PERSPECTIVES ON DOCUMENTATION STANDARDS IN DESIGN EDUCATION: A STRATEGIC APPROACH TO AUTOCAD IMPLEMENTATION

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1 ABSTRACT

Landscape architects have many software options for computer-generated construction documentation output. A recent survey of 482 ASLA members found AutoCAD most prevalent, with 82% of respondents using it on a daily or weekly basis (George & Summerlin, 2019). Despite its widespread use, landscape architecture students often must implement a trial-and-error approach in school or use on-the-job training upon graduation to achieve program proficiency. One threat to student learning is a lack of program proficiency amongst instructors, which may threaten effective communication in using AutoCAD for graphic production and documentation workflows. In light of these challenges, the University of Georgia College of Environment and Design (CED) implemented college-wide AutoCAD (CAD) graphic standards. The standards create a common language that is utilized by students and instructors to collaborate on graphic production and quality. Borrowing from standards used in professional practice, the college-wide standards familiarize students with basic AutoCAD concepts used in the industry and teach students how to use AutoCAD for interdisciplinary design collaboration and production of construction documents. This paper shares knowledge on the implementation of AutoCAD graphic standards in an academic setting. Additionally, we explore the foundational principles behind the standards and their application to design studio pedagogy. The investigation includes a varied assessment of the standards through case study, expert, and survey methods. Survey results show that 86% of respondents believe that the CED AutoCAD Standards helped improve their graphic output at least moderately, and 80% believe that the standards at least moderately improved their productivity upon graduation. Overarching findings reveal the importance of exposure to documentation standards while in school, as well as considerations for future application.

1.1 Keywords:

AutoCAD, documentation, professional practice, landscape architecture

2 INTRODUCTION

AutoCAD (CAD) is the most commonly used software program for documentation in the landscape architecture industry. However, literature reveals a steep learning curve to obtain proficiency in the program (Hamade, 2011; Mohler, 1997). During the early stages of CAD adoption, a window of three weeks to six months was projected before the CAD user could develop commercial proficiency (Philak, 1992).

This study explores the adoption, use, and assessment of applying AutoCAD standards in an academic environment at the University of Georgia's College of Environment and Design (CED.) These standards were adopted in the hope of reducing the AutoCAD learning curve, improving quality of graphic output, and preparing students for professional practice.

Development of the CED AutoCAD standards began several decades ago as a graduate thesis which tested two different pedagogical methods. Findings from this thesis were used to develop CAD standards for a large land planning firm and in teaching AutoCAD to landscape architecture students at the University of Georgia.

Over time, college administrators determined a college-wide CAD standard could be an effective pedagogical tool. The CED CAD standard was created with the goal to improve the graphic quality of student work and provide consistency in CAD instruction. It was also hoped that by using the standard students would develop a greater understanding of the collaborative nature of how CAD data is used in landscape architectural practice.

The process of creating a school-wide CAD standard began by evaluating the CAD standards that faculty members had used individually in practice. The National CAD Standard (United States National CAD Standard, n.d.), The National Park Service guidelines for design and construction drawings (National Park Service, n.d.) and a chapter from *Landscape Architectural Graphic Standards* were also used to develop a more robust framework. The CED CAD standards were implemented in the 2015-2016 academic year. It is a living document which is revised every year based on feedback from instructors and students.

What follows is a highly technical level case study of the software components of the CAD Standard and its applicability in an academic setting. In an attempt to determine the effectiveness of the standard, an informal survey was conducted of Alumni to assess their perceptions of the Standard and its impact on their academic and professional experience. Results from this survey are discussed along with the opinions and experience of faculty experts who have created and used the system both in professional practice and in the classroom at the University of Georgia. Finally, we conclude with a discussion of what implications this study might have for future iterations of the CAD Standard and implications for future research.

3 LITERATURE

Problem solving is defined as attempting to reach a goal with an unknown methodology (Wærn 1989). Optimally, the individual is able to represent all of the various options available to them and then assess which options will assist them in reaching the goal (Anderson, 1980, Rassmussen, 1990, Wærn, 1989). The problem space of a computer system such as AutoCAD encompasses all the possible command options for that system (Wærn 1989.) Users of the system face several threats which prevent optimal problem solving. These are previous experience, applicability to the task at hand and the amount of effort required to reach the goal state (Wærn 1989; Wærn 1990; Shaw,1990; Schindler and Schuster, 1990; Briggs,1990).

Top-down training helps address these threats by teaching the system as a set of domain specific tasks which can be used as a problem-solving heuristic (Rassmussen 90, Wærn 90.) Bottom-up training provides the user a set of rules which the individual must determine how to apply to arrive at the goal state (Rassmussen 90, Wærn 90.) Research by Longenecker (1997) tested how well individuals receiving the different training methods performed on a problem-solving activity. Results from this study indicated that bottom-up training produced a significantly higher level of proficiency on the study measures. Individuals who were allowed to experiment with a set of rules appeared to be more adept at applying this knowledge to a new situation. It was hypothesized that the top-down training hindered problem solving activity by providing an incomplete or incorrect heuristic.

Bottom-up training is an effective way to learn if the system's user interface is consistent (Schindler and Schuster 90.) Top-down training is effective when it provides the user with a set of operators to arrive at a desired goal state (Anderson, 1980; Rassmussen, 1990; Wærn, 1989). Allowing individuals to experiment with a set of consistent and reliable operators can help aid skill development (Rassmussen, 1990). Given these findings, would it be possible to combine the training techniques by creating a consistent, rule-based system of AutoCAD training that is applicable to landscape architecture students' domain of knowledge?

