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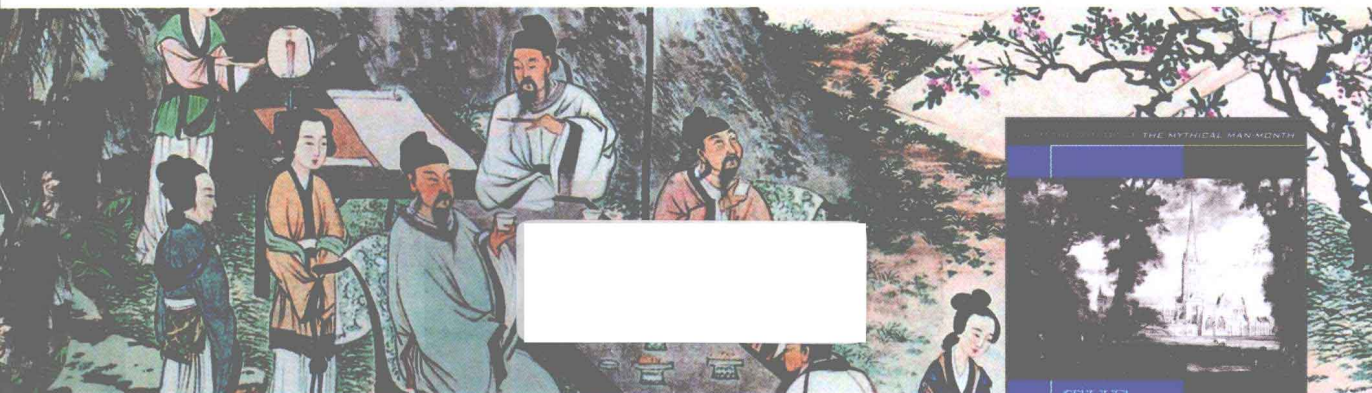
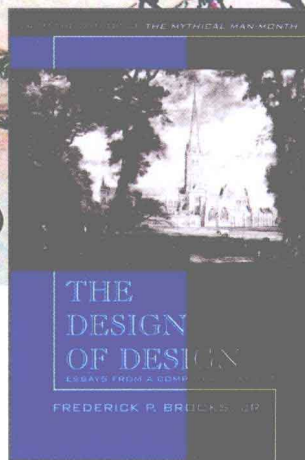## 计算机科学巨匠
Frederick P. Brooks 的思考 (评注版)

[美] *Frederick P. Brooks, Jr.* 著

郭耀 评注

The Design of Design:
Essays from a Computer Scientist

THE DESIGN OF DESIGN
ESSAYS FROM A COMPUTER SCIENTIST
FREDERICK P. BROOKS, JR.

设计原本：

计算机科学巨匠Frederick P. Brooks的思考（评注版）

The Design of Design: Essays from a Computer Scientist

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内 容 简 介

本书从原理的角度阐述了面向对象程序设计的 6 大原则；讲解和剖析了 23 种常见的设计模式，并进行了扩展，通俗易懂、趣味性极强而又紧扣设计模式的核心；对各种相关联的设计模式进行了深入分析和比较，旨在阐明各种设计模式比较理想的应用场景和它们之间的区别；探讨了设计模式的混编，讲解了如何在实际开发中将各种设计模式混合起来使用，以发挥设计模式的最大效用。全书结合设计实例，从面向对象设计案例中精心选择了一些设计模式，总结了面向对象设计中最有价值的经验，并将其用简洁、可复用的形式表达出来。

本书适合大学计算机专业的学生、研究生及相关人员参考。

本书是 *The Design of Design* 一书的评注版，力邀国内资深专家执笔，在英文原著的基础上增加了中文点评和注释，旨在融合二者之长，既保留经典的原创文字与味道，又以先行者的学研心得与实践感悟，对读者的阅读和学习加以点拨，指明捷径。

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悦读上品 得乎益友

孔子云："取乎其上,得乎其中；取乎其中,得乎其下；取乎其下,则无所得矣"。

对于读书求知而言,这句古训教我们去读好书,最好是好书中的上品——经典书。其中,科技人员要读的技术书,因为直接关乎客观是非与生产效率,阅读选材本更应慎重。然而,随着技术图书品种的日益丰富,发现经典书越来越难,尤其对于涉世尚浅的新读者,更为不易,而他们又往往是最需要阅读、提升的重要群体。

