Portfolio Skills
Product Design

PROTOTYPING AND MODELMAKING FOR PRODUCT DESIGN

Bjarki Hallgrimsson

PROTOTYPING AND MODELMAKING FOR PRODUCT DESIGN

A comprehensive modern prototyping approach is crucial to making informed design decisions, and forms a strategic part of a successful product designer's toolkit. *Prototyping and Modelmaking for Product Design* explains how prototypes are used to understand design problems, explore more imaginative solutions, investigate human interaction more fully and test functionality. Specific materials, tools and techniques are examined in detail, with step-by-step tutorials and case studies.

- Practical, step-by-step guide to tools and materials
- Tutorials and case studies illustrating how materials can be used
- Health and Safety guidelines

Bjarki Hallgrimsson is a practising product development consultant and an Associate Professor at the School of Industrial Design, Carleton University, Ottawa.

Related study material is available on the Laurence King website at **www.laurenceking.com**

'A great introduction to the modelmaking process for students and educators, and a timely reminder of the value prototyping still has for our craft.'

Paul Backett, Industrial Design Director, Ziba Design, Inc.

'This book provides designers of all abilities with a complete guide to the processes needed to achieve any industrial design. I have learned these techniques over three decades; now they are all available in this ultimate reference book.'

Yves Béhar, founder Fuseproject

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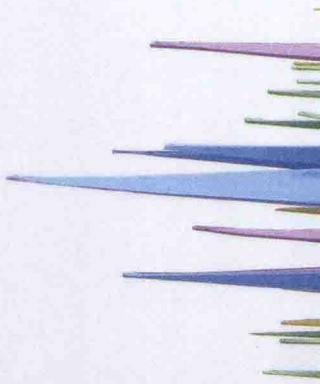

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CONTENTS

IMPORTANT NOTICE ON SAFETY

Chapter 5 of this book covers good health and safety practice, and a further series of safety checks have been included at the beginnings of Chapters 6 to 20 which cover tools, materials and processes. Chapter 8 features an overview of typical modelmaking tools and machines, but this chapter does not provide specific instruction on tool-operation, as it is beyond the scope of this book. The methods, processes, case studies and tutorials in this book are general in nature and should never be attempted without proper consultation, training and supervision from a professional shop technician. Although Laurence King Publishing and the author have taken steps to ensure the safety information provided is accurate and up-to-date at the time of writing, this information is not exhaustive, and they cannot assume responsibility for any improper use, changes, errors or omissions. The reader should be aware that he or she is responsible for his or her own safety and, potentially, that of any nearby individuals when undertaking the types of activities described herein and should govern himself or herself accordingly.

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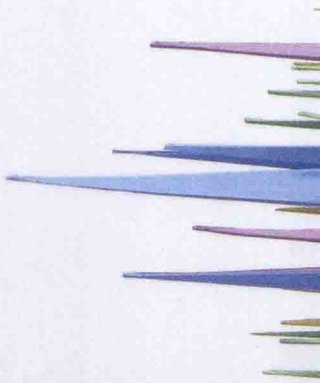

