

Product Design

A course in first principles

Elvio Bonollo

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To my father Umberto Bonollo (1893-1973) who gained his diploma of Industrial Design (building crafts) in 1911, with first class honours, from the School of Arts and Crafts, Schio, Province of Vicenza, Italy.

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NOTES ON PRESENTATION STYLE:

In addition to highlighting the titles of books cited in this text, *Italics* are used to emphasize terms and phrases that are important in design thinking and communication, and which may form relevant parts of a design language and vocabulary. In order to maintain flow in the text, and to keep the length of design briefs to a minimum, endnotes have been used instead of footnotes: these are located as needed at the end of each part of the four main chapters.

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➔ Foreword

From the buildings we live in, to the cars we drive to the furniture we sit in and the mobile phones we can't live without, the subject of design influences and shapes practically everything in our built environment and natural world. Design drives competitiveness in business and industry; it can help develop a more sustainable society and make a significant contribution to the quality of our daily lives. Design is now recognized as more than just a value-add to products and services: it is applied by many professions to form new ways of thinking in tackling the big issues of society. With the environment high on the agenda of business and governments around the world, the role of professional design is being elevated as a key instrument in addressing the challenges that lie ahead. This renewed focus on the importance of design places greater emphasis on the learning of this important subject and the need to 'get it right'.

In this book, Elivio Bonollo takes us on a 'learning journey' about design including a scholarly explanation of the characteristics and power of the design process. It provides valuable insights into the attitudes, knowledge and skills that underpin the design discipline at an introductory level of expertise, and has been developed to meet the needs of aspiring designers in many areas including industrial design, engineering design and technology, art and architecture. Elivio uses an operational model of the design process—along with related educational strategies, learning outcomes and an ordered set of design briefs—to develop a systematic, problem-based method for learning design from a first principles viewpoint.

The beauty of this approach is that it brings structured learning to aspiring designers whilst being mindful of diverse cultures and backgrounds. Each part of this book encourages self-expression, self-confidence and exploration: it has been carefully *designed* to take you on a highly motivating journey of design thinking and creativity, supported by excellent sample solutions to design problems, lucid discussions and extensive references. These solutions, developed by design students at the National University of Singapore, serve as novel examples of how to solve real problems through innovative design without restraining creative freedom and individual personality.

The design learning method and strategies in this book will greatly assist design and technology teachers, students of design, aspiring designers and any individual with an interest in professional design practice; and it will open your eyes to the beauty of design thinking. I am deeply honoured to provide this foreword to *Product Design: A Course in First Principles*. If you have a passion for good design, as I do, I am positive that you will learn from and enjoy each page as much as I did.



Brandon Gien
Executive Director,
Australian International Design Awards
Executive Board Member,
International Council of Societies of Industrial Design (ICSID)

➔ Acknowledgements

Many friends have had a hand in writing this book and my students are the first ones that I must thank for their enthusiasm, patience, diligence, collaboration and kind permission to include extracts from their creative design work. Eighty first and second year industrial design degree students, in the Department of Architecture at the National University of Singapore, have generously made contributions, directly and indirectly, beginning with design work in Human Factors studies, in the second semester of the first year of the program in 2005, and then moving through to Design Studio projects in the first and second semesters of second year up to the middle of 2007. Regrettably, I could not fit much of their work into the text as it would have taken several books to do that not just one. The modest array of work shown in this text provides only a glimpse of the unique personalities, design talents and potential of these novice designers who, I am confident to say, will go on to successful and distinguished careers.

Special thanks are due to Professor Heng Chye Kiang, Professor of Architecture and Dean of the School of Design and Environment, National University of Singapore, for his strong encouragement and support in the development of this text. I also wish to thank Assoc. Professor Teh Kem Jin, foundation Director of the Industrial Design Course, for kindly sharing his innovative ideas on design learning. Professor Cheong Hin Fatt, former Dean of SDE, and Professor Lim Seh Chun, Head of Mechanical Engineering, have been most helpful during my terms as visiting professor at the National University of Singapore. I am also grateful for the help received from my colleagues, who shared the teaching with me in the ID program at NUS, especially Christiane English, Sivam Krish and Karle Mänty. I thank Yen Ching-Chiuan, for his helpful cooperation and friendship; Carlos Montana Hoyos for his many suggestions, photography, feedback and friendly help, and Christian Boucharenc for sharing ideas on basic design. I am most thankful to Muji Bin Hochri and Mohd Sah Bin Sadon who have continually supported me and the design students in supervising safe modelling and prototyping activities.