所谓经典书,或说上品,是指选材精良、内容精练、讲述生动、外延丰盈、表现手法体贴入微的读品,它们会成为读者的知识和经验库中的重要组成部分,并且拥有从不断重读中汲取养分的空间。因此,选择阅读上品的问题便成了有效阅读的首要问题。当然,这不只是效率问题,上品促成的既是对某一种技术、思想的真正理解和掌握,同时又是一种感悟或享受,是一种愉悦。

与技术本身类似,经典 IT 技术书多来自国外。深厚的积累、良好的写作氛围,使一批大师为全球技术学习者留下了璀璨的智慧瑰宝。就在那个年代即将远去之时,无须回眸,也能感受到这一部部厚重而深邃的经典著作,在造福无数读者后从未蒙尘的熠熠光辉。而这些凝结众多当今国内技术中坚美妙记忆与绝佳体验的技术图书,虽然尚在国外图书市场上大放异彩,却已逐渐淡出国人的视线。最为遗憾的是,迟迟未有可以填补空缺的新书问世。而无可替代,不正是经典书被奉为圭臬的原因?

为了不让国内读者,尤其是即将步入技术生涯的新一代读者,就此错失这些滋养过先行者们的好书,以出版 IT 精品图书,满足技术人群需求为己任的我们,愿意承担这一使命。本次机遇惠顾了我们,让我们有机会携手权威的 Pearson 公司,精心推出"传世经典书丛"。

在我们眼中,"传世经典"的价值首先在于——既适合喜爱科技图书的读者,也符合专家们挑剔的标准。幸运的是,我们的确找到了这些堪称上品的佳作。丛书带给我们的幸运颇多,细数一下吧。

得以引荐大师著作

有恐思虑不周,我们大量参考了国外权威机构和网站的评选结果,并得到了 Pearson 的专业支持,又进

一步对符合标准之图书的国内外口碑与销售情况进行细致分析，也听取了国内技术专家的宝贵建议，才有幸选出对国内读者最富有技术养分的大师上品。

向深邃的技术内涵致敬

中外技术环境存在差异，很多享誉国外的好书未必适用于国内读者；且技术与应用瞬息万变，很容易让人心生迷惘或疲于奔命。本丛书的图书遴选，注重打好思考方法与技术理念的根基，旨在帮助读者修炼内功，提升境界，将技术真正融入个人知识体系，从而可以一通百通，从容面对随时涌现的技术变化。

翻译与评注的双项选择

引进优秀外版著作，将其翻译为中文供国内读者阅读，较为有效与常见。但另有一些外语水平较高、喜好阅读原版的读者，苦于对技术理解不足，不能充分体会原文表述的精妙，需要有人指导与点拨。而一批本土技术精英经过长期经典熏陶及实践锤炼，已足以胜任这一工作。有鉴于此，本丛书在翻译版的同时推出融合英文原著与中文点评、注释的评注版，供不同志趣的读者自由选择。

承蒙国内一流译（注）者的扶持

优秀的英文原著最终转化为真正的上品，尚需跨越翻译鸿沟，外版图书的翻译质量一直屡遭国内读者诟病。评注版的增值与含金量，同样依赖于评注者的高卓才具。好在，本丛书得到了久经考验的权威译（注）者的认可和支持，首肯我们选用其佳作，或亲自参与评注工作。正是他们的参与保证了经典的品质，既再次为我们的选材把关，更提供了一流的中文表述。

期望带给读者良好的阅读体验

一本好书带给人的愉悦不止于知识收获，良好的阅读感受同样不可缺少，且对学业不无助益。为让读者收获与上品相称的体验，我们在图书装帧设计与选材用料上同样不敢轻率，惟愿送到读者手中的除了珠玑章句，还有舒适与熨帖的视觉感受。

所有参与丛书出版的人员，尽管能力有限，却无不心怀严谨之心与完美愿望。如果读者朋友能从潜心阅读这些上品中偶有获益，不啻为对我们工作的最佳褒奖。若有阅读感悟，敬请拨冗告知，以鼓励我们继续在这一道路上贡献绵薄之力。如有不周之处，也请不吝指教。

电子工业出版社博文视点

评注者序

一谈到软件工程领域的经典著作，几乎所有 IT 界人士都会想到 1975 年出版的 Fred Brooks 的《人月神话》（*The Mythical Man-Month: Essays on Software Engineering*）。然而，计算机科学巨匠 Brooks 对业界更为重要的贡献是在 IBM 公司任职时作为主管研发了 IBM System/360 系列计算机和 OS/360 操作系统。在 1999 年美国计算机协会（Association for Computing Machinery，简称 ACM）把图灵奖颁发给 Brooks 的时候，对他的评价是"在计算机体系结构、操作系统和软件工程领域均做出了里程碑式的贡献"。