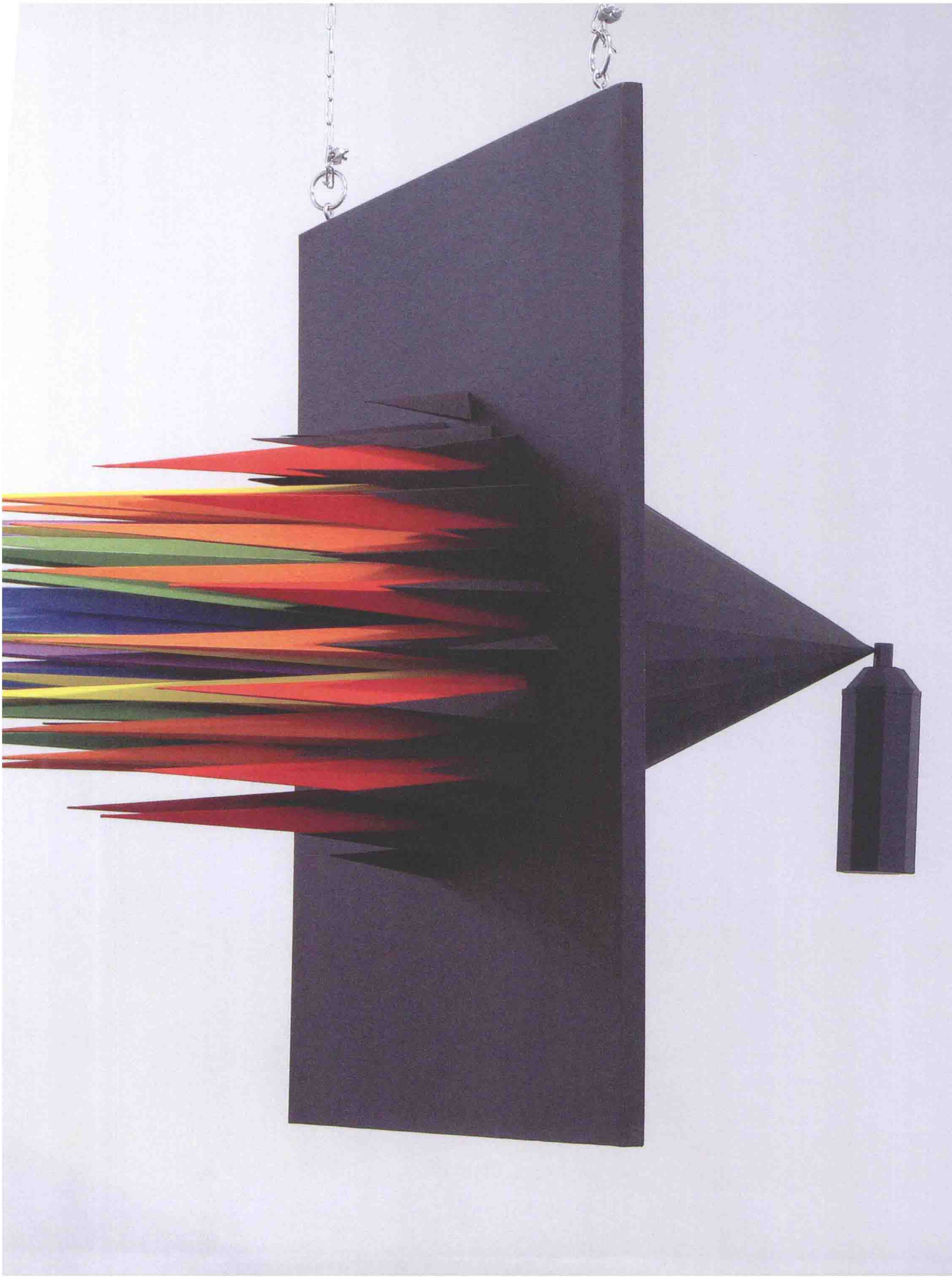

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INTRODUCTION
Why We Prototype

Behind every successful product design is a story of numerous refinements and much hard work. The fact is that the transformation of an idea into a real product takes a great deal of work, involving more than simply creating pictures on the computer. Product design is a complex activity, which involves working with other people and disciplines, coming up with creative and useful ideas (that hopefully are also sustainable) and slugging through all the iterations of making something work and look good at the same time. One method that has always been used by designers, and continues to be embraced, is that of physical prototyping. The primary message of this book is that building and testing in 3D is a continuing and critical component of a successful design process. Whereas 3D Computer Aided Design (CAD) has made it easier to visualize, analyze and implement product solutions, physical prototypes can still be played with and scrutinized in a way that is not possible on screen. As a result they precede and complement most of the computer rendering and animations that happen in real-life projects. Just as the computer helps integrate interdisciplinary activities on screen, physical prototypes draw people together in face-to-face discussions that lead to a different level of interaction between clients, designers and end users.

Definition of Prototyping and Modelmaking

The terms *physical prototype* and *model* can be used interchangeably to describe a preliminary three-dimensional representation of a product, service or system. In recent years the use of the word 'prototype' has become favoured as it is more encompassing. A wide range of physical prototypes is used throughout the design process to simulate different aspects of a product's appearance and function before it is produced. This book will show why physical prototypes are essential to the design process, and how they are used to solve a range of problems associated with new product development. Each new version of a prototype or model is known as an iteration.