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➔ Introduction

Design is a fundamental part of the history, culture and technology of societies all over the world. It is a critically important process in the business and creative industries affecting national prosperity. As informed by promotional activities such as those conducted by the Australian International Design Awards program of Standards Australia, and by the Design Singapore Council among many others, our quality of life is affected greatly by the products that are developed by such collaborative design professions as engineering, industrial, graphic, interior, fashion and architectural design. The related outputs from the design process can have significant effects on our artificial and natural worlds: positive if they contribute to our health and well being, and negative if they damage the environment in which we and our neighbours live. Of course, many designed products give rise to both positive and negative effects and this has led, for example, to the *EcoDesign* and *Design for Sustainability* movements which aim to minimise the negative effects and achieve a reasonable balance between the two. Design has also developed a significant media-centric and political focus especially in the environmental context where climate change is a serious contemporary issue. And there are other important trends that need consideration such as where design is heading in the future: we know that it is becoming more people-centred and that it is crossing discipline boundaries more often than in the past, but more research needs to be done in terms of identifying future directions for this discipline especially at the postgraduate level of studies.

Design is now a global process: designers need no longer be tied to a specific product manufacturing base or geographic setting—a computer file, which contains information that defines the physical characteristics of a product or component, can be sent electronically to a rapid prototyping facility on another continent and the finished prototype sent back by air in days or even hours. Needless to say, the global process of design also carries with it associated ethical, social and environmental responsibilities. Of course, design education needs to keep up with these trends as best it can if it is to remain responsive and a valued basis for the respective professions, and this may create problems of where and how to focus educational activities. As often happens, design education curricula can be focused to develop attitudes and skills in the senior years of design, engineering and architecture courses, especially if complex technical systems and futurist issues are involved. And it can also be incorporated, as part of a progressive continuum, in the junior levels of design programs in these and related disciplines: this is where an understanding of the design process is a fundamental consideration in learning the first principles and heuristics of how to design, and it is this latter area of education which is the primary motivating factor in the writing of this book.

This text is about investigating, understanding and applying the design process as part of an introductory learning program in product design. It is also essentially a “workbook” concerned with learning the fundamental principles of product design in a self-directed and ordered manner without delving too deeply into the technical aspects. It invites you, the reader, to become involved in studying, analysing, reflecting upon and, hopefully, solving design problems with the purpose of developing your motivation, knowledge and creative skills. In this setting, this method about the teaching or pedagogy¹ of product design complements and builds on the basic design and *foundation courses* concerning the principles

of two and three-dimensional design covered in many design schools [1-3]. Although this book focuses primarily on designing products in the industrial design discipline framework, I like to use the descriptor *product design* to encompass more generally the attitudes, knowledge and skills covered in this field. This provides a wider, more inclusive context and scope for appreciating the basic elements of design practice in relation to associated disciplines, especially engineering design and architecture.

I am mindful of the fact that there are many ways of planning a design learning program—which in many respects is a process akin to designing a product or a system—comprising a learning rationale, curriculum content and learning outcomes, learning methods and practice problems. My approach to encouraging a particular “way” of learning to design—a “*learning method*,” if you like, that has been influenced by many teachers, colleagues and students—includes specifying a graded set of design briefs described respectively in terms of *learning objectives* (the expected, broad outputs of the design process) and, where appropriate, *learning outcomes* (the estimated and observed actual learned outputs of the process). These project briefs, which are set in various contexts, focus on progressively developing one’s motivation, creativity and cognitive strategies—especially critical thinking and problem solving skills, and perceptual motor abilities such as freehand drawing and model making. These affective attributes and cognitive skills are further reinforced by introducing one to design tasks and planning activities that are typical of the design process at an elementary level of expertise [Lewis & Bonollo, 4, 5].

As explained in Chapter 1 onwards, this problem-based approach is also configured so as to encourage learner designers to cultivate an understanding of various product materials, manufacturing processes and simple technologies in an experimental and open-ended manner, and without going too deeply into fundamental knowledge related to the engineering sciences. This is part of the exciting and captivating process of learning to design objects or artefacts² which are socially and environmentally worthwhile. Akin to the arts and crafts, product design education at this level is also very much about learning how to prototype or “make things” in order to better appreciate and communicate their functional attributes [6, 7]. Making an object, even if it is just to the stage of a simple model or prototype, is very motivating since it helps us to understand how an *idea* for a design is transformed into a *creative design concept* and, in turn, how a design concept may be developed as a *physical reality*. This motivating effect applies in design learning as well as in the real world of design. Of course, design is also very much about *communication*, and we’ll talk more about the various meanings of the term *design* later as we work our way through the book.