作为一位精通软/硬件的计算机大师，Brooks 显然不满足于人们把《人月神话》作为他的标志性著作。因此，在《人月神话》出版 35 年之后，Brooks 又写成了《设计原本》（*The Design of Design: Essays from a Computer Scientist*）。顾名思义，这本书涉及的范围从软件工程扩展到了计算机科学以及计算机科学之外的其他学科，浓缩了 Brooks 这位年近 80 岁的计算机科学巨匠对计算机软/硬件设计、（广义的）产品设计乃至人生的思考。

与 *The Mythical Man-Month* 一样，*The Design of Design* 也以随笔（Essay）的形式写成，行文优美，语句易懂，虽然没有太多"语不惊人死不休"的名言警句，但是也字字珠玑，值得反复琢磨。

本书内容主要包括以下 6 个部分。

- 设计模型（Models of Designing）：讲解设计的基本概念和经典的理性设计模型，以及理性模型中存在的问题。
- 协作和视频协作（Collaboration and Telecollaboration）：讲解设计协作的概念，以及远程协作和视频协作等新兴技术为设计带来的好处。

- 设计的观点（Design Perspectives）：本书最为重要的一部分，讲解作者关于设计的主要观点，包括对设计中存在的问题的分析以及各种解决思路。
- 用于住宅设计的梦想系统（A Computer Scientist's Dream System for Designing Houses）：作者以设计自家住宅的经验为例，介绍计算机软件系统在设计中的作用。
- 伟大的设计师（Great Designers）：伟大的设计离不开伟大的设计师，那么伟大的设计师又来自哪里？
- 案例研究（Trips through Design Spaces: Case Studies）：通过多个领域的设计案例，讲解如何在不同的设计中体现设计思想和设计技巧。这里的领域包括房屋设计、计算机软/硬件设计、图书（教材）设计，甚至一个计算中心组织架构的设计。

接受为 *The Design of Design* 做评注的任务，其实是非常冒险的。基于广大读者，特别是中国读者对 *The Mythical Man-Month* 的崇拜，*The Design of Design* 显然也会成为关注的焦点。笔者曾经参与 *The Mythical Man-Month* 的评注工作，因此深感为大师巨作添加评注的困难。

在做评注的过程中，笔者的目标是释义和释疑。首先，对书中涉及的非常用专业术语和背景知识加以解释。其次，试图对读者在阅读过程中可能遇到的疑问进行解答。此外，注重提炼文中的主要观点，为对英语无法做到像母语一样一目十行的读者提供快速浏览和定位的提示。最后，也试图对一些有争议的问题给出国内外的相关观点和自己的评价。

面对 *The Design of Design* 这样一部经典著作，笔者的所有评注均力求站在为读者服务的立场，尽量少带主观看法，从而帮助读者更好地理解原著、更多地了解背景知识。在为本书做评注的过程中，笔者查阅了大量的资料，以免去读者的部分案头工作。当然，如果读者能够熟练阅读原文，并且拥有足够的计算机软/硬件背景知识，则完全可以略去评注，细细品味原文。评注中如有任何不妥之处，敬请读者批评指正。

最后，非常感谢电子工业出版社的张春雨先生及其他同事的帮助和耐心，使本书得以呈现在读者的面前。

郭　耀
2012 年 5 月于北京大学

Photo credit: © Jerry Markatos

▶ Frederick Brooks是著名的
计算机科学家，1999年图灵奖
的获得者。他曾经负责IBM著
名的System/360系统以及该
系统之上的操作系统OS/360
的设计。本书介绍的很多经
验都来自他在IBM的工作经
历。更为中国读者所熟悉的是
他所著的《人月神话》（*The
Mythical Man-Month*）一书。
该书出版30余年来一直畅销
不衰，被翻译为多种文字，是
软件工程领域当之无愧的经
典巨著。

ABOUT THE AUTHOR

Frederick P. Brooks, Jr., is Kenan Professor of Computer Science
at the University of North Carolina at Chapel Hill. He is best
known as the "father of the IBM System/360," having served as
project manager for its development and later as manager of the
Operating System/360 software project during its design phase.
For this work, he, Bob Evans, and Erich Bloch were awarded the
National Medal of Technology in 1985. Earlier, he was an archi-
tect of the IBM Stretch and Harvest computers.