The Fiskars Multi-Snip pruning tool went through many iterations and evolutions, as shown in this progression of prototypes.

Prototyping and *modelmaking*, although inherently related terms, actually refer to different activities. Prototyping is a design method that uses physical prototypes to study and test how a new product will be used, and how it will look and be manufactured. Modelmaking, on the other hand, is the step-by-step method of producing the prototype. For this reason, this book has been divided into two sections: Prototyping and Modelmaking. The first section, Prototyping, describes what physical prototypes are and how they are used in product design and development. The second section, Modelmaking, specifically addresses the many issues regarding materials and options for construction. By being mindful of the reasons why we prototype, we should be able to make better choices about how we make prototypes.

A student examines progress on a drill appearance prototype in the lab.

Prototyping Is a Form of Problem Solving

Prototyping is a key problem-solving activity in product design. It starts right from the beginning of a project and continues right into production. Given the complexity of product development, it is critical to take as much of the guesswork out of the design process as possible, and prevent surprises from showing up later in a project. It is much less expensive to solve problems early in a project than later, when tooling may have been started and sales commitments made. Prototypes evolve along with the design process; simple prototypes serve as initial three-dimensional sketches and are then replaced by iterations of successively more refined versions.

The more complicated the product, the more disciplines will be involved and the more prototypes typically needed. Physical prototypes enable teamwork and collaboration, since they serve to gather team members around for discussion and reflection. The prototypes oblige the team to deal with real issues, which are more easily ignored in memos and verbal discussions alone. Prototypes are also used to study and compare alternative approaches. This includes testing everything from technical requirements of construction to usability.

Modelmaking

The rich design tradition of developing sensitivity to materials, manufacturing and workmanship is based on the idea of learning by doing, which goes back to the beginning of product design. We actually learn different things from making the prototype (modelmaking) than we do from using the prototype (prototyping). Material properties do not have any real connection to the world we live in unless we first inform our senses in a hands-on way. By experiencing real materials and processes, the material qualities gain meaning. The sensibility and experience attained from this process form the basis for intuition and are therefore essential for conceptualization.

Physical and Digital Prototypes

Product designers need to have competency in several skills, including sketching, CAD and modelmaking. These are all critical tools and should be used effectively and not exclusively. A workflow that shifts back and forth between different skills expands the creative possibilities and is more balanced.

Computer technology has completely changed the way in which products are conceived and developed. Virtual computer models allow us to visualize the product, see how parts fit together, calculate the weight and carry out performance simulations along the way. Physical prototypes, on the other hand, answer questions that are hard or impossible to address on the computer alone. These questions usually have to do with the qualitative human aspects. Whereas computer simulation can be used to verify many technical requirements, physical prototypes can be placed into real environments and have tangible qualities, such

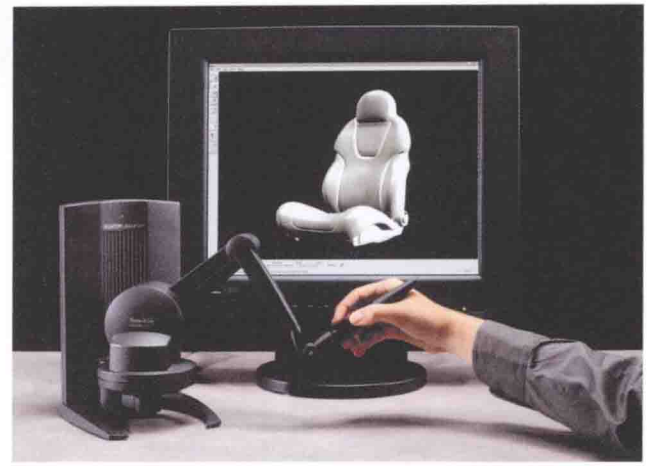
as weight, size and texture, that can be experienced at first hand. Experienced designers build a great many physical prototypes along with virtual computer models. It is not a question of physical versus digital, but rather a matter of how the two approaches complement each other best. The tutorials in this book show workflow that involves sketching, CAD and physical modelmaking used in a complementary fashion.

