COMPARING DRAFTING SYSTEMS AGAINST THEIR IMPACT ON EFFICIENCY AND EFFECTIVENESS IN THE CREATIVE DESIGN PROCESS

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1 ABSTRACT

BIM software is only a partial solution for landscape architects. Compared with drafting in a landscape architecture specific BIM software, or BIM(L), the design process employed by landscape architects who solely use BIM software is not as efficient nor as effective, and can hinder BIM ideals. Tools specific to landscape architectural design are requirements in making a CAD-based workflow compatible with a creative landscape design process. The purpose of this study is to gain insight on the effectiveness of common workflows in the field. This paper argues that BIM alone is not much better than CAD alone when compared in terms of efficiency, training time, team coordination, and quality of output and creative design, but that BIM(L) is best for all these factors. The "design process" is defined as "Analysis - Concept - Public Outreach - Construction Drawings - Construction Management" and is used as the basis to compare four basic drafting systems: hand drafting with and without technology, CAD, BIM, and BIM(L). Past research is reviewed, along with a survey of the landscape architecture community's used workflows and their perceived values of each drafting system. The results find that a majority of Landscape Architects are not using BIM(L) methods, and believe they are not required in projects, but most responses think it's the most efficient option. The conclusions find that there are advantages for BIM(L) workflow after the concept phase, but that there is a reluctance to adopt the most efficient and effective workflow due to perceived barriers of cost and training.

1.1 Keywords

BIM(L), Computer Aided Drafting, Creative Design Process, Efficiency, Professional Tools

2 INTRODUCING THE STATE OF LANDSCAPE ARCHITECTURE AND BIM

Since its advent in the 1970s and popularization in the 1980s, computer-aided design (CAD) has gained acceptance as the standard to overtake hand drafting. More recently, CAD systems have evolved into building information modeling (BIM) systems. While BIM in fact encompasses a process rather than a particular technology, software is still the prevailing means of achieving this process (The Landscape Institute [TLI], 2016). However, working with software labeled “BIM” is only a partial solution for landscape architects to achieve the goals of the BIM’s process.

This paper does not seek to validate BIM as an effective process. Rather, the intention is to define and evaluate the type of BIM toolset that is effective for landscape architects, as well as the type of BIM toolset that is not, from within the current range of available toolset options. The future ideal BIM, defined by TLI (2016) as “BIM Level 3” [BIMv3] where all design disciplines work within an environment with fully automated connectivity, does not yet exist. Complex site projects can require a full suite of professionals including landscape architects, as well as “architects; civil, structural, mechanical, electrical, plumbing, heating, ventilating, and air conditioning engineers; interior designers; ... and others whose services have … traditionally been considered "professional" activities, require licensing or registration by the state, or otherwise require the knowledge and application of design principles appropriate to the problem at hand.” (University of Colorado, 1997). Not all professionals in this broad list can use Revit—or any other single available BIM toolset, for that matter—for their work.

We are then left with BIM Level 2 [BIMv2], where several software toolsets are currently available—some better suited to some tasks, professions, or practices than others. Nevertheless, the industry continues to use tools not best suited for the tasks at hand. This practice pulls landscape architects’ focus and efforts of landscape architects away from making creative leaps with the BIMv2 process and overall landscape design, and instead forces them to use their creative energy to work within or manipulate the CAD environment to accomplish otherwise-simple tasks. This “square peg and round hole” situation applies to both simple CAD, and to BIM software designed for non-landscape architectural professionals.

This study focuses on drafting (used synonymously here and throughout with “drawing” or “communicating” for the purposes of method comparison) as a key component used throughout the creative design process. The creative design process is used here as the collection of tasks needed to arrive at the completed and successful design. In professional practice, this can span from the conceptual phase through to construction. In this paper, the “creative design process” is defined as the whole of the following key tasks: “Analysis - Concept - Public Outreach - Construction Drawings - Construction Management”.

This study seeks to compare both efficiency and effectiveness in the creative design process because of a common concern that BIM software can stifle creativity, or effectiveness of the design.