The context, aims and layout of this book will now be outlined in more detail. In context, it aims at providing introductory studies in product design which may be undertaken in the early years of programs in industrial and engineering design, design and technology, product design engineering and architecture as studied in art and design schools, polytechnics and universities. This book may also be used to provide introductory design experiences for students in high schools and technical schools, or for aspiring designers learning informally under their own initiatives. In scope, it is primarily about systematic, *self-directed learning in design*. As noted, this book is based on a design curriculum that incorporates an aligned set of projects, each specified by a *design brief*³ that explains the requirements, context and scope

of the respective design problems. In turn, each design brief is supported by sample solutions, which you may use to guide you in developing your own understanding of the design process and approach to learning to design.

The sample solutions to the design problems tabled in the subsequent chapters of the book are the enthusiastic work of first and second year industrial design students who studied in my Human Factors and Design Studio classes at the National University of Singapore from 2005 to mid 2007. These solutions, selected from three successive cohorts of students, track the development of these learner designers over a time line of eighteen months to two years, beginning in semester 2 of the first year of studies and progressing on to the end of the second year of studies. Some clues as to the progressive development of design attitudes, knowledge and skills are indicated by the increasing level of sophistication and maturity over time of the tabled design solutions—these are presented sequentially in the text in keeping with the intended curriculum order of the respective project briefs, and not necessarily chronologically with respect to each cohort of designers. Extracts, in the form of diary entries and textual narratives, have been quoted verbatim from the project reports of these designers (as originally submitted for confidential assessment) and are reproduced as protocols in the text in a concise format without any major corrections or amendments from me. What I have done is to add theory, discussion and comments, as needed, in order to explicate the design concepts, design thinking and related design process outcomes presented. These written protocols provide very interesting exemplars and valuable insights into the personality, motivation, design thinking and problem-solving styles of these learner designers.

Each of these *novice* or *learner* designers—descriptions which I use generically with all due respect for anyone learning to design—brings a creative and uniquely personal style to solving these design problems whilst following the general design method outlined in the text. A visual example of their many design concept models follows, namely, as proposed by Foo Jee Hong Benjamin Mark for the eyewear design project described in Chapter 3; this photo shows one of his preferred design concepts. Another example shown in this Introduction is a concept working model by designer Cher Li Jun: this is part of her *detailed design* (a specific *design language* term along with many others which I'll explain later) to the contemporary lamp design project detailed in Chapter 4. Several more visual examples of design concepts follow without discussion in Chapter 1 in order to give you a brief preview of some of the many interesting and informative design cases presented in the text. Unless otherwise stated, all photographs, drawings, models and prototypes are the original work and contributions of the designers listed. The cultural setting of the students' work is Singaporean and with the impressive global outlook of this Community [8]. In addition, the learning method that I shall explain as we go on—although generally based on easily understood design problems—may also be adaptable to the various continuing levels of these educational programs up to the stage of neo-professional practice [4]. However, it is fair to say that much more challenging design briefs than those described in this book would normally be involved in advanced learning in design, along with complementary supporting studies in related subjects. Specifically, this book has been written with the following aims in mind:

- (1) To develop a learning method, from an industrial design perspective, which focuses on understanding the design process whilst developing design attitudes, knowledge and skills, all in the context of an introductory course in product design.
- (2) To compile an ordered and aligned set of project design briefs, of gradually increasing cognitive and technical complexity (supported by sample solutions), that can be used as a basis for inclusive, experiential learning in design.
- (3) In the light of aims 1 and 2, to encourage the intuitive, creative, technical and social design talents of learner designers mindful of cultural and educational backgrounds.
- (4) Mindful of aims 1 to 3, to develop learning conditions and a method that are flexible enough to adapt to the educational requirements and connections of different design disciplines, including engineering design at a basic, qualitative level.
- (5) To promote scholarship in design education and provide an adaptable data base and learning model for teachers of design, and design and technology, and to provide a rationale foundation program for studies in more advanced design courses.