This paper is a preliminary and informal attempt to assess the impact of such a system. For the last six years, AutoCAD production standards have been developed and implemented in the Landscape Architecture curriculum at the University of Georgia. The standards have been created in a manner which relates to faculty understanding of current methods in professional practice – thus attempting to provide domain specificity. Finally, the standards attempt to provide a set of tools and methods which can be consistently applied and experimented with throughout the curricula.

4 RESEARCH OBJECTIVES

While the CED CAD Standards have been in place for approximately five years, this approach has not been shared beyond the college. We believe that lessons learned from this extensive effort would be helpful to faculty and institutions outside of the University of Georgia. However, in order to share this knowledge, we felt that it was first important to explore various facets of the implementation and effects of CED CAD Standards. Therefore, the purpose of this study is to answer the following questions:

1. What do the CAD Standards consist of, so that they might be implemented at other institutions?
2. How is the implementation of AutoCAD Standards in an academic setting perceived by various internal perspectives?
3. How do alumni of the school perceive the effects of the CAD Standards on quality of work while in the program?
4. How do alumni of the school perceive the effects of the CAD Standards on productivity after graduation from the program?
5. What might be modified in the AutoCAD Standards to suit the changing needs of design students?

By answering these questions, we hope to shed some light on how digital documentation standards can be applied in an academic setting. Various perceptions of the CAD Standards are investigated for a transparent look at the benefits and setbacks of this approach.

5 METHODS

A number of methods were used to investigate the research questions, including a case study of AutoCAD standards as an intervention within the academic environment, the expert method, and an online survey distributed to program alumni. These methods relate to identifying perceptions of the benefits, setbacks, and potential further applications of the CAD Standards.

5.1 Case Study

A case study is a strategy of investigation which can be appropriate when a study focuses on variables of interest rather than data points (Yin, 1994). This research presents a case study of the application of AutoCAD design standards within an academic setting, serving as an overarching method under which the expert method and a survey are applied. The use of multiple methods within this case study results in complementarity, where findings from each approach provide a more elaborate look at the use of CAD standards in the context of a higher education teaching and learning environment. By analyzing the context and application of CAD standards through this exploration, a roadmap is created for execution of similar CAD Standards in landscape architecture and design programs outside of the UGA CED, revealing the college's methodology for successfully creating and executing design documentation standards.

5.2 Expert Method

In order to share knowledge related to the implementation of CAD Standards in an academic setting, it is important to explore the various academic perspectives that provide insight into the execution and applications of the standards. The expert method is based on opinions and assessments of competent individuals in a topic, in this case, those who've witnessed and personally carried out the graphic documentation standards. It helps answer the research question related to how the implementation of AutoCAD Standards in an academic setting are perceived by various internal perspectives. The method is effective when decisions need to be made, sometimes in relation to innovations in education including the pedagogical process (Iriste & Katane, 2018). The method is appropriate for this study considering the decision to apply CAD and similar standards in an academic setting may be significant for other landscape architecture and design programs. Our article provides key insights through four academic perspectives: 1) A teaching and professional practice perspective, where the expert has over 30 years of experience using the program, has worked as a CAD Manager at a major landscape architecture firm, who regularly teaches construction documentation courses in higher education, and whose Master's thesis explored the use and implementation of CAD Standards; 2) An academic professional perspective, where the expert has used AutoCAD for over three decades, has a 20 year career as a CAD Manager, including for two offices of a major landscape architectural firm, helping establish the company-wide CAD standards and who wrote the CAD and Construction Documents sections of the popular construction documentation reference book Landscape Architecture Graphic Standards (Hopper, 2007); 3) A new academic perspective from an individual who recently switched to the academic realm from professional practice with over a decade of experience using both AutoCAD and BIM software programs, regularly teaches construction documentation and graphic communication courses at the higher education level, and whose research incorporates the intersection of landscape architecture and technology; and, 4) An administrator perspective from an expert with 25 years of experience using AutoCAD who has been teaching the software since 2001, has overseen decisions related to technology within the college, and whose research has incorporated technology and landscape architecture. These perspective opinions are written by the authors of this article and share the various discernments of each role.

5.3 Survey

In order to answer three of the research questions related to perceptions of quality of CAD drafting while in college, productivity of graphic output after graduation, and the needs of design professionals related to the CED CAD Standards, an online survey was distributed to 131 alumni of the College of Environment and Design. Alumni were located via the social media platform LinkedIn, where they were current contacts of the research team during the time of data collection and had the term *UGA College of Environment and Design,* or *UGA CED*, in their profile. The survey was created using Qualtrics software and distributed individually to potential respondents using LinkedIn's messaging system. Survey results were open-access and anonymous, though the survey could only be taken once by each respondent. Survey questions are as follows:

1. Did AutoCAD (CAD) Standards exist in the College of Environment and Design (CED) when you were enrolled in the program?
2. Did the CED CAD Standards help improve the quality of your graphic output while in college?
3. Did the CED CAD Standards enhance your productivity when you entered the professional world?
4. Does your work office currently use AutoCAD Standards?
5. How important is it that landscape architecture students learn to use digital drafting standards?
6. Please provide any additional information you'd like to share related to the implementation of CAD Standards during college.