“BIM” has become a much more frequent requirement of professional Landscape Architectural project requirements. A practitioner with the highest available BIM capability (BIMv2) would be seen to be meeting these requirements at a higher capability and so would be more successful at obtaining a project with that requirement. Many professionals still use non-BIM drafting systems, so these will be compared against BIMv2.

This task of communicating via documents and tools is a prominent need in both the “Design and Construction”, and “Handover and Aftercare” processes within any given BIMv2 project. Comparisons are needed for all methods currently available to and actively used by landscape architects today to determine an ideal toolset workflow for achieving BIMv2 principles.

2.1 Drafting systems and BIM

A “drafting system”, as used within this paper, is a method used to communicate the design intent. It can be software such as a CAD system, or a manual technique such as hand drafting or model building. BIMv2 involves much more than the use of one method or system to achieve its goals. Rather, it compromises a process of beginning a landscape design with the end in mind and incorporating the maintenance aspect early. However, software is still a significant means for achieving BIMv2. Descriptions of software that are BIMv2-compliant include their ability to traverse 2D and 3D, along with the inclusion of data specific to the objects within the overall model (TLS, 2016). The benefits of using BIMv2 tools culminates in peak efficiency for the design process and the resulting design, ultimately keeping design costs low (World Landscape Architecture, 2017).

BIMv2 research has already focused heavily on the architectural process, where analyses have explored how the design process changes between CAD and BIM for architecture [BIM(A)]. Simply

introducing a new tool for BIM(A) has been shown to change the design process itself. The visual feedback systems of a BIM(A) software alert designers immediately to how their designs are behaving, which in turn helps them develop new strategies quickly. (Salman, Laing & Conniff, 2014).

A BIMv2 process requires an understanding of the other design team members' needs in the support of their work. Arguably, this understanding should extend to the team's comprehension of what a landscape architect needs in order to meet the standards of a BIMv2 process. While BIMv2 is more than a technology, requirements for information inclusion mean that technology is the primary means of communicating a design's intent (Poirer, Forgues & Staub-French, 2017).

BIM as a process has been defined thus far into levels 0 through 4, BIM level 0 [BIMv0] being simple line drawings (CAD, hand drafting), BIM level 1 [BIMv1] being segmented 2D and 3D information within the same discipline, BIMv2 being some connectivity between 2D and 3D with industry-specific tools and connected data, and BIMv3 being a fully integrated system where all data for the life of the project is connected for real-time sharing (TLI, 2016). As previously noted, the available tools are at BIMv2. Benefits of BIMv2 include identifying and removing clashes before the costly construction phase. In reality, not every team member will be able to work in a single software, and effort needs to be taken to coordinate compatible file formats (Green, 2017). Consequently, it's necessary to compare the benefits of clash-detection vs. error checking and automation within a single discipline among the available software for landscape architects.

BIMv2 can be a strong system to help guide and shape an ideal design process, but in the industry today too much emphasis is put on BIM as a single-software solution and landscape architects who try to achieve BIMv2 end up using an architect's software – BIM(A). This paper intends to explore these systems and their current impact on landscape architects.

Since it's common for Landscape Architects to use different drafting systems for different tasks throughout the creative design process, this research intends to explore what is used for and what is most efficient and effective for each task, Analysis - Concept - Public Outreach - Construction Drawings - Construction Management.

3 METHODOLOGY FOR COMPARING DRAFTING/COMMUNICATION SYSTEMS

3.1 Research on Drafting Systems, BIM, and the Landscape Architectural Design Process

Since the 1980s, the design industry has looked increasingly to CAD tools as a means to achieving greater results in the design process. As CAD has evolved into BIM, so have the expectations from CAD to BIM. CAD adoption since 2000 has grown steadily as the primary toolset used by landscape architects.

The concurrent globalization of information and communication has made more data readily available over the Web, and that information has steadily been assimilated into BIMv2 technologies. Complex toolsets like Revit are a prime example of the power this data can hold. An architect using Revit has access to a vast database of materials and manufacturer testing parameters. The success of BIM(A) tools and BIM for Engineering has propelled BIMv2 processes into the spotlight of the public and politics. In reality, BIMv2 requirements and expectations are outstripping its actual ability.