The layout of this book follows a logical and interconnected plan based on four chapters that form a continuum of *design learning conditions* related to a model of the design process. Following this **Introduction**, a brief discussion is given in **Chapter 1, Theoretical Constructs**, in order to provide a basic understanding of *design thinking* and *epistemology*. This includes a description of the characteristics of an operational *model of the design process* [4, 5], along with notes explaining the challenges of developing design learning methods and the

importance of realising sensible *learning outcomes* and safety practices from project work. Then follow three active **Chapters** involving design briefs and projects that vary gradually in terms of context, complexity and scope supported by explanatory guidelines and principles: each of these chapters concludes with a **Reflections** section in which I review and explain important ideas and principles relevant to the design learning method and problem-solving strategies presented. Finally, an extensive **Bibliography** is included.

In more detail, **Chapter 2** presents three projects consecutively, accompanied by respective solution concepts, under the basic theme of **Design Process**: this work begins by demonstrating how to carry out a *functional analysis* of existing products—based on a novel theoretical framework—and concludes by showing how the design process can be employed in the creative design of products.

The first project is about understanding how products of relatively low configurational complexity—meaning the relative

Designer: Foo Jee Hong Benjamin Mark.
Sunglasses Concept model based on a set of interchangeable components; eyewear design project (see Chapter 3)



simplicity of their physical structure or syntax—have been designed and how they work, including identifying their *use* and *esteem functions* and understanding what these mean. The basic operations of *analysis* and *synthesis* are explained in a design context along with the use of related *analytical tools* and the on-going development of a suitable *design language*. The second project is concerned with *user-centred design* and how to go about *redesigning*

simple products to improve their functions; and the third project builds on these first two by calling for the *creative design* of products especially in relation to their *form* as well as their intended *functions*. All of these projects are *aligned* in the sense that they aim to build on progressively in terms of developing affective abilities, design knowledge and especially intuition, creativity and problem-solving skills. ①

Chapter 3 contains three design briefs and a number of related solution concepts under the theme of **Design for Context**: these projects cover heritage lighting, creative eyewear and furniture forms, respectively. This chapter explores open-ended, intellectually challenging design problems in three different contexts beginning with the noted cultural setting for a lamp design in the first project. *Ergonomics*, *anthropometry*, *marketing matrices* and *user-centred design* studies are also covered in more detail in this chapter along with

introducing

EcoDesign investigations

and *project planning* techniques. As before, the projects are ordered so as to enable declarative and procedural knowledge and skills to be acquired progressively in a gradual, step-wise fashion whilst introducing new *design variables*, *parameters* and *constraints* that require consideration in the analysis and synthesis of the respective design problems. ②

① The theory and experiential learning elements developed in Chapters 1 and 2 are mainly aimed at learners who have little or no prior knowledge or experience in design at an elementary level. I also strongly recommend, especially as an important revision and update of design thinking, that these chapters should be read carefully by learners who already have this or comparable levels of design knowledge and skills.

② The experiential learning conditions developed in Chapter 3 assume that learners have already acquired the required background knowledge and skills comparable to those obtained by completing Chapters 1 and 2—that is, the attitudes, knowledge and skills acquired from completing Chapters 1 and 2 are in effect desirable (but not essential) prerequisites to Chapter 3.

3 As previously, the design work and learning conditions called for in Chapter 3 have been arranged to act as a desirable (but, again, not essential) prerequisite for undertaking the creative work required in Chapter 4, especially in terms of procedural and declarative knowledge relevant to the design process, design materials and manufacturing technology.