The survey was distributed individually to each alumnus over the course of approximately one week and was open for responses for an additional week. The study was preliminarily reviewed by the UGA Institutional Review Board IRB and did not qualify as human subjects research.

6 CASE STUDY CAD STANDARDS INTERVENTION RESULTS AND DISCUSSION

The CED CAD standards are comprised of a series of AutoCAD drawing templates, including both .DWG and .DWT formats, that contain the elements of the standard, as well as a user guide with an overview of the use of these elements and installation on student's computers. Templates are included for decimal, architectural, and metric unit drawings. The standards are housed on a CED website for easy access by students and instructors. The website also contains instructional videos and CAD-related downloads, including annotatively-scaled blocks, such as detail titles and reference call-outs.

The standards are introduced and presented to students in a classroom setting in their first year in the landscape architecture program, and then subsequently are incorporated into expected class output throughout the curriculum. Students make use of the standards by installing the .DWT template files on their machines, or by opening one of the .DWG template files and using SAVEAS to place a copy in their project folder, thereby maintaining the template in original form. Instructions for both methods are included in the user guide. The user guide includes depictions of the components of the standards, a predefined page-setup, for example, along with explanatory text describing the page-setup. Students learn to navigate the software and read the ‘syntax’ of the standards through these examples, which also provide instructors with prompts for classroom presentation. The templates contain the elements of the standards. From standard layer names, to preloaded linetypes, to titleblocks created using attributes for editable preformatted text, to annotatively-defined text and dimension styles, all components are predefined in the templates, creating a simple solution for students new to AutoCAD. When students are assigned a specific task or product, such as a layout plan, for example, the components required are at-hand, providing a task-specific educational opportunity, which has been shown to be effective in software instruction (Gray, 1990).

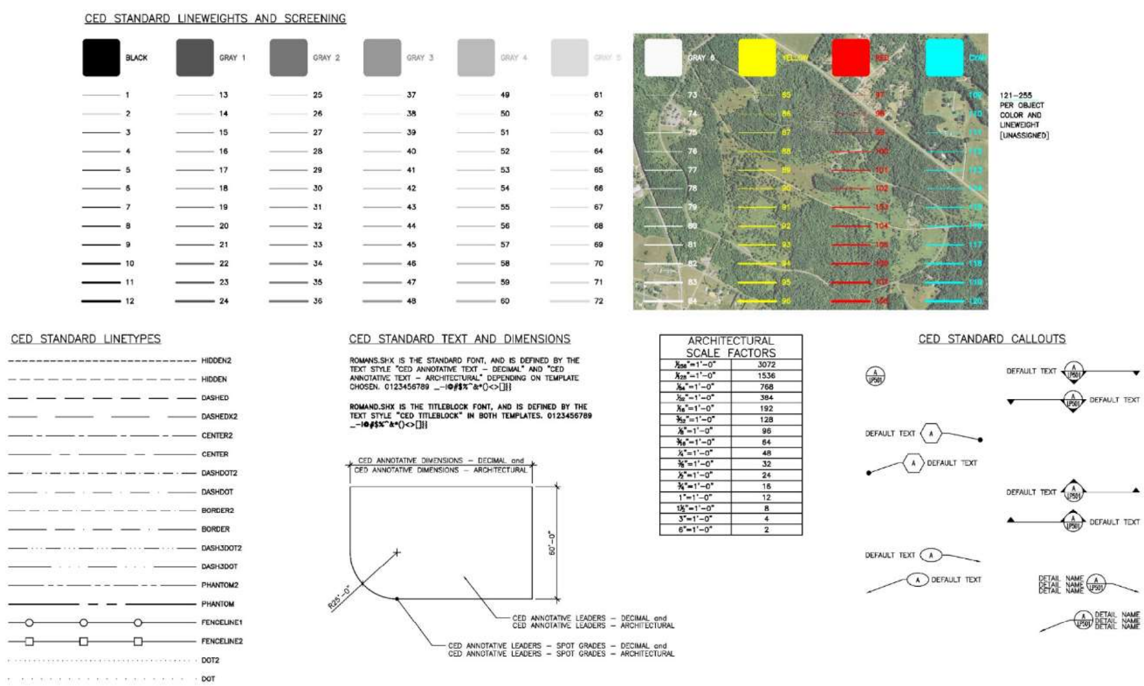

Figure 1: Summary poster describing main elements of the CED CAD Standard, from the User's Guide.

The standards are designed to improve students’ graphic products and enhance the instruction of design communication by addressing the typical stumbling-block issues encountered in CAD use, particularly by new users, based on our observations of student progress. In so-doing, the standards present students with a professional-level example to follow when, for example, they are creating titleblocks or labelling a planting plan. Students learn what is expected in a titleblock by entering the information prompted by the standards examples. They learn to recognize what text size is appropriate for a planting plan by using the included styles, and the standard is designed to reinforce their understanding of scale by using annotatively-defined text and dimension styles. Throughout the standard, included elements not only give students an indication of graphic expectations, but also give instructors a direct way to show these expectations. The intent of the standard is to show students how to communicate graphically, to navigate a CAD standard similar to what they will likely encounter professionally, and to use new software. We believe addressing these technical aspects in the standard improves efficiency by allowing focused studio instruction on the crafting of a wall detail or grading plan, for example, and not the creation of a text style or a layer-naming system.