At Chapel Hill, Dr. Brooks founded the Department of Computer
Science and chaired it from 1964 through 1984. He has served
on the National Science Board and the Defense Science Board.
His current teaching and research is in computer architecture,
interactive computer graphics, and virtual environments.

*To all who have shared in my
design adventures:*

Family,

Colleagues,

Friends, and

Construction professionals

Preface

I write to prod designers and design project managers into thinking hard about the *process* of designing things, especially complex systems. The viewpoint is that of an engineer, focused on utility and effectiveness but also on efficiency and elegance.[1]

Who Should Read This Book?

In *The Mythical Man-Month* I aimed at "professional programmers, professional managers, and especially professional managers of programmers." I argued the necessity, difficulty, and methods of achieving conceptual integrity when software is built by teams.

This book widens the scope considerably and adds lessons from 35 more years. Design experiences convince me that there are constants across design processes in a diverse range of design domains. Hence the target readers are:

1. Designers of many kinds. Systematic design excluding intuition yields pedestrian follow-ons and knock-offs; intuitive design without system yields flawed fancies. How to weld intuition and systematic approach? How to grow as a designer? How to function in a design team?

Whereas I aim for relevance to many domains, I expect an audience weighted toward computer software and hardware designers—to whom I am best positioned to speak concretely. Thus some of my examples in these areas will involve technical detail. Others should feel comfortable skipping them.

2. Design project managers. To avoid disaster, the project manager must blend both theory and lessons from hands-on experience as he designs his design process, rather than just replicating

▶ Brooks博士的上一本全球畅销的著作《人月神话》(*The Mythical Man-Month*) 主要关注与软件工程有关的领域，目标读者是专业程序员、专业管理人员，特别是专业的程序员管理人员。而本书涉及的范围不仅包括软件开发的方法，还包括一般意义上的设计。因此，本书目标读者的范围也就更加宽泛，包括：

● 各种项目的设计人员；

● 设计项目的管理人员；

● 与设计相关的研究人员。

some oversimplified academic model, or jury-rigging a process without reference to either theory or the experience of others.

▶设计研究（Design Research）是一个专门的学科，指把研究运用到设计过程中，也指在设计过程中进行研究。总的来讲，都是为了更好地理解和改进设计过程。设计研究的研究对象涉及所有设计领域的设计过程，因此它与一般的设计方法和特定学科的设计方法密切相关。

3. Design researchers. The study of design processes has matured; good, but not all good. Published studies increasingly address narrower and narrower topics, and the large issues are less often discussed. The desire for rigor and for "a science of design" perhaps discourages publication of anything other than scientific studies. I challenge design thinkers and researchers to address again the larger questions, even when social science methodology is of little help. I trust they will also challenge the generality of my observations and the validity of my opinions. I hope to serve their discipline by bringing some of their results to practitioners.

Why Another Book on Design?

Making things is a joy—immensely satisfying. J. R. R. Tolkien suggests that God gave us the gift of subcreation, as a gift, just for our joy.[2] After all, "The cattle on a thousand hills are mine. ... If I were hungry, I would not tell *you*."[3] Designing per se is fun.

▶设计是充满情趣的、快乐的工作，也是上帝给予我们的创造灵感——这句话来自约翰·罗纳德·瑞尔·托尔金（John Ronald Reuel Tolkien），他是《指环王》（*The Lord of the Rings*，也译作"魔戒"）系列小说的作者。

The design process is not well understood either psychologically or practically. This is not for lack of study. Many designers have reflected on their own processes. One motivation for study is the wide gaps, in every design discipline, between best practice and average practice, and between average practice and semi-competent practice. Much of design cost, often as much as a third, is rework, the correction of mistakes. Mediocre design provably wastes the world's resources, corrupts the environment, affects international competitiveness. Design is important; teaching design is important.

So, it was reasoned, systematizing the design process would raise the level of average practice, and it has. German mechanical engineering designers were apparently the first to undertake this program.[4]

The study of the design process was immensely stimulated by the coming of computers and then of artificial intelligence. The initial hope, long delayed in realization and I think impossible,

was that AI techniques could not only take over much of the drudgery of routine design but even produce brilliant designs lying outside the domains usually explored by humans.[5] A discipline of design studies arose, with dedicated conferences, journals, and many studies.

With so much careful study and systematic treatment already done, why another book?