In particular, BIMv2 for landscape architects is in a precarious position. The expectations for BIM are for it to be level 3, where all drawings and information are fully automated and reported in real time on a Web-based platform. Some BIMv2 project contract requirements have incorporated these expectations, forcing landscape architects to work in a platform meant for architecture, such as Revit. While it is possible for a landscape architect to use a tool designed for an architect, the entire process becomes "clunky" outside of the building. Architecture is primarily rectilinear, while landscape architecture is much more organic (Barth, 2016). Topography is a struggle, and while the "wall" tool is suggested for curbs in the available site add-on tools for Revit, even guides for this tool show that an L-shaped curb island is not possible with the wall tool (Autodesk Help, 2017).

There are several design methods that are commonplace in the field of landscape architecture today. They fall broadly within the categories of hand drafting with and without technology, CAD (2D or 3D), BIM(A) (used in this paper more broadly to represent any non-landscape-architecture BIMv2 toolset), and BIM(L). The following paragraphs will define these terms for the purposes of the research in Section 3. A further explanation of the reasoning behind the BIM(L) and BIM(A) terms is explored in section 4.2.

Hand drafting with and without technology is a highly respected and widely used method among landscape architects. Improvements in technology have allowed hand drafting to migrate from pen and paper to stylus, tablet and mouse. Hand drafting or drawing remains an important tool in the BIMv2 kit, because with the integration of some technology, hand drafting or drawing can be easily integrated with other communication and drafting methods.

CAD is designated as a simple drafting method at the BIMv0 or BIMv1 level. Lines are just lines and although those practicing exclusively CAD methods might use both 2D and 3D, those drawings would not be linked in any way to each other. CAD can graphically show much of the same end result as BIM(A) or BIM(L) methods, but does not allow for any error checking, clash detection or automated processes. CAD can be customized and linked with small-scale macro processes that start to trend toward BIMv2 capability. The transition from CAD to BIM(A) to BIM(L) is a sliding scale, as opposed to a hard line.

BIM(A) and BIM(L) toolsets are fundamentally the same from a BIM standpoint—both are BIMv2 methods. A BIM(L) technology would provide tools designed specifically for common landscape architecture tasks. Conversely, BIM(A) technology as defined for this paper is a toolset that landscape architects may use but is developed for another allied design profession. For BIM(L), capabilities can include and already-established means to identify plant species within the data tied to the technology, or tools to assign data based on manufacturers that a landscape architect would specify. BIM(L) tools might cover organic grading, landscape details, or pedestrian circulation, as opposed to a BIM(A) tool platform, where landscape architect may be able to manipulate a toolset meant for another profession's purposes. Again, the line here is grey, but it is typically simple to identify which side of the line on which a software falls in the BIM(A) to BIM(L) spectrum. While this paper will not cover comparing various BIM(L) technology, BIM(L) is usually an add-on or additional toolset pack to plug into another BIM(A) or CAD software. In this paper, using that base BIM(A) software alone is considered BIM(A), and it would not be considered BIM(L) without the plug-in or add-on tools for landscape architects.

Landscape architecture can be a varied and specialized profession. Professionals and even educational programs can focus on wildly different types of projects, from regional planning to small artistic installations to ecological restoration (Gazvoda, D. 2002). The life of a project is commonly laid out broadly in five major processes: inventory and analysis, concept development, public engagement, construction documentation, and construction management. These are the process terms that will serve as the focus of comparison in this paper.

3.2 The Trends and Popular Opinion in the Industry

An open survey was created to gather data on tools used in landscape architecture today, as well as how these tools are used throughout the creative design process. The survey was created and hosted with Google forms tools and distributed through social media on Linkedin, Twitter, Facebook, and on the subreddit /LandscapeArchitecture. The survey was closed February 2018 (Google Forms Document, 2018). Most respondents were obtained after the subreddit post was added, as this proved to be a more effective method of reaching interested Landscape Architects.

Questions were mostly mandatory multiple choice with some optional long-form answers to allow the respondents to clarify answers, summarize thoughts, and give feedback. Questions to establish demographics included professional designation; years of experience; work in academic, private, and/or public sectors; age; gender; and continent.