Text, dimension, and multi-leader styles are defined by the standards. Typical of comparable standards, the CED uses .SHX fonts (AutoCAD native fonts) for maximum compatibility. Annotatively-defined text styles are included for decimal, architectural, and metric-unit drawings. Annotatively-defined items in AutoCAD are those which respond to viewport scale automatically. As opposed to creating text or dimension styles for each scale that might be needed, with the text or dimensions sized based on that scale-factor, annotatively-defined objects adjust to the viewport scale. The standard is a tool that shows students how to navigate these kinds of objects in model-space and paper-space (layouts) by following the prompts given, and thereby gain proficiency using this aspect of the software while also grasping the impact of scale in their drawings. Text, dimension, and multi-leader styles are included for the three template formats (decimal, architectural, and metric units), as well as a specifically defined multi-leader style for grading plans and a text style for use in paper-space.

Titleblocks are likewise included and are a primary visual element of the standards. Each template in the CED CAD standards includes saved page setups defined for sheet sizes from 8.5"x11" up to 36"x96". Each of these page setups includes a titleblock defined both vertically (along the narrow edge of the sheet) as well as horizontally (along the long edge of the sheet). The standard page setup uses the Autodesk DWG to PDF plot device, so that all output is created as a .PDF file for maximum compatibility. Titleblocks are all defined as AutoCAD blocks, with the titleblock text defined as attributes of the block. Students modify the contents of the text using the AutoCAD attribute editor. Block Attributes in AutoCAD are text placeholders that are defined as a part of the block, but remain editable independently, while maintaining their graphic properties. Font type, size, orientation, and so forth is retained as students edit the content of each text entity. Once again, students are not only learning professional graphic expectations by example, they are also learning to master AutoCAD by working with the elements included in the standards, as is shown through observed and documented progress in courses that incorporate AutoCAD Each titleblock includes a separately-defined scale bar and north arrow block, with increments on the scale bar included as attributes of that block for adjustment as needed.

The standards make use of Color-Dependent Plot Style Tables (.CTB files) rather than Named Plot Style Tables (.STB files), as this is more common in professional practice in our experience, and in reference standards such as the previously mentioned National Park Service guidelines (National Park Service, n.d.). Color-Dependent Plot Style Tables allow each AutoCAD standard color number (1 through 255) to be assigned a line weight and a shading value, along with many other aspects. This method of defining and setting lineweight and value harkens to the days of the use of technical pens and ink-based hand drafting, in which each technical pen's width was identified by a color band near the nib. In AutoCAD, every color can be assigned separately, creating a wide range of possible weight and value combinations. The CED standard .CTB file is setup with a recurring sequence of twelve lineweights, from hairline to sheet border thickness. The lineweight sequences are established to plot as full black, as six shades of gray, and as yellow, red, and cyan. The first 120 AutoCAD colors are defined in the system, with the remaining open for any necessary customization outside of this range.

A layer naming system can be considered critical in a formal set of CAD standards, as layers are the primary organizational element of CAD data. The CED CAD standards employ a system commonly seen in professional practice that is based on the National CAD Standard. The naming formula begins with a single character Discipline Designator, followed by a four-character Major Category or Group, then another four-character Minor Category or Group. If additional layer breakdown is required, the standards prescribe adding additional four-character designations. A Status or Phase Category is sometimes required, represented by a single character (e.g. X for existing conditions) at the end of the layer name. Thus L-PLNT-TREE-STRT would be an appropriate layer for street trees, L-SITE-WALL would contain wall information, and L-SITE-WALL-X existing wall linework. The organizational schema for layer naming is clearly defined, while allowing a great deal of flexibility for individual project or drawing needs. Lineweight is set by color as we employ a .CTB based system, so object color is always set to BYLAYER individually, so that the layer color setting ascribes a lineweight to all elements on a given layer. Likewise, linetypes are always set to BYLAYER for individual elements, so that the layer setting applies. Lineweight is individually set to BYLAYER (although left as "default" in the layer settings), as is Transparency. All of these are preset to be the default setting in the CED CAD Standard template files.

Table 1: AutoCAD Color assignments in CED CAD Standard

AutoCAD Color	Lineweight / Value	AutoCAD Color	Lineweight / Value
1	0.0508 mm Black	13-24	Repeat pattern at 75% gray
2	0.1778 mm Black	25-36	Repeat pattern at 50% gray
3	0.2794 mm Black	37-48	Repeat pattern at 40% gray
4	0.3810 mm Black	49-60	Repeat pattern at 30% gray
5	0.5080 mm Black	61-72	Repeat pattern at 20% gray
6	0.5588 mm Black	73-84	Repeat pattern at 0% gray
7	0.6096 mm Black	85-96	Repeat pattern in yellow
8	0.7112 mm Black	97-108	Repeat pattern in red
9	0.7874 mm Black	109-120	Repeat pattern in cyan
10	0.9906 mm Black	121-255	Unassigned
11	1.1938 mm Black		
12	1.5748 mm Black		