First, the design process has evolved very rapidly since World War II, and the set of changes has rarely been discussed. Team design is increasingly the norm for complex artifacts. Teams are often geographically dispersed. Designers are increasingly divorced from both use and implementation—typically they no longer can build with their own hands the things they design. All kinds of designs are now captured in computer models instead of drawings. Formal design processes are increasingly taught, and they are often mandated by employers.

Second, much mystery remains. The gaps in our understanding become evident when we try to teach students how to design well. Nigel Cross, a pioneer in design research, traces four stages in the evolution of design process studies:

1. *Prescription* of an ideal design process
2. *Description* of the intrinsic nature of design problems
3. *Observation* of the reality of design activity
4. *Reflection* on the fundamental concepts of design[6]

I have designed in five media across six decades: computer architecture, software, houses, books, and organizations. In each I have had some roles as principal designer and some roles as collaborator in a team.[7] I have long been interested in the design process; my 1956 dissertation was "The analytic design of automatic data processing systems."[8] Perhaps now is the time for mature reflection.

What Kind of Book?

I am struck by how alike these processes have been! The mental processes, the human interactions, the iterations, the constraints,

▶作者写作本书的一个重要原因是，第二次世界大战以来，尽管设计过程发生了非常迅速的演化，却很少有著作认真讨论它们。

现在，相对复杂的事物或产品通常都需要由团队来设计，而团队在地理位置上通常是分散的，这也给设计带来了新的挑战。有兴趣的读者可以参考《世界是平的》（*The World is Flat*）一书中对类似观点的深入阐述。

▶设计过程演进的4个阶段是：
●对理想设计过程的规划；
●对设计问题内在本质的描述；
●对设计活动现实情况的观察；
●对设计的基本概念的反映。

▶作者过去60年的设计经历涵盖了5种媒介。在本书中，作者会根据在如下领域的经历来讲解他对设计的理解。
● 计算机体系结构：IBM System/360计算机的设计。
● 计算机软件：OS/360操作系统的设计（作者还是软件工程领域的专家）。
● 房屋：作者自己设计的家庭住宅。
● 图书：包括本书、《人月神话》，以及作者与他人合著的《计算机体系结构》。
● 组织机构：作者是美国北卡罗莱纳大学计算机科学系的创始人和首任系主任。

the labor—all have a great similarity. These essays reflect on what seems to be the underlying invariant process.

> Whereas computer architecture and software architecture each have short histories and modest reflections about their design processes, building architecture and mechanical design have long and honorable traditions. In these fields design theories and design theorists abound.

I am a professional designer in those fields that have had only modest reflection, and an amateur designer in some long and deep fields. So I shall attempt to extract some lessons from the older design theories and to apply them to computers and software.

I believe "a science of design" to be an impossible and indeed misleading goal. This liberating skepticism gives license to speak from intuition and experience—including the experience of other designers who have graciously shared their insights with me.[9]

> Thus I offer neither a text nor a monograph with a coherent argument, but a few opinionated essays. Even though I have tried to furnish helpful references and notes that explore intriguing side alleys, I recommend that one read each essay through, ignoring the notes and references, and then perhaps go back and explore the byways. So I have sequestered them at the end of each chapter.

Some case studies provide concrete examples to which the essays can refer. These are chosen not because of their importance, but because they sketch some of the experience base from which I conclude and opine. I have favored especially those about the functional design of houses—designers in any medium can relate to them.

I have done functional (detailed floor plan, lighting, electrical, and plumbing) design for three house projects as principal architect. Comparing and contrasting that process with the process of designing complex computer hardware and software has helped me postulate "essentials" of the design process, so I use these as some of my cases, describing those processes in some detail.

In retrospect, many of the case studies have a striking common attribute: *the boldest design decisions, whoever made them, have accounted for a high fraction of the goodness of the outcome.* These bold decisions were made due sometimes to vision, sometimes to

▶计算机体系结构和软件体系结构的历史相对较短，因此可以从传统的建筑体系结构和机械设计中抽取一些设计过程和设计理念，并用它们来指导相对较新的计算机软/硬件设计过程。

体系结构（Architecture，或译为"架构"）一词的本意就是"建筑"。建筑的发展历史显然比计算机硬件或软件的发展历史更为悠久。

▶作者认为，"设计的科学"是一个不可能达到而且错误的目标。因此，本书提供的并不是严谨的理论和证明，而是与《人月神话》一样，汇集了表达作者观点的短篇论文（或散文）。

desperation. They were always gambles, requiring extra invest-
ment in hopes of getting a much better result.

