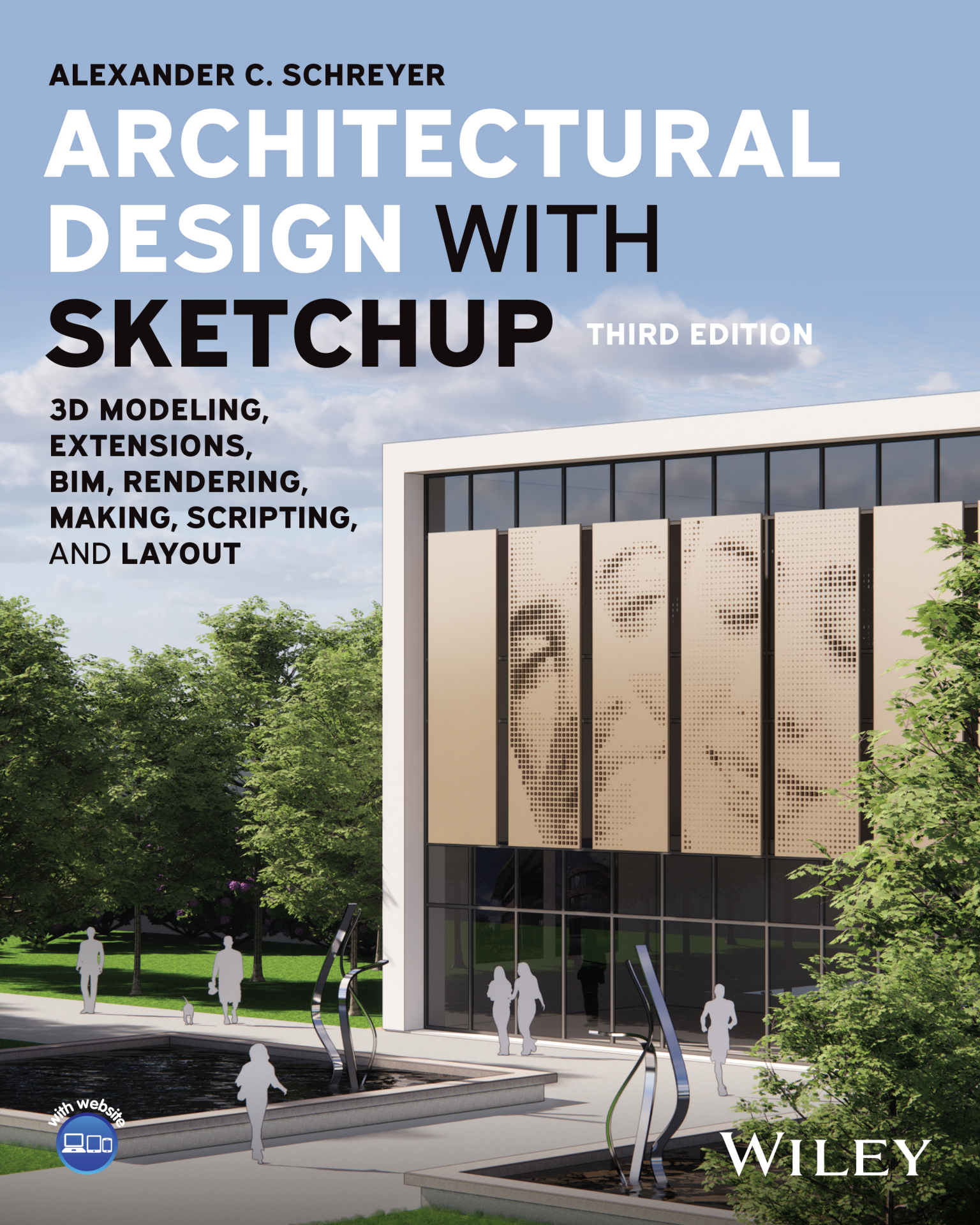
ALEXANDER C. SCHREYER

ARCHITECTURAL DESIGN WITH SKETCHUP

THIRD EDITION

3D MODELING, EXTENSIONS, BIM, RENDERING, MAKING, SCRIPTING, AND LAYOUT



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Architectural Design with SketchUp

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3D Modeling, Extensions, BIM, Rendering, Making, Scripting, and LayOut

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Alexander C. Schreyer

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Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

Edition History:
John Wiley & Sons, Inc. (1e, 2012; 2e, 2016)

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Library of Congress Cataloging-in-Publication Data

Names: Schreyer, Alexander (Alexander C.), author.
Title: Architectural design with SketchUp : 3D modeling, extensions, BIM, rendering, making, scripting, and layout / Alexander C. Schreyer.
Description: Third edition. | Hoboken, New Jersey : Wiley, [2023] | Includes bibliographical references and index.
Identifiers: LCCN 2023007041 (print) | LCCN 2023007042 (ebook) | ISBN 9781394161133 (paperback) | ISBN 9781394161140 (adobe pdf) | ISBN 9781394161157 (epub)
Subjects: LCSH: Three-dimensional modeling. | Engineering graphics. | Architectural design—Data processing. | SketchUp.
Classification: LCC T385 .S3347 2023 (print) | LCC T385 (ebook) | DDC 620/.0042028566—dc23/eng/20230216
LC record available at https://lccn.loc.gov/2023007041
LC ebook record available at https://lccn.loc.gov/2023007042

Cover Design: Wiley
Cover Image: © Alexander C. Schreyer

Dedicated to my parents,
Rosemarie and Gerhard Schreyer.
With eternal love and gratitude!