Creating construction details, although a seemingly simple task, involves several decision points that are addressed in the CED CAD standards. Tools and methods for sizing and scaling of details, along with aligning details on a sheet, are included in the standards. To address overall alignment on a sheet of construction documents, the standards include a grid as a part of the template. This grid is based on a 24”x36” (Arch D) sheet, divided into 12 cells in a 4x3 arrangement. The grid is used in paper-space (layout) to guide viewport placement. Corresponding to this alignment grid, the standards include a series of detail title and area blocks, used in model-space, that are sized to fit the cells in multiple ways. The standard detail is a 1 cell block, but as some details require more sheet area to be fully documented, blocks are included for cell arrangements of 1x2, 2x1, 2x2, 1x2, 1x3, etc. As with standard page setups, it is unlikely that the entire range of these options would be needed, but flexibility is key. These detail title and area blocks are inserted in model-space, and scaled up based on the scale factor of the detail (a scale factor chart is included in the standards). If a ¾”=1’-0” detail is needed, the block is scaled up by a factor of 16. The details are drawn using CED standard annotatively-defined text and dimensions, so callouts adjust automatically, while the title and area blocks are created using standard text, so that the title text scales appropriately when the block is scaled. The text in these title and area blocks is created as block attributes, and is editable just as the text in the CED standard titleblock. For a drawing with multiple detail scales, the Annotation Scale setting is adjusted based on the detail being edited. When editing a detail at ¾”=1’-0”, the Annotation Scale is set to ¾”=1’-0”. When editing at 1”=1’-0”, the scale is likewise set to correspond. Text in the title and area blocks is unaffected, as it is a non-annotative block attribute, while text and dimensions describing the detail adjust accordingly because they are defined as annotative objects.

The standards include several additional components designed to address stumbling-blocks before they are encountered. Students often struggle, for example, in visualizing the area in model-space that their viewport will display at a particular scale. Viewport area blocks for each sheet configuration and size are included in the standards. These blocks are inserted in model-space, then scaled up according to the intended scale being explored. To determine sheet area for a 24”x36” sheet with a vertical titleblock at 1”=20’, students insert the correspondingly sized viewport block, scale it up by a factor of 20, and then move it around to visualize what can be displayed on that sheet. Further, once all adjustments are made, the student can create and save a view, using the corners of the viewport block in model-space that they then restore in their paper-space (layout) viewport. As the viewport block is an exact duplicate of the viewport in paper-space, scale will be set appropriately when the view is restored and has the added benefit of being saved in the file. Therefore, if the viewport area is reset, simply restoring the view corrects the problem. When laying out complex sites that require multiple sheets, such as a streetscape, this visualization tool becomes particularly useful.

Another useful tool for removing potential stumbling-blocks includes several typical plan and detail reference callouts within the standards. These callouts are created as annotatively scaled blocks with editable attributes. Since the entire block and included attributes are defined as annotative objects, when the callout is inserted into a drawing, it automatically sizes appropriately according to the Annotation Scale setting. If it is determined that the layout and materials plan, for example, is better documented at 1”=10’ rather than 1”=20’, simply changing the Annotation Scale setting corrects the size of all the callouts.

Linetypes and hatch patterns are preloaded in the templates, removing another obstacle for new-users while also providing instruction via demonstration on additional features of the software. Linetype scaling is universal, so individual object linetype scales are always set to 1 and the global variable LTSCALE is used for fine-tuning. A default setting of 0.35-0.50 is recommended. MSLTSCALE and PSLTSCALE variables are both set to 1 by default, so the overall linetype scaling always responds to the Annotative Scale setting when in model-space, and the viewport scale when in paper-space. Hatch patterns are defined annotatively, so just as with the text, dimensions, and linetypes, the pattern density responds to the Annotation Scale setting. This is not always the best application of hatch patterns, so flexibility is allowed. CED students are required to take a professional internship as a part of their studies which can serve to reinforce the use of standards.

7 EXPERT AND SURVEY METHOD RESULTS AND DISCUSSION

Two methods were used to explore the use and perceived impact of the CED AutoCAD Standards, including the expert opinions of several faculty members who carry out and put into practice or witness the use of the CAD Standards with students on a regular basis, as well as a survey distributed to alumni regarding experience with the CAD Standards. The following sections outline the results of these two investigations. First, the section highlights the experiences of the authors with the implementation of the CAD Standards, incorporating a variety of academic and professional perspectives. Then, quantitative and qualitative data findings from the survey analysis are shared.

7.1 Academic and Professional Perspectives on the CAD Standards

7.1.1 Teaching and Professional Practice Perspective

CAD Standards in a studio setting accomplishes several goals to preparing students for professional practice. First, it helps close the gap between expert and novice knowledge. By preparing detailed instructions which thoroughly explain all of the various steps involved in creating CAD output, “…the expert learner’s implicit knowledge..[is]… made explicit in order to be accessible to the novice learner.” (La, Dyjur, Bair, 2018)

Secondly, it provides an opportunity for deliberate practice. Deliberate practice creates an opportunity to practice a skill in an environment which simulates reality (Grenny, 2017; Ericcson and Charness, 1994). Requiring landscape architecture students to utilize a CAD standard as the means for producing documents which successfully combine data from an outside source with their original design concepts replicates many facets of landscape architectural professional practice.

Using this set of explicit directions and allowing students to practice applying these tasks in a manner simulating professional practice has helped integrate application of CAD software in the studio. It provides the instructor with the opportunity to place more focus on design education in their pedagogical approach. It also assists many students in successfully transitioning their productivity from the academic studio to the landscape architectural office.

