

Impacts of Computer-aided Software on Introducing Architectural Drafting to Beginning Design Students

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Introduction

Today's architectural and interior design education curricula include courses in design, construction, drafting, environmental control, structures, history, professional practice, and selected topics related to 21st century advancements in the field. As Clayton (2006) explained, this educational method was adjusted to the Bauhaus model in the 1950's. Although some academics may argue differently, this process has not been changed significantly despite rapid shifts in the tools available to support the design process. These technological innovations have changed the emphasis of design from "form making" to "form finding," and fundamentally refocused the ways in which we analyze and convey ideas (Agkathidis, 2015; Kolarevic, 2003).

New digital tools have affected how design education introduces the foundations of design drafting, its process, and the means of presentation in today's architectural and interior design education curricula. As a result, beginning design students are now introduced to digital methods and ways of maneuvering through various software packages to produce automated drafts and explore design possibilities even before they cultivate a cognitive perspective on holistic drafting and its place in the design process. This research argues that while digital methods of creating photo-realistic renderings and automated drafting are likely to produce design information with reduced effort, they may also keep students from learning the poetic expression of the architectural arts, as well as the value of holistic design to the greater design process. This work describes a handful of recent research efforts and case studies of multi-year experiences in the Environmental Design program at Texas A&M University and Environmental and Interior Design program at Syracuse University, in order to illustrate the strengths and weaknesses of both manual and digital drafting methods when introduced as design drafting tools to beginning design students.

This study also presents a literature review of the generational changes in design communication in both academia and industry, as well as the challenges presented by and benefits of the current design communication tools. Moreover, the results of two case studies are reported in order to effectively illustrate the impacts of digital design methods on beginning design students seeking to understand the principles of technical drawings and further explore design concepts.

Design Communication in Academia and Industry

While the core of the architectural design curriculum may not have been altered from the Bauhaus model in order to align with rapid changes in digital tools, the contents of design communications has changed greatly in the past few years (Syracuse University, 2016). The original context of design communication in many institutions today is a pedagogical emphasis on the theories of design representation, use of visual means, freehand drawings, graphic communication, orthographic views, and the use of perspective renderings to analyze and convey ideas (Texas A&M University, 2016; Syracuse University, 2016). In many cases, the contents of these courses support and complement projects in design studios. While they maintain the integrity of the original context, the medium for these types of visual presentations has shifted to digital graphic applications, with an emphasis on computer-aided drafting and modeling.

The ways in which we represent the built environment in design have changed since the 1950s, and most rapidly in the past few decades (Clayton et al., 2010). In the mid 1960's, design drafting shifted to computer-aided techniques for outputting design drawings without the use of conventional drafting tools; by the 1970's, such techniques were fully commercialized. AutoCAD evolved from 2D drafting to 3D modeling in the 1980's and 1990's (Ozkan & Yildirim, 2016; Clayton et al., 2010). Innovations in Revit and building information modeling have changed the culture of designers and engineers; where they once were separated, the trend is now moving towards a more collaborative architecture (Quirk, 2012). The research completed by Black Spectacle found that design firms now prefer and often require digital drafting skills in design school graduates. The percentage is growing every year (Black Spectacle, 2017), and without these skills students will not have the credentials necessary for today's job market. Since many argue that it is our responsibility to prepare our design students for the professional job market (Karle & Kelly, 2011), schools expend a great deal of effort on keeping up with these innovative tools for design and drafting.

Design Communication for the *i*Generation

As technology has evolved, so have our students. Different generations have diverse ways of communicating. Today's junior design faculty, including myself, are what is considered Generation X; we were the first generation to grow up with computers. While a high percentage of design drafting education in the 1990's and early 2000's focused on manual drafting, later in our education we were taught the effectiveness of digital drafting tools. Every desk had a drafting table with a parallel bar for trace paper, and handmade models scattered about. The study of the manual, technical graphics in multi-view and pictorial drawings was one of the most important parts of our architectural design education.