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Acknowledgments

Having taught SketchUp to audiences of eager students from many different backgrounds, I should start my acknowledgments with exactly those students whose questions and creative ideas have inspired me not only to look deeper into the software but also to put this text down on paper. To them I say: *Keep pushing the boundaries of the third dimension in your work!*

An amazing product can often be judged by the community that develops around it. SketchUp has always been a nimble and transformative piece of software, whose simplicity and power have enthralled users for many years. This has created a large user community, which in forums, in blogs, at user meetings, and at other venues has—often passionately—taken to using it to design whatever comes to their creative minds and educating others in how to use it to realize their ideas. I would like to acknowledge that community for its devotion, support, and inventiveness, and I am with this book paying forward any support they ever gave me. Specifically, I would like to thank the following members of that community for their feedback and the various images of their work that I was able to add to this book: Mike Brightman, Omar Calderon, Tom Chung, Andrew Dwight, and Eric Schimelpfenig. Among the makers of SketchUp, I would like to thank current and former Trimblers (*I am guessing that is the correct term?*) John Bacus, Chris Brashar, Aidan Chopra, Aaron Dietzen, Chris Fullmer, Mark Harrison, Allyson McDuffie, Amy Northcutt, Thomas Thomassen, and Ian Warner for their feedback whenever I had a request—*and of course for the great times I had at 3D Basecamp, SketchUp's bi-annual user conference*.

This book would not have been possible without the support and feedback from my current and former editors at John Wiley & Sons: Paul Drougas, Todd Green, Judy Howarth, and Seth Schwartz. Even after several editions, I am still in awe of the amount of work that the editorial and production teams put into a publication like this. In particular, I would like to acknowledge the work of the following people at Wiley on the current and former editions of this book: Praveen Bondili, Ginny Carroll, Nancy Cintron, Kelly Gomez, Cheryl Ferguson, Kathy Grider-Carlyle, Mike New, and David Sassian. Judging by the editing initials in the manuscript, it passed through many more hands whose anonymous (to me) work I hereby gratefully acknowledge.

Finally—and most importantly—I would like to thank the love of my life, my wonderful wife, Peggi, for her tremendous encouragement and constant support; and our two girls, Sophia and Mackenzie, for their patience with me while I was preparing the manuscript. I couldn't have done it without them!

About the Companion Website

This book is accompanied by a companion website

www.wiley.com/go/adsu3e

This website includes:

- Assignment Examples
- Ruby Code Examples

Chapter 1
Introduction

This chapter introduces the book and lays out how you can work with it. It also introduces SketchUp as a design tool and explores the various ways in which you can use this software for a wide range of professional (or personal) work.

Key Topics:

- SketchUp's capabilities and uses
- Approaches for working with SketchUp
- Versions of SketchUp and their peculiarities
- SketchUp's context within Trimble's product family
- Conventions used in this book

1.1 A Multitude of SketchUp Users

During my years of teaching SketchUp, creating SketchUp extensions, and interacting with a large number of SketchUp users, I have come across many highly proficient users of this software and have marveled at their amazing work. Students and professionals take easily to SketchUp, and, before long, most of them produce very detailed building models and professional-grade renderings, only to name a few results. Some of this exemplary work is featured in this chapter and elsewhere in this book.

I have also found that too many people don't go beyond the core features of this software and believe that some of the advanced modeling, high-quality photorealistic rendering, or digital fabrication must be done using other software. Very often, they painstakingly pick up that other application without realizing that what they wanted to do was possible with SketchUp all along.

Sometimes even advanced users of SketchUp fully master one aspect of the software (photorealistic rendering, for example) but are completely unaware of the power that SketchUp holds in other areas—parametric components and Ruby scripting are good examples. As you will find out in this book, SketchUp is a very powerful design and 3D modeling tool that can be used for rough sketch-based designs as well as detailed, highly precise modeling tasks. Some of its core features—for example, SketchUp Pro's extendibility with *extensions* (sometimes also called *plugins*)—give it flexibility that makes it useful for

Architectural Design with SketchUp: 3D Modeling, Extensions, BIM, Rendering, Making, and Scripting, Third Edition. Alexander C. Schreyer.
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Figure 1.1: Photorealistic rendering brings in reflections and better-quality materials, which can then still be combined with hand-sketched elements to add personality

a large variety of disciplines. The immense popularity of this software and the large number of high-quality extensions that are currently available for SketchUp bears powerful witness to this.

This book is a resource for basic to intermediate users and helps them make the leap from simply creating "something" in SketchUp to using it as a powerful design tool. It also contains several advanced topics (such as photorealistic rendering, parametric components, building information modeling (BIM), digital fabrication, and Ruby scripting), and provides a clear learning path that takes the reader through easy-to-follow exercises to a thorough understanding of the core topics. As an example of what can be achieved using the principles learned in this book, **Figure 1.1** shows how one could use extensions to model curved beams and various architectural elements, employ Ruby scripting for patterned shading devices, and then render the scene using photorealistic rendering software. A sketched-style overlay and small details, all added in Photoshop, then finally "dress up" the image for presentation.

1.2 How Does SketchUp Fit into the Designer's Toolbox?

As a professional or student, you likely already have assembled a sizable software "tool chest" by now. Depending on your discipline, this might include various office software, other CAD (computer-aided design) software, image-editing software, print layout software, analysis software (for energy or structural analysis, for example), construction coordination tools, and many others.

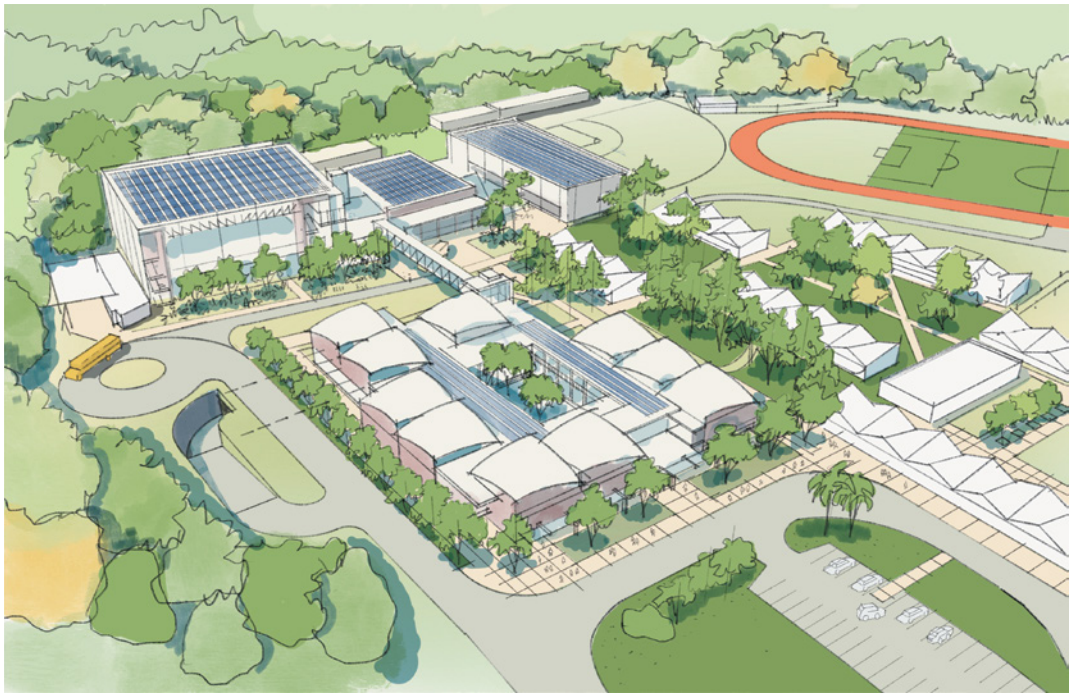

Figure 1.2: Early-stage design concept illustration for a campus site. The designer used a SketchUp model to represent massing and shadows, which was then traced over in an iPad app (Procreate) to create a hand-sketched appearance. *(Image courtesy of Omar Calderon, Perkins Eastman)*

Figure 1.3: Architectural design visualization model that was used to evaluate various shading solutions for an academic building. *(Image used with permission of Leers Weinzapfel Associates)*

SketchUp fits into this collection very well. One approach is to use it as an early-stage design tool—after all, as its name indicates, it was developed for 3D sketching. In that capacity, it shines by providing easy editing and immediate 3D visualization (see **Figures 1.2 and 1.3**)—something that can be very useful during quick design iterations and discussions with clients. Materials can be applied in the software, which provides realistic visualization capabilities right in the 3D modeling environment. Shadows can also be displayed, which makes evaluation of overhangs, shading devices, and window recesses, for example, very intuitive.

You can also use SketchUp for the complete design process from initial stages to a finished product (whatever that may be—buildings, landscapes, gadgets, etc.) (**Figure 1.4**). For that approach, it provides the capability to create precise, organized models that can contain any amount of data. Those models can then be used as the basis for construction or production documents (created *e.g.*

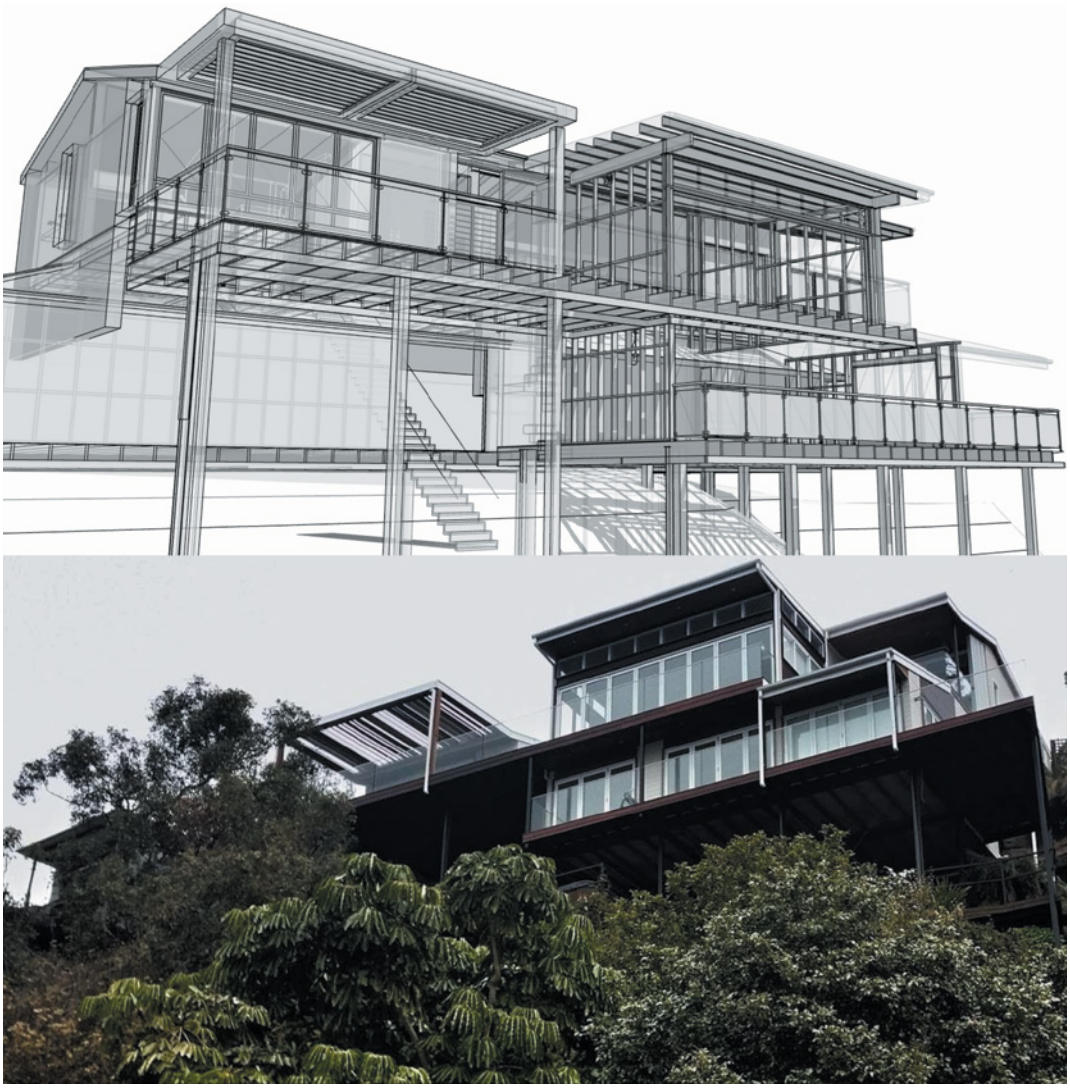

Figure 1.4: Detailed SketchUp model and photo of constructed residence. This project used a BIM extension, RubySketch, which is parametric and can create detailed building models that can even include a complete framing layout. *(Image Courtesy of RubySketch © / Photo by Andrew Dwight)*

with SketchUp Pro's LayOut software) and/or be exported for digital-process-based fabrication, such as CNC milling of parts.

The ability to visualize something in 3D is useful not only for a finished product but also for the process of making it. A good example is a construction site where material storage and handling, equipment locations and capacities, and safety considerations often need to coexist in a very limited space (**Figure 1.5**). This can be laid out and evaluated completely in 3D in SketchUp, which often simplifies stakeholder feedback.

Other analytical uses of SketchUp can include scientific or analytical data in the model (e.g., infrared thermography images as shown in **Figure 1.6**, or daylight-intensity data) and visualize those in a 3D-environment, such as by augmenting a correctly sized building model. Such models can then be annotated and shared as images, or entire models can be shared using 3D viewers that can be embedded on websites and become interactive for the user to be explored using their mouse or a virtual reality (VR) headset.

SketchUp also works well with other software: 3D models from SketchUp can often be opened directly in those programs, making data exchange easy. Even where that isn't available, SketchUp's built-in file exchange options allow you to export a 3D model in a variety of formats. As shown in **Figure 1.7**, built-in services and bespoke extensions exist that connect SketchUp to online collaboration platforms, where you can share your models with only a few clicks.

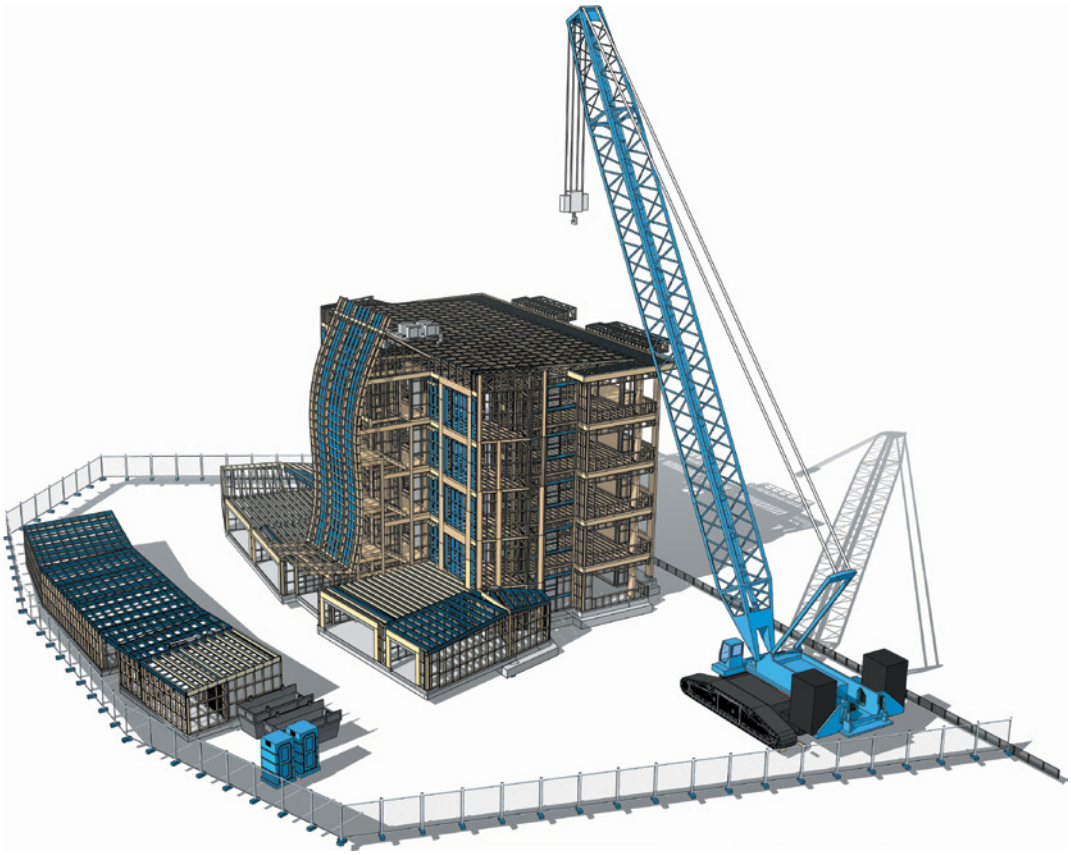

Figure 1.5: Construction site layout that includes the building's structural frame, construction equipment, and the site fencing. The turning radius of the large crane and the siting of pickup and drop-off locations can be considered in such a model. *(Image Courtesy of RubySketch ©)*

Figure 1.6: Thermal infrared house model made in SketchUp (top) and physically built as a paper model using extensions (bottom). For this project, images from a thermal infrared camera were pasted as textures to all surfaces using SketchUp's texture positioning tools

If SketchUp is already part of your toolset, then the best use of your time will be to expand on the skills you have already developed and deepen your knowledge of this software. This book provides you many avenues to do so.

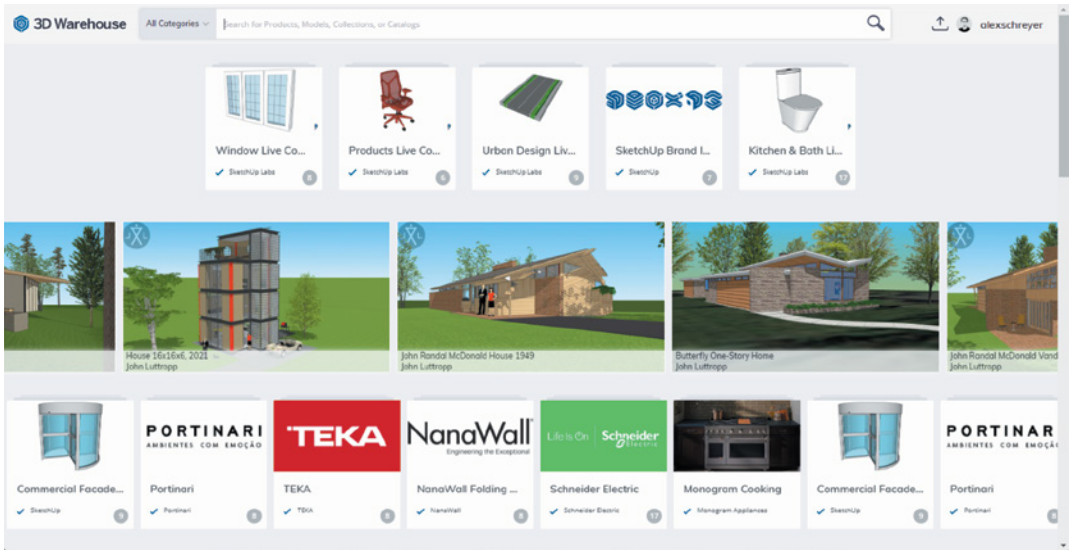

Figure 1.7: Trimble's 3D Warehouse website is one example of an online repository where users can share and acquire 3D models, including many commercially available products

1.3 Easy 3D for Everyone

Because SketchUp is not domain-specific, it has found a following with professionals and enthusiasts from many disciplines. This is why you will find SketchUp used on projects not only by architects, landscape architects, urban planners, engineers, construction professionals, woodworkers, and timber framers but also by robot builders, artists, sculptors, model-plane builders, mapmakers, historians, 3D game developers, and movie set designers (just to mention a few).

Figure 1.8 shows how SketchUp was used for the set design of a recent movie. Luke Whitelock, the designer, created the entire set virtually in 3D so that not only construction details could be resolved, but also camera perspectives could be pre-visualized. SketchUp's ability to save several camera positions, adjust the field-of-view for each, and then document everything in LayOut makes this process easy.

The techniques in this book are applicable to a variety of disciplines. Although many examples come from architecture or construction, some are from other, related disciplines (e.g., landscape design or interior design). Whatever your background is, feel free to take the examples that are presented here and adapt them to your work. The skills you acquire will be equally useful.

Taking this one step further, I can even say that I can't think of anyone who should *not* be using SketchUp. Living in a three-dimensional world and dealing with three-dimensional objects, everyone has the need at some point to model and visualize virtually in three-dimensional space.

Consider these hypothetical (but very common) situations: A homeowner wants to build a deck in their backyard and needs to explain to the builder how it should look. Another example is a scientist

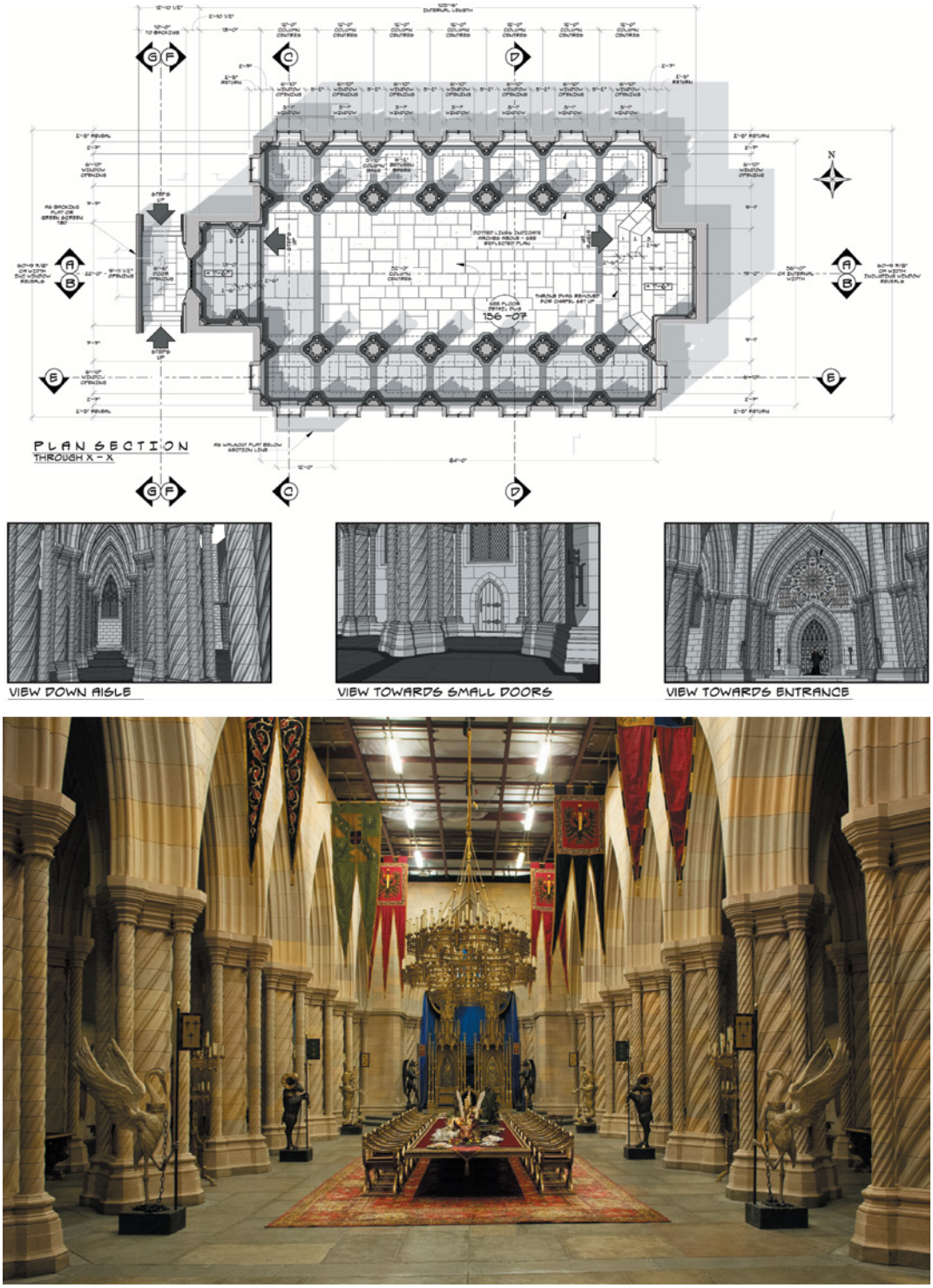

Figure 1.8: Several views of a movie set design with camera previsualization created in SketchUp and presented using LayOut (top), and the completed set as built (bottom) *(Images courtesy of Luke Whitelock)*

who needs to illustrate a lab setup for a presentation. Far too often, we resort to 2D representations of our thoughts (the classic floor plan, for example), which leave too much unknown and unexplorable. 3D views are intuitive, are easy to understand, and make it simpler to discover issues and fix problems.

Admittedly, many people are not trained in hand-sketching in 3D, which often leads to poor visualizations of things that can actually be quite interesting when presented properly. *That* is where SketchUp shines. Its 3D modeling capabilities and its ease of use make it a simple yet very powerful tool for anyone to give shape to their thoughts.

1.4 Windows or Mac, Pro or App, iPad or Phone?

SketchUp now comes in a multitude of flavors: Desktop-based SketchUp Pro has always been the core commercial product and is available for both Windows and Mac computers. A few years ago, Trimble started to develop adapted versions on other platforms, too. First was a web-based version (available at the URL **app.sketchup.com**), which can run in any browser on any operating system (even on Linux-based machines, which had been a longtime user request). It replicates most of SketchUp Pro's core functionality, with the most important difference being that the user cannot install extensions in it.

Most recently, Trimble also produced a version of SketchUp that runs on the iPad (**Figure 1.9**) and makes full use of Apple's stylus, which allows for an even more intuitive workflow than the desktop version already had. Add to those SketchUp's viewer applications for computers (on both platforms), as well as iOS and Android phones and tablets, and an augmented reality (AR, sometimes also called

Figure 1.9: SketchUp's iPad app works with Apple's stylus

extended reality—XR) edition that works with Microsoft's Hololens. With this breadth of products, Trimble has expressed its ongoing commitment to a free version, which was in the past a scaled-down desktop program (called Make, discontinued in 2017), but now it is a feature-limited edition of the browser-based app.

Like most other software manufacturers, Trimble now uses a subscription model for its software. This means, that depending on the needs of the user, one of several tiered plans can be bought, which all come with an annual fee (instead of a one-time cost for a perpetual license, as was common in the past). The most basic plan is the "Free" version, which gives access to the web app, mobile viewer, and Trimble Connect (more on this service in the next section). The most comprehensive "Studio" plan currently offers access to all the features of the mobile and desktop apps (including the ability to use extensions), LayOut (SketchUp's drawing creation software), the iPad app, AR/XR viewers, and includes access to point cloud and rendering software as well as several other tools and features. As a result, hobbyists, makers, and private 3D modelers will likely start off with the free version and may subscribe to one of the lower tier plans as their needs increase. Design professionals will likely be enticed by the full-featured upper-tier plans.

Qualified students can get access to individual licenses of SketchUp at a significantly reduced annual cost and universities will likely want to procure entire computer lab packages. And primary/secondary students often have access to the free "SketchUp for Schools" program, which is based on the web app. You can find out more about these plans and see current costs on SketchUp's website: **sketchup.com/plans-and-pricing**.

TIP

SketchUp uses the same SKP file format for all of its applications. This means that you can work on the same file and move it back and forth (e.g., between SketchUp Pro and the web version without any loss of fidelity). This is useful if a particular tool is only available in only one of these (e.g., video export, extensions, or the ability to use a stylus).

All versions are currently available in a multitude of languages, and even though the software is produced in the United States, it very capably handles metric units as well, which gives this software global reach. When comparing the various versions of SketchUp (and the subscription plans), it may be useful to base your evaluation on the following feature differences:

- LayOut comes only with the desktop version, SketchUp Pro. It can replace other drawing- and presentation-creation software, enabling you to keep that aspect of your workflow tightly aligned with SketchUp. 3D models created in SketchUp are always live-linked to LayOut so that updates propagate through the entire drawing set.
- Style Builder is a small software that only comes with SketchUp Pro and allows you to create custom sketchy lines.
- File import/export is limited in the free version. Make sure the version you subscribe to has the capability you need, e.g., DWG/DXF for CAD import/export, PDF creation, EPS for line art, and various 3D file formats: DAE, 3DS, FBX, OBJ, XSI, VRML. For file exchange with BIM software, make sure IFC is available. Fortunate for hobbyists that use 3D printers, STL is already available in the free version.
- Solid Tools, which are great for Boolean-based solid-type modeling (add, subtract, trim . . .) are not available in the free version.
- Some of the data-exchange and advanced authoring tools are also typically limited on lower tiers, such as image/video export, component-based report generation, Dynamic (and Live) Component authoring, or point-cloud modeling. The latter is also limited to Windows.

Many of the more advanced features allow the professional SketchUp user to integrate it into their workflow by making it easier to exchange data with CAD software (such as Autodesk AutoCAD), BIM software (like Autodesk Revit), online collaboration platforms (like Trimble Connect), and presentation software (like Adobe Illustrator). Modeling and workflow enhancements (such as the ability to create Dynamic or Live Components) also provide the professional user with the capability to create and disseminate product-model databases that facilitate planning and estimating tasks. The current iteration of the top-tier subscription even includes a license for V-Ray, a rendering software.

Depending on your needs, you have to decide which version is right for you. If you use SketchUp only for hobby projects or for basic training and you have no need for any of the advanced features, then the free web-based version should suffice. This book then offers a cost-efficient entry into relevant and current topics (such as 3D modeling, rendering, and digital fabrication). Note, however, that this book's chapters on extensions, rendering (where extension-based rendering software is used), computational geometry, and LayOut will not be applicable to you. If you, however, need and want to learn about the more advanced features and are planning on using SketchUp professionally, then your best approach is to get the Pro version right away. In that case, the entirety of this book will prove useful.

While this book's illustrations have been created using the Windows version of SketchUp, the tasks and tutorials are similarly usable with the Mac version. Menus and dialogs generally look similar and are in a similar location on both platforms. There are minor user-interface differences, but they are easy to figure out. Consult SketchUp's help system if you run into trouble.

1.5 Trimble's Product Ecosystem

Trimble Inc. is a technology company that was founded in 1978 and is headquartered in Colorado. Its product range combines software applications with (mainly surveying) hardware in every field it engages in. While it has a large division that centers on the built environment, its products are likewise used in agriculture, transportation, utilities, and many other fields. Professionals in the AEC (architecture, engineering, and construction) area may know Trimble from using its surveying hardware (optical- or satellite-based) on construction sites (**Figure 1.10**). Or they may have worked with its Tekla software for building planning and steel/concrete fabrication. Trimble also provides solutions for estimating, project delivery, and facilities management.

When Trimble acquired SketchUp in 2012 from Google, it added a crucial piece to its already quite large array of tools. SketchUp's ease of use and extendibility makes it ideal for field-based solutions, design concept development, visualization, and web-based collaboration. Since that time, Trimble has integrated SketchUp into many of its work areas and is actively pursuing a broadening of its software offerings (**Figure 1.11**). Case in point being the 2014 acquisition of Gehry Technologies and its software, which now lives on as Trimble Connect.

Because of this close integration with other Trimble services and products, SketchUp can be used in the following applications:

- **Collaboration and data exchange.** The Trimble Connect web-based platform serves as the central data hub between many Trimble products (**Figure 1.12**). A direct file upload/download connection is now built into many Trimble software products (including all versions of SketchUp) and can be added to others (e.g., Autodesk Revit by installing an add-on). At this point, everyone who signs up for a Trimble account (even if only to use SketchUp Free) even gets 10 GB of online file storage in this service, which makes this one of the more generous file storage platforms available. Trimble Connect goes beyond file storage and exchange, though, by providing markup, versioning, and workflow assignment tools as well as an online 3D viewer for various file formats, which can even perform basic clash detection tasks.

Figure 1.10: Trimble's R10 GNSS units in action during a workshop at the UMass Amherst Trimble Technology Lab

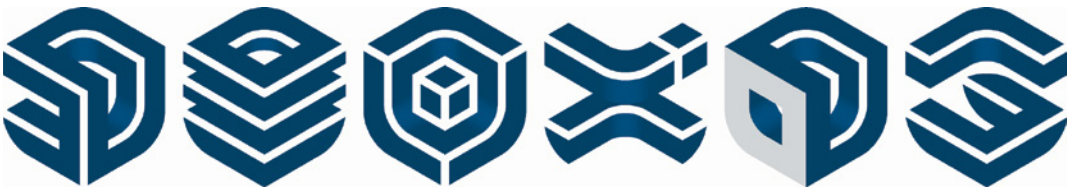

Figure 1.11: SketchUp's product family icons (left to right): SketchUp, LayOut, 3D Warehouse, Extension Warehouse, Pre-Design, Style Builder

- **Laser scanning and point cloud modeling.** Trimble makes a range of scanners (e.g., the TX-8 or their scanning total station SX-10) whose point clouds can be processed in their Realworks software and then used in SketchUp Pro for 3D modeling with the Scan Essentials extension. See Chapter 3 for an example of this workflow.
- **Surveying.** Trimble's total stations (e.g., the robotic S9) or its GNSS (global navigation satellite system) satellite-based tools (like the R12) can be used to survey (or lay out) points on a variety of terrains. That data can then be processed in Trimble's Business Center software for further use, such as in SketchUp.
- **Building performance analysis.** In 2016, Trimble acquired Sefaira, a software that allows for real-time building performance analysis and daylight assessment. It integrates into SketchUp Pro