7.1.2 Academic Professional Perspective

Preparing students to enter practice with a professional degree requires not only reaching educational goals in the studio, but also continuing support outside the studio in the application of these new skills and abilities. Using the CED CAD Standard in the digital graphics sequence allows for rapid advancement into the production of “good-looking” documents that the students are proud of, and this motivates them to keep learning and push through the more difficult aspects of the software. The standard is used as a teaching tool for AutoCAD itself, as well as professional expectations.

In providing support outside of the studio, the standard often helps students structure their questions or frame the particular problem they’re having, aiding in the process of guiding them to the solution. If there is a lineweight issue, for example, students will generally present a checklist based on walking through the standard, “I’ve checked the .CTB, I’ve made sure the page setup is correct…” and so forth, and often they’ll discover the error on their own in this process… “oh, the color isn’t set to BYLAYER” or something similar. This provides the potential to instill confidence in the use of a complex tool with encouragement from progress made.

Using the standard also addresses many common output issues that are a notorious source of technical support frustration. Students create .PDF files by default when using the standard, which of course are quite ‘portable’ and easy to send to a printer, email to an instructor, or to use in other graphic or page layout applications.

7.1.3 New Academic Perspective

AutoCAD and other documentation programs are applied in landscape architecture instruction in various contexts. For example, AutoCAD may be used in a studio course to create a site base plan, in an advanced graphics class as a foundation for more complex modeling and visualization, and in an implementation documents class as the primary platform to communicate design intention for construction purposes. As a newer faculty member who teaches computer-aided design in all these contexts, the CAD standards serve as a common thread throughout my courses. As a result, I spend less time teaching basic CAD knowledge because the students have a set standard and instructions to always refer to, with other faculty members and IT professionals also familiar with the expected CAD output.

Differentiation in instruction can benefit students and instructors when the topic being taught is subjective, such as design or planning. Here diverse expertise from different faculty members over various courses may strengthen student learning outcomes since the knowledge builds and take different shapes. However, for technical-based skillsets such as basic AutoCAD applications, disparity in instruction can potentially lead to confusion by the student, and too often students may be left to figure out the rudimentary steps in a computer program needed to execute their assignments. This is particularly true if a faculty member is not proficient in the programs needed to complete the work. The CAD Standards serve as a safety net for both faculty and students and provide a clear expectation for quality output and a clean CAD process.

7.1.4 Administrator Perspective

Perhaps the most important outcome since adopting the standards is an improvement in instructional consistency when it comes to teaching AutoCAD software. Because of our large undergraduate program, freshmen students are divided into three or four different sections of digital graphics each academic year. Each section is taught by a different faculty member or teaching assistant whose knowledge, experience, and familiarity with AutoCAD varies to some extent. The variations impact instructional consistency in terms of content and method. Before the standards were adopted, it was not uncommon for students to exit the class with good foundation in digital drafting, but students in different sections and in some cases students from the same class would set up drawing standards or execute AutoCAD commands differently as they moved forward in the curriculum. The lack of consistency caused unnecessary confusion and frustration amongst students and faculty in subsequent classes where AutoCAD was used as part of the graphic workflow.

While the introduction of the AutoCAD standards has not eliminated these issues entirely, the standards have initiated a level of teaching consistency that has reduced the occurrence of competing workflows and subsequent confusion and frustration that this causes. Because many of the survey respondents indicated the standards were just being implemented during their time in school, it is too early to conclude that the adoption of the AutoCAD standards has improved the quality of student work. However, the survey results overwhelming show that students agree that having knowledge of digital drafting standards is important as the vast majority use some type of standards in professional practice. Finally, just over 75% of survey respondents agree that the AutoCAD standards did enhance their productivity when they entered the workforce.

The next challenge is to implement the standards beyond the foundation classes and embed them throughout the entire undergraduate curriculum. This will require that studio faculty become familiar with the standards and require their use during class each semester. Only with consistent reinforcement and repetition will the full impact of the AutoCAD standards become apparent through the work our students produce while in school and after they graduate.

7.2 Survey Results

The survey received a 45% response rate, with 59 respondents out of the 131 alumni distribution. Of those who responded, 49 indicated that the CED AutoCAD standards existed while they were enrolled in the landscape architecture program at UGA, while 10 respondents did not have the standards in place. The survey was distributed to a wide-ranging age demographic of program alumni, and this reveals the variety of respondents. Furthermore, 83% of respondents specified that they have AutoCAD standards in the office where they currently work, suggesting that most respondents are familiar with the use of AutoCAD in a professional setting. Descriptive statistics were used to answer research questions related to the perceptions of alumni on various topics, and the qualitative assessment of an open-ended survey question helps to further define the research topic.

7.2.1 Quantitative Survey Results

Several survey questions used a likert-type scale to measure various potential effects of the CED CAD standards through the viewpoints of CED alumni. First, to measure the perceived relationship between the CED CAD standards and quality of graphic output while in college, we asked the question “Did the CED CAD standards help improve the quality of your graphic output while in college?”. Of those who experienced the CED AutoCAD Standards, 53% of respondents indicated that that the standards improved their graphic output either considerably or very much, 33% noted that it helped them moderately, and 14% slightly or not at all. Therefore, 86% of respondents believe that the CED AutoCAD Standards helped improve their graphic output at least moderately (*Figure 4*).