Acknowledgments

I have borrowed my title from a work of a generation ago by
Gordon Glegg, an ingenious 'mechanical designer, a charming
person, and a spellbinding Cambridge lecturer. It was my privi-
lege to lunch with him in 1975 and to catch some of his passion
for design. His title perfectly captures what I am attempting, so I
reuse it with gratitude and respect.[10]

I appreciate the encouragement of Ivan Sutherland, who
in 1997 suggested that I grow a lecture into a book and who
more than a decade later sharply critiqued the draft, to its great
improvement. My resulting intellectual journey has been very
rewarding.

This work has been possible only because of three research
leaves granted by UNC-Chapel Hill and my department chairmen,
Stephen Weiss and Jan Prins. I was most graciously welcomed by
Peter Robinson at Cambridge, Mel Slater at University College
London, their department chairmen, and their colleagues.

The NSF Computer and Information Science and Engineer-
ing Directorate's Science of Design program, initiated by Assis-
tant Director Peter A. Freeman, provided a most helpful grant
for the completion of this book and the preparation of the associ-
ated Web site. That funding has enabled me to interview many
designers and to concentrate my principal efforts for the past few
years on these essays.

I am deeply indebted to the many real designers who have
shared their insights with me. An acknowledgments table list-
ing interviewees and referees is an end piece. Several books
have been especially informative and influential; I list them in
Chapter 28, "Recommended Reading."

My wife, Nancy, co-designer of some of the work herein, has
been a constant source of support and encouragement, as have my
children, Kenneth P. Brooks, Roger E. Brooks, and Barbara B. La
Dine. Roger did an exceptional review of the manuscript, provid-
ing dozens of suggestions per chapter, from concepts to commas.

I've been blessed by strong administrative support at UNC from Timothy Quigg, Whitney Vaughan, Darlene Freedman, Audrey Rabelais, and David Lines. Peter Gordon, Publishing Partner at Addison-Wesley, has provided unusual encouragement. Julie Nahil, Full-Service Production Manager at Addison-Wesley, and Barbara Wood, Copy Editor, have provided exceptional professional skills and patience.

John H. Van Vleck, Nobel-laureate physicist, was Dean of Harvard's Division of Engineering and Applied Science when I was a graduate student there, in Aiken's lab. Van Vleck was very concerned that the practice of engineering be put on a firmer scientific basis. He led a vigorous shift of American engineering education away from design toward applied science. The pendulum swung too far; reaction set in; and the teaching of design has been contentious ever since. I am grateful that three of my Harvard teachers never lost sight of the importance of design and taught it: Philippe E. Le Corbeiller, Harry R. Mimno, and Howard H. Aiken, my adviser.

Thanks and praise to The Great Designer, who graciously grants us the means, the daily sustaining, and the joys of subcreation.

Chapel Hill, NC
November 2009

Endnotes

1. The caption for the book cover is based on Smethurst [1967], *The Pictorial History of Salisbury Cathedral*, who adds, "... Salisbury is thus the only English cathedral, except St. Paul's, of which the whole interior structure was built to the design of one man [or one two-person team] and completed without a break."

2. Tolkien [1964], "On Fairy Stories," in *Tree and Leaf*, 54.

3. Psalm 50:10,12. Emphasis added.

4. Pahl and Beitz [1984], in Section 1.2.2, trace this history, starting in 1928. Their own book, *Konstructionslehre*, through seven editions, is perhaps the most important systematization. I distinguish study of the *design process* from rules for design in any particular medium. These are millennia older.

5. The major monograph, tremendously influential, was Herbert Simon's *The Sciences of the Artificial* [1969, 1981, 1996].

6. Cross [1983], *Developments in Design Methodology*, x.

7. A table of the specific design experiences is included in the appendix materials on the Web site: http://www.cs.unc.edu/~brooks/DesignofDesign.

8. Brooks [1956], "The analytic design of automatic data processing systems," PhD dissertation, Harvard University.

9. I thus do not contribute to the design methodologists' goal as stated in http://en.wikipedia.org/wiki/Design_methods (accessed on January 5, 2010):

   > *The challenge is to transform individual experiences, frameworks and perspectives into a shared, understandable, and, most importantly, a transmittable area of knowledge. Victor Margolin states three reasons why this will prove difficult, [one of which is]:*
   >
   > > *'... Individual explorations of design discourse focus too much on individual narratives, leading to personal point-of-view rather than a critical mass of shared values.'*

   To this I must plead, "Guilty as charged."

10. Glegg [1969], *The Design of Design*.

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