Building by Hand and Using Computers

All physical prototypes used to be built manually by hand. Nowadays, as will be shown later in this book, new digital technologies enable 3D computer files to be output to automated computer-controlled prototyping machines. This may create the impression that prototypes no longer need to be made by hand at all, but that would be far from the truth. As will be shown in the case studies in this book, early ideas are actually explored faster by hand. What starts as sketches and quick handmade models gradually migrates to the computer and eventually from there to rapid prototyping or CNC machining.

Chapter 7 discusses how manual and digital ways of working complement each other and how new technologies such as laser scanning help designers reverse-engineer handmade models into CAD. There is, in other words, a convergence happening between traditional hand skills and computer skills. The computer mouse is probably going to be increasingly displaced by more natural and fluid input devices, which electronically simulate the sketching and sculpture-making process. This has already happened with the digital sketching pad, where the stylus is now the input device. Similarly, 3D haptic devices allow for hand-forming digital models in space. Modern design process is evolving, requiring designers to have one foot inside and one outside the virtual world every step of the way.

The Fiskars post-digging tool was first made by hand and tested (left) before creating a 3D computer model in CAD (right).



New interfaces are changing the way designers work. Products such as the Cintiq® interactive pen display (left) and the PHANTOM® haptic (force-feedback) device (below) blur the lines between analogue and digital methods of working.

Organization of this Book

The first chapters of the book explain why prototyping is so important to the design process. The many uses of prototyping will ultimately be shown in the context of several comprehensive projects by some of the world's leading design firms.

The second part of the book is an introduction to the typical materials used by designers in their prototyping efforts and how to work with them. In all cases the approach is to use digital and manual tools in a complementary and effective fashion. Tutorials were specifically developed for the book that underline the back and forth of digital and manual ways of working. The emphasis is on the kinds of construction that can be done by the designers themselves. Health and safety is stressed in terms of personal responsibility and awareness. As students leave their universities, they are likely not to have access to some of the world-class facilities to which they may have become accustomed. Being able to create models in simple materials in a healthy and safe manner will be important.

PROTOTYPING

CHARACTERISTICS OF PROTOTYPING

1

Successful prototyping requires thinking about building and making in a way that is different from the way we think about manufacturing and fabrication. First and foremost a prototype is not a final product. Before going into detail about how prototypes are used and before getting into the specifics of working with materials, it is worthwhile discussing some of the important characteristics of prototyping.

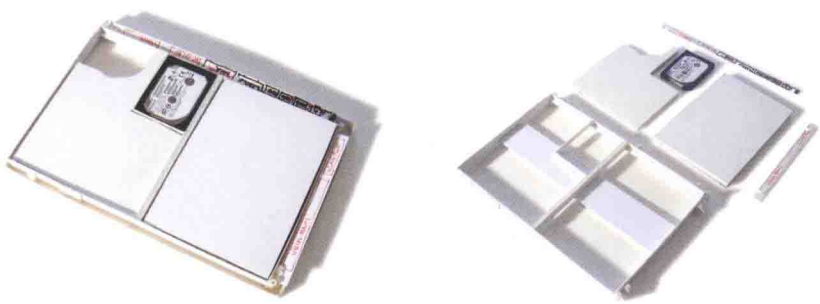
The Difference between Prototyping and Manufacturing

Prototyping and manufacturing are separate activities. Mass-manufactured products achieve their economy of scale through tooling. The time involved and the cost of making various types of tooling and setting up an assembly line, is a huge capital investment. Products have to sell in the thousands before this investment starts to pay off. Prototypes serve many purposes in order to reduce the risk associated with that level of investment. Since prototypes are built only in small numbers, they do not typically require any tooling and can be produced in a completely different fashion. At the early stages of a project, the focus may not even be on manufacturing at all, but on figuring out basic configurations and how the product will be used. As the design gets closer to production, it will be necessary to prototype all parts before tooling is made.

Material Substitution

Early on in a project, it is typically more cost- and time-efficient to substitute softer materials in place of production materials. Polyurethane foam, for example, is frequently sculpted to study the shapes of injection-moulded plastic parts, while a sheet of plastic can be painted in metallic pigment to look like sheet metal.

Functional configurations can also be simulated very quickly with simple prototypes. This is really useful when designing products that have internal components, as it allows the engineers and designers to play around with component placement in an effective and dynamic way.



A simple foamboard mock-up allowed engineers and designers to study internal component placement for the Motion Computing J3400 computer.