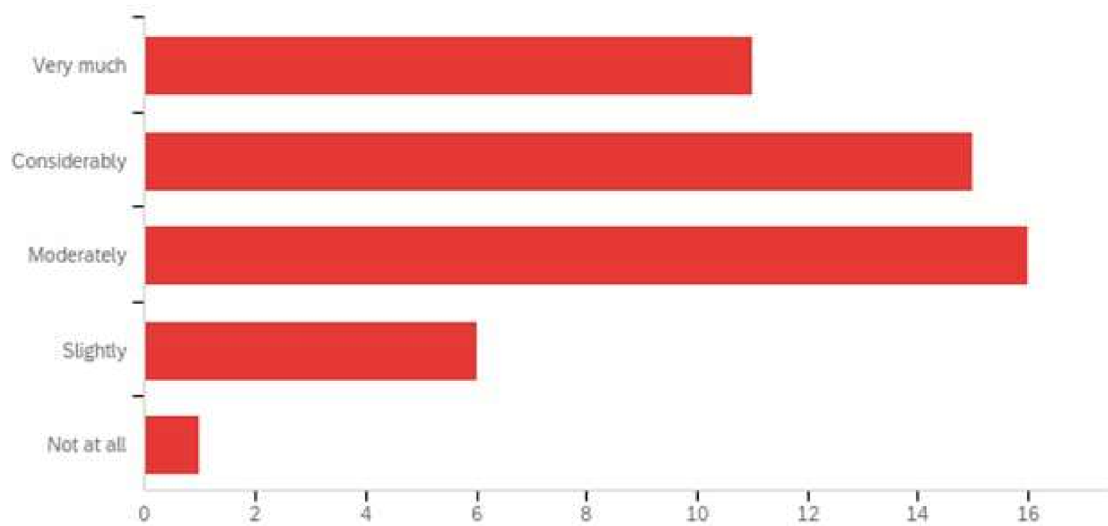

Figure 4: Survey response to question regarding if the CED CAD Standards helped improve the quality of the respondent’s graphic output while in college.

Another survey question measured the perceived relationship between having the CED AutoCAD standards while in the program and productivity upon entering the professional world. The question states, “Did the CED CAD Standards enhance your productivity when you entered the professional world?”. Of respondents who experienced the CED CAD standards, 45% indicated that the standards enhanced their post-graduation productivity either considerably or very much, 35% moderately, and 20% slightly or not at all (*Figure 5*). With an 80% response that the standards at least moderately improved their productivity upon graduation, we can conclude that the standards are, at a minimum, at least somewhat effective at increasing productivity when entering the workplace.

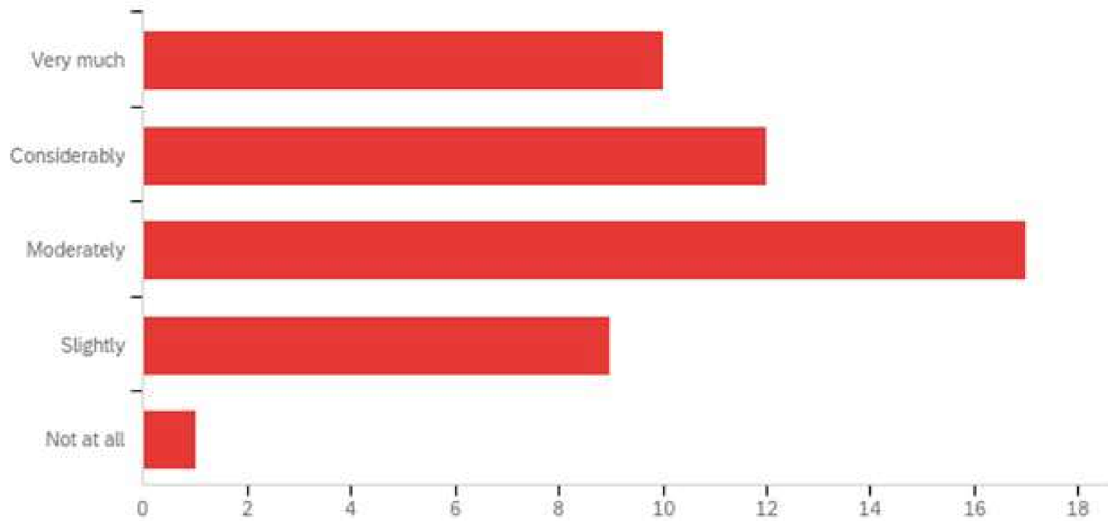

Figure 5: Survey response to question regarding if the CED CAD Standards enhanced productivity upon the respondent entering the professional world.

7.2.2 Qualitative Survey Results

Overall, the quantitative findings of this study support the continued use, and further reinforcement and development, of the CED AutoCAD Standards. Qualitative data strengthens this finding, revealing the perceived importance of introducing documentation standards in the college setting:

> "The standards definitely helped me learn CAD for the first time and learn the importance of standards in professional practice. Our standards were also very similar to those my firm uses now which made it much easier to pick up when starting my first job."

> "CAD Standards were one of the most important things I learned in school."

Four recommendations emerged through the thematic coding of qualitative survey responses using NVivo software. Qualitative data was gathered through the open-ended survey question, "Please provide any additional information you'd like to share related to the implementation of CAD Standards during college." While some responses spoke generally to the benefit of having standards introduced in the college setting, many provided recommendations for how to further enhance the use and effectiveness of the standards. Recommendations which received more than three open-ended comments and a significant focus within those comments are included in the list below.

