lecturers in engineering design throughout the UK) "quite simply because design practitioners relate to it" (Pugh [Pug96] p.xxxii):

> A perennial problem that arises at design conferences and discussions is understanding just what is meant by design and design engineering ... I described design as a highly manipulative activity in which the designer has to continuously and simultaneously pay attention to and balance several factors that impinge and influence design ... a step further was the proposition of the design activity model [shown in Figure D.2] ... We made significant progress, and this was recognised by Sharing Experiences in Engineering Design (SEED), an organisation based in the U.K. academia at varying levels. This model now forms the basis of design teaching in more than eighty U.K. institutions (Pugh [Pug96] p.xxviii).

Part of the success of the model is that it provides a guide to rather than prescribes how design should be done: "I regard the model's structure as being analogous to

a child's climbing frame: it provides the framework on which to climb, it imparts confidence and safety, yet it doesn't prescribe or predetermine the methods by which the child gets to the top of the frame or indeed around inside it" (Pugh [Pug96] p.50). This is consonant with the view of EM as a framework for systems modelling in this thesis.

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