The first set of questions established the actual tools, techniques, methods, and software used by respondents. An extensive list was supplied with an open "other" option. Next, respondents were asked how much time they spend on specific common tasks. They were then asked which techniques they use to accomplish those tasks, ranging from hand drafting unaided by technology, to BIMv2 enabled software, differentiating between software with and without tools specific to landscape architecture. Examples of software that fit each category were provided to give clarity to the category. Finally respondents were asked questions of self-reflection on their own workflow and on workflows available to landscape architects. They were then asked how they perceive the impact of different processes on the profession, efficiency, and the creative design process. Responses were anonymous.

The questions were simplified to refer to CAD processes with and without landscape-specific tools. For the purposes of discussion, we'll call these CAD and BIM(A) vs. BIM(L).

4 FINDINGS

4.1 Results of the Survey

A total of 30 responses were collected and compared (Google Sheet Document, 2018). Most respondents described themselves as active landscape architects, interns, technologists or designers. Six respondents clarified themselves as students or educators. There was an even distribution of experience, ranging from 0 to 20 years of experience, with most respondents being 30 to 39 years of age. Most respondents resided in North America, with Asia, Australia represented by 10%. Responses came from private, academic, and public sectors, with many respondents reporting experience in more than one sector.

Notably, only 90% of respondents reported that they use hand drafting, in comparison with the number of those using Autodesk and SketchUp (93% to 87%). Yet 100% of respondents reported using Photoshop and the Adobe Suite, suggesting a shift to hand drawing with technology instead of paper. Rhino was used by 27% of respondents, and 17% reported using various photorealistic rendering software. Some respondents may use more than one. Landscape-architecture-specific tools were used by 7, but only 4 of those respondents listed that tool as being among their top-3 used tools. GIS tools were used by 13, and Revit was used by 6. The responses to the individual tools used are summarized into the following overall methods and displayed in Figure 1: hand drafting with and without technology, CAD, BIM(A), and BIM(L). This figure is included as an overall look at the drafting systems being compared.

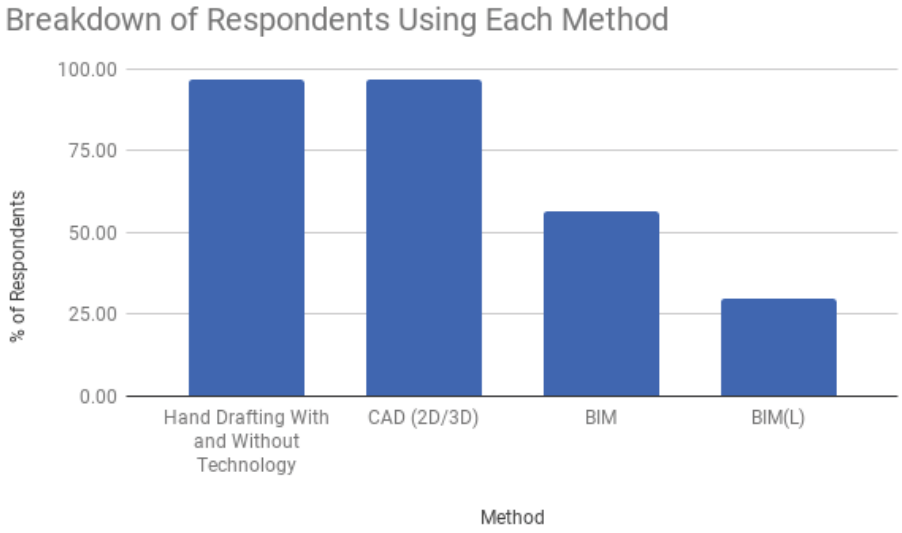

Figure 1. Breakdown of Respondents Using Each Method (2018). Diagram by the author

The comparison of use of each method throughout the design process is summarized in Figure 2. This figure breaks down “Hand Drafting with and without technology” into more specific methods since there were a significant number of respondents using these in the Inventory and Analysis phases. Technology was used much more toward the end of a project, with 73% preferring to use hand drafting or other sketching means. This trend does not switch until the public engagement phase into the majority using non-sketching means, where presentation graphics come into the design process