1. ***Understanding AutoCAD basics well is important for student learning and future professional development.*** Respondents stressed the importance of introducing CAD standards to familiarize students with basic drafting and detailing concepts, commands, and functions, as well as file management, layer management, and how to work with annotative blocks. However, alumni respondents who highlighted the importance of basic knowledge also had recommendations for further CAD learning and reinforcement of concepts beyond an introductory class.

    > "Ultimately, they just need to learn the basics of CAD file management, layer management, and drawing cleanup tools. They will be able to adapt quickly to whatever office they go to."

    > "A standardized CAD curriculum - so students with a bad professor don't fall through the cracks - and/or a semester dedicated just to learning CAD would have been so helpful in school.."

2. ***More advanced concepts in AutoCAD and other documentation programs should be introduced.*** Several respondents mentioned more advanced concepts that they believe should be introduced in a more extensive CAD curriculum. These include an understanding of external references (XREFS), Layerstates, UCS, CTB versus STB standards, and the page and plot setup managers. These alumni indicated that AutoCAD and other documentation programs such as Revit could be taught more widely, rather than packaged with other programs in an introductory course.

   > "Xreffing is a huge part of CAD which I didn't learn until after college. Manipulating blocks, troubleshooting printing, sifting through absolute garbage files you receive.. Essentially the very non glorious, confusing and custodial work.."

   > "... a semester dedicated just to learning CAD would have been so helpful in school."

3. ***The CED CAD Standards should be more significantly reinforced within other classes in the curriculum.*** Many alumni who left qualitative feedback stated that CAD standards needed further reinforcement throughout the program. While having a set standard provides a platform for faculty and students to maintain consistent quality work in design documentation and other CAD applications, the standards are not required across the board like in a professional office setting. This was identified as a gap by survey respondents. Additionally, standards could be intentionally reinforced in a variety of classes to reach an overall goal of student CAD proficiency.

   > "I think continuing to learn and building upon CAD Standards throughout the curriculum would be very helpful. Learning basics in first year and building up those tools in each semester... would increase productivity in a professional setting."

   > "The standards were emphasized very little while I was enrolled... in my experience, among the first questions I have been asked when interviewing is "can you do CAD?", or something having to do with CAD competency."

4. ***Students should learn to work with multiple people on the same CAD file.*** When AutoCAD is first introduced to students in the CED, they experience the program for the first time and do not share files. Later in design studios and more advanced graphics classes, work is often parsed where one student is responsible for the CAD file. Survey respondents identified that the program could intentionally teach students the value of using standards by having them share files, thereby better preparing them for what they'll find in a professional setting.

   > "It's difficult as a student to understand the importance of CAD standards because to some degree you're working on your projects alone (more or less) … In a workplace, you're either helping or hurting your team."

   > "One thing I wish I experienced in school was "trading files"... When you are given a file from someone else you begin to see the value in a properly set up file."

8 CONCLUSIONS

The purpose of this study is to assess the impacts associated with the development and implementation of CAD Standards into the Landscape Architecture curriculum at the University of Georgia. The intent behind creating the standards was threefold: (1) better relate AutoCAD software to professional practice and student learning; (2) minimize confusion regarding software use and application; and (3) improve instructional consistency and quality of student work across the curriculum.

The CED CAD Standards are based on industry standards and best practices. By developing the standards in this manner, students are able to associate how the software is used in a professional design office to their ongoing design work while they are in school. The standards add relevance and explain not only how, but also why the standards are important to their professional development. Early findings suggest incorporating the standards has minimized confusion and has begun to improve instructional consistency across the curriculum. However, additional studies need to be conducted in order to fully assess whether or not the quality of student work has improved.

Future work on the CAD standards centers on the development of the next version. We treat the standard as a living document and there are several components that are scheduled for improvement. One area is the use of external references (XREFS). Survey results indicate that students and practitioners recommend incorporating XREFS in order to fully prepare students for work in a professional design office. One specific example under consideration includes prescribing a workflow in which all consultant files (e.g. architectural drawings, site surveys, etc.) are included as XREFS in the design base. Additionally, a workflow incorporating XREFS could be added to the construction detail instructions in the current standard. One final addition planned for the next version is incorporating a file and folder naming structure. Adding this component will reinforce the concepts of project collaboration, file sharing, and overall organizational skills related to project management.

Beyond AutoCAD, there are plans to expand the CAD Standard to include additional software students need to enter practice. Proficiency in the use of Building Information Modeling (BIM) software, such as Revit, is one of these needs. Additionally, some aspects of the CAD standards apply to the use of other Autodesk tools such as Civil3D or Map3D, but the specifics of these tools have not yet been addressed. Finally, standardization of the use of visual simulation tools (e.g. SketchUp, Lumion, etc.) is envisioned to be part of a future revision.

Future research should include longitudinal studies that look at student learning and change over time from the freshmen to senior year and possibly during the initial years of private practice. Studies could also investigate the best way to improve faculty adoption and use of the standards in their individual classes. A study of this kind could easily expand to other Landscape Architecture programs. Additionally, future research could investigate the continued prevalence of AutoCAD in the landscape architectural industry which serves as the basis for this study, and the relationship between what is taught in higher education versus software use and choices in the industry.

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