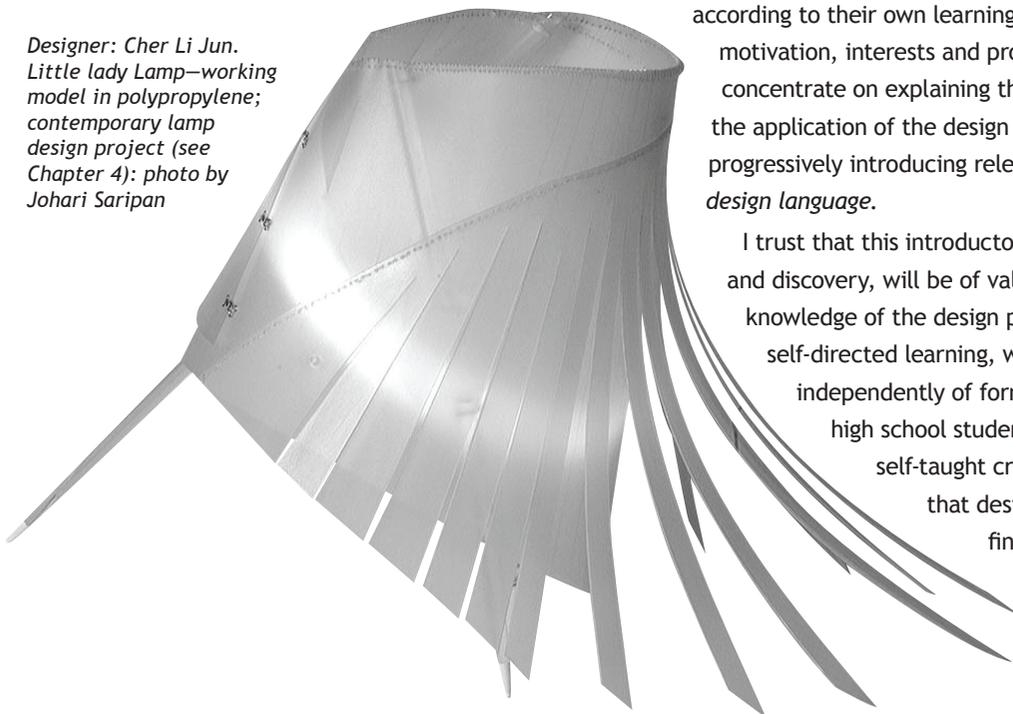
Finally, Chapter 4 contains four challenging design briefs under the general theme **Design for Connectivity**: This chapter aims to provide *authentic learning experiences* [4] in contemporary design contexts that involve more open-ended problems and clients in the real world, as well as in settings that explore the *communication* needs of specific communities. These communities may include such bodies as Condominium or University social systems—where *connectivity* related to design for security and services are important people issues. In these cases, designing for ‘clients’ and *communities*—also known

as *external design projects*—means that information on design requirements, and feedback on the quality of the design solutions realised, is to be obtained directly from persons external to the immediate learning environment. These include professional managers and designers who are prepared to act as sponsors or collaborators subject to certain ethical guidelines. 3

The chapter *learning conditions* noted above provide the recommended sequence for attempting the tabled design projects but, of course, readers may wish to vary this according to their own learning and teaching environment, prior experience, motivation, interests and problem-solving style. In sum, these chapters concentrate on explaining the characteristics of the design process and the application of the design learning method underlying the text, whilst progressively introducing relevant educational principles, guidelines and a *design language*.

I trust that this introductory course in product design, a journey of learning and discovery, will be of value to aspiring designers keen to develop their knowledge of the design process and related design expertise through self-directed learning, whether it is in private schools and universities or independently of formal courses in design. This includes technical and high school students taking design and technology subjects, and self-taught craft persons and designer-makers. Finally, I hope that design teachers, in any of the above contexts, will find this book useful in their teaching and learning of industrial and product design at entry levels of knowledge, skill and sophistication.

Designer: Cher Li Jun.
Little lady Lamp—working
model in polypropylene;
contemporary lamp
design project (see
Chapter 4): photo by
Johari Saripan





About the Author

Elivio Bonollo PhD (Melb), CPEng MIEAust, CEng MIET is one of Australia's leading industrial design educators and researchers. In 2008 he was conferred with the Honour of Cavaliere by the President of the Republic of Italy in recognition of his collaborative work in design and education. He is Emeritus Professor of Industrial Design at the University of Canberra (UC). He was recently Visiting Professor in the School of Design and Environment (2004-2007), and the Department of Mechanical Engineering (2007) at the National University of Singapore (NUS). He is also a visiting professor in the Faculty of Applied Art and Design at Ubon Rajathanee University, Thailand. He was Foundation Professor of Industrial Design at UC (1997-2002) and a pro vice-chancellor (1999-2001). Earlier he was Dean of the Faculty of Environmental Design (1997-98). Elivio (Livio) was Professor and Director of the Centre for Industrial Design at Monash University (1989-96) and before this senior lecturer in charge of industrial design in the Faculty of Art at RMIT (1979-89). He is the founder of the industrial design discipline at Monash University and the principal author of the original industrial design degrees at RMIT (1982) and Monash University (1989). After a cadetship at General Motors Holden in Melbourne, he began his teaching career at RMIT as a lecturer in the Department of Mechanical and Production Engineering before moving on to the Department of Design in 1979. He has taught and consulted in many universities including appointments as external examiner in design at Ngee Ann and Temasek Polytechnics in Singapore.

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