Students today are called the "iGeneration." They do not remember a time without the internet or laptop computers (Twinge, 2017). Writing and drawing has shifted to the use of a keyboard, mouse, digital pen, and monitor. Today's design studio is full of computers, sometimes with multiple screens, plotted drawings, laser-cut pieces, and 3D printed models. Design communication has evolved from manual drafting supplemented with a CAD education seen in the 1990's to computer-aided design drafting with minor or almost no hand drafting (Syracuse University, 2016). As Ali (1993) described in his research, "the old days' fine-line drawings of shading and washes are gone forever; artistic talent is no longer a prerequisite to learning the fundamentals of the graphic language." Manual drawings require hours of concentration, advanced intellectual skills, a strong mathematical foundation, and an ability to understand and visualize the objects represented (Lewis, 1990). Unfortunately, not everyone has these skills. Therefore, CAD has become an attractive visual communication tool for today's generation.

The fundamentals of design in the digital age advance computational design and digital fabrication using 3D printers, CNC machines, and laser cutters. These fabrication tools require formal objects to be designed or drawn via computers. While many design educators hesitate to introduce digital tools in their beginning design curricula, projects in design studio courses mandate that students use computers as a basis for processing their designs. Therefore, digital form-making has affected design communication education. In one of Borhani's (Personal Communication, 2017) conversations with his first-year architecture students, he described asking them what they would most like to achieve in their first year; 9 out of 10 students responded "learning software." Seductive photo-realistic computer-generated images confound young designers, convincing them of infinite design possibilities (Carraher, 2011). As they wished, these beginning design students learn countless programs in the course of their education. Unfortunately, each program has its own capabilities and constraints; therefore, students must invest a significant amount of time, from the very start, just to learning how to maneuver these software products.

Case Studies

To determine the impacts of computer-aided software as a means of introducing architectural drafting to beginning design students, two case studies were analyzed and the existing body of literature on the topic evaluated. Conventionally, design communication courses, as part of the core curriculum, have taught students to develop designs from simple sketches and create freehand perspective drawings of the environment or still objects (Lee, 2016). In many cases, these develop into analytical drawings that students can use as study tools for conceptualizing their own designs (see Figure 1). These courses emphasize the effectiveness of high-quality drawings, horizontal and vertical projections producing orthographic views that use proper line weights and types. This is now known as “legacy” content because it belongs to the traditional curriculum (Presnky, 2001). In this curriculum, one must “know the basics” of technical drawing and manual drafting before being introduced to CAD (see Figure 2).



Figure 1: Student sketches from a manual drafting-focused design communication course (courtesy of Tung Nguyen, Texas A&M University).

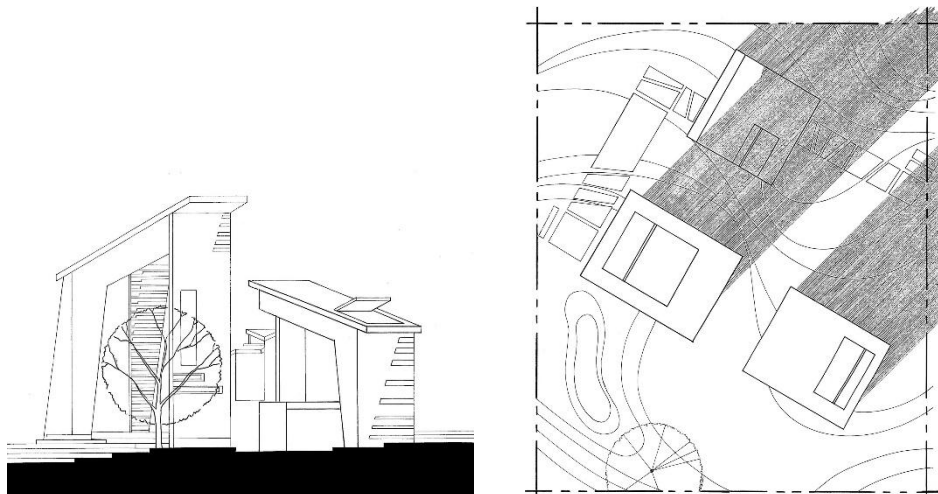


Figure 2: Student elevation and site plan from a manual drafting-focused design communication course (courtesy of Tung Nguyen, Texas A&M University).

Manual drafting requires knowledge of the timeless principles of design drawing; it develops cognitive thinking skills, helps students gain a greater sense of artistry, develops abilities in spatial awareness,

and allows the designer to feel a sense of ownership in their design (McLaren, 2008). It is not, of course, for everyone. Special skills are required to produce high-quality drawings. Since individual techniques and quality outcomes are significantly aligned, beginning designers tend to be highly motivated, yet often discouraged (Bhavnani & John, 1996). In our observation, manual drafting helped students experience both good and bad hand-drafting techniques, developing in them a deeper understanding of the meanings behind the lines and symbols on the page, and growing their ability to visualize and have mental conversions with three-dimensional spaces. After a full semester of manually producing all of their design drawings, the students were introduced to CAD exercises. This slowly converted their drafting media to a digital format. As Leopold, Gorska, and Soby (2001) expressed, students who develop problem-solving skills through descriptive, hands-on drafting have improved spatial abilities.

As stressed above, for many years design educators have debated where and how digital tools should be incorporated into the curriculum (Carraher, 2011). Similarly, for over a decade, members of the Association for Computer Aided Design in Architecture (ACADIA) have argued that the 21st century contents of design communication should solely depend on digital media (Clayton, 2006). The Environmental and Interior Design program at Syracuse University decided to test a similar notion by removing traditional design communication courses and reformatting them to focus on computer software. The first semester emphasized AutoCAD 2D, Sketchup, the basics of Rhinocera, and the Adobe Creative Suite. The second semester featured a more complex application of Rhinocera and Revit, as well as rendering programs such as Keyshot.

The first course was formatted to introduce CAD operational exercises and teach students about the purposes of drawings and concept of projections. Students attempted to learn orthographic views using AutoCAD and the significance of line weights and types by manipulating layers in plot styles (see Figure 3a). CAD was capable of producing precise drawings with a minimum amount of effort, so long as the students fully grasped the capabilities of the program (McLaren, 2008). When learning 2D AutoCAD drafting, the students used the overlay with vertical projection methods but did so digitally (see Figure 3b). As Kashef (1990) discovered in his quasi-experimental research, there were no significant differences in students' understanding of pictorial and multi-view drawings in manual versus digital drafting courses.

Rhino and Sketchup gave the students new ways of discovering forms and auto-drafting orthographic views (see Figure 4a). With Revit, the students were just clicks away from creating elevations or building and wall sections. Various plug-in software packages and Autodesk Cloud helped them to create photo-realistic rendering images (see Figure 4b). This reduced production effort and accelerated their activities. In contrast to individual drafting, everything was automated. More information was collected to support design their decisions, but there was an insufficient amount exploration of what was being provided. They were fed quick and seductive computer-generated images (Carraher, 2011). At the same time, much effort was spent on acquiring the extensive experience needed to properly maneuver the software (Clayton et al., 2011). The beginning design students spent more time learning about the technical aspects of certain software products than cultivating ways to design. In addition, there were new plug-ins and constant updates, meaning that it was difficult to keep up.

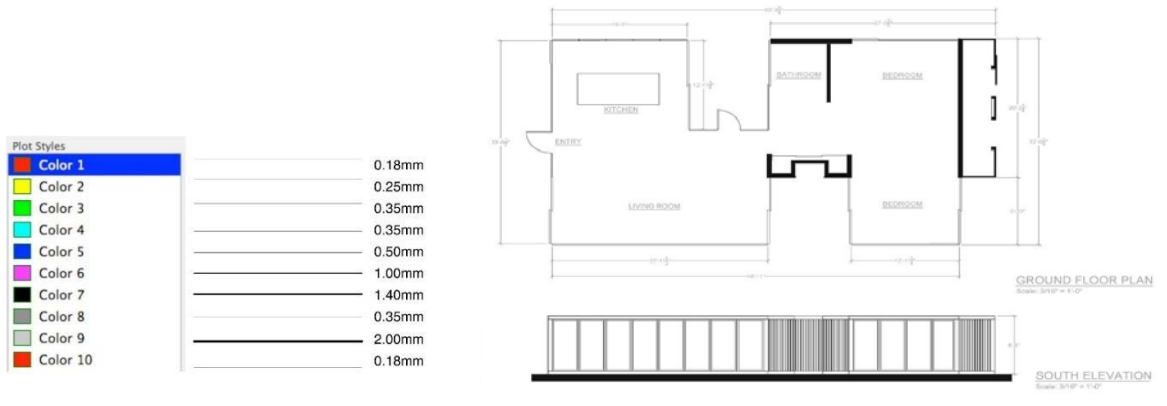


Figure 3a: Screen capture of AutoCAD Pen Styles window (left); 3b: 2D AutoCAD plan and elevation drawing (courtesy of Erin Toy, Syracuse University).

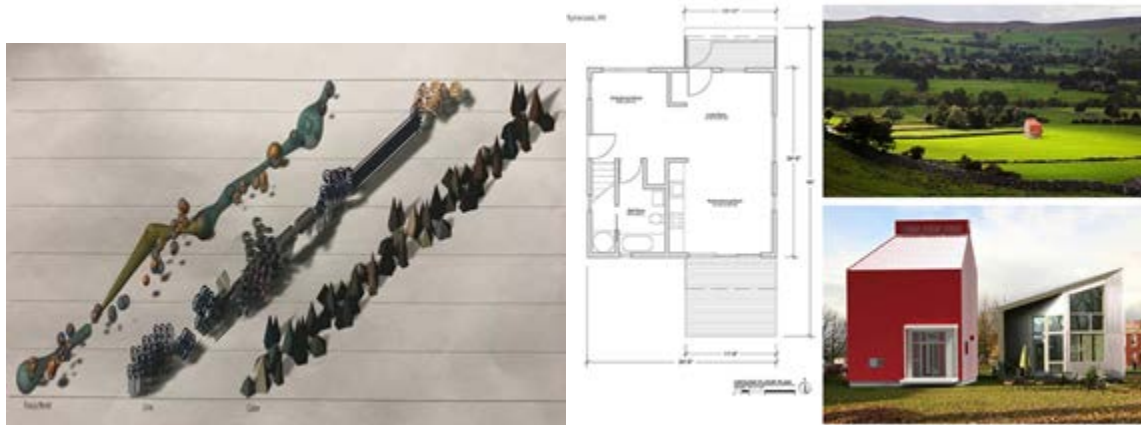


Figure 4a: Rhinocera 3D form study image (courtesy of Yeyan Xu, Syracuse University) (left); 4b: 2D AutoCAD plan and 3D rendering images from Sketchup and Keyshot (courtesy of Ziyao Li, Syracuse University).

Most problems arose due to a lack of knowledge of the software and general drafting conventions. As the students rotated their models, they commonly asked “which side is the [blank] ‘elevation’?” Since it was a matter of clicking and unclicking boxes, they also asked what information should be included in a particular drawing. Everything was just “views.” In most cases, students could not differentiate between plans and plan perspectives. Their Revit-produced automated drawings were riddled with drawing tags. Since much practice was required to become comfortable with maneuvering the software, students did not have the time necessary to fully foster an understanding of basic drafting principles. Their lack of technique resulted in poor quality overall. Over time, their software skills improved, but their ways of utilizing drawings as design tools did not. While the photo-realistic imagery provided a false sense of construction, the students lacked the cognitive skills needed to analyze the elements identified by the lines and symbols.

Conclusion

During the National Conference for Beginning Design Students at University of Cincinnati, several discussions led to the concerns for the diminishing of the manual drafting and sketching. As we have experienced in our program, many other schools were having the similar issues. Many beginning design students were limiting themselves in design exploration, because they could not figure out how to generate or study forms and space in computer software programs as they intended. By the time they

become comfortable using various software programs, they would lack the understanding of “designing” as a process, and see design as a product only.

Beginning with the next school year, the design communication courses in the Environmental and Interior Design program at Syracuse University will be resurrected and employed as a balanced curriculum emphasizing traditional drafting for the first semester. The focus will be on the principles of projecting multi-view drawings and perspectives. Then, CAD drafting using various software packages will be introduced in the second semester. This will improve students’ thinking and encourage them to take better care of and more ownership in their design work. The debate over whether architectural design is art or science has, at various levels and times, received a great deal of attention. It is likely that this oscillation in design communication between both types of media will also continue among design educators (Senyapili & Basa, 2006). However, regardless of how powerful the digital tools are, they will not completely eliminate the need for hand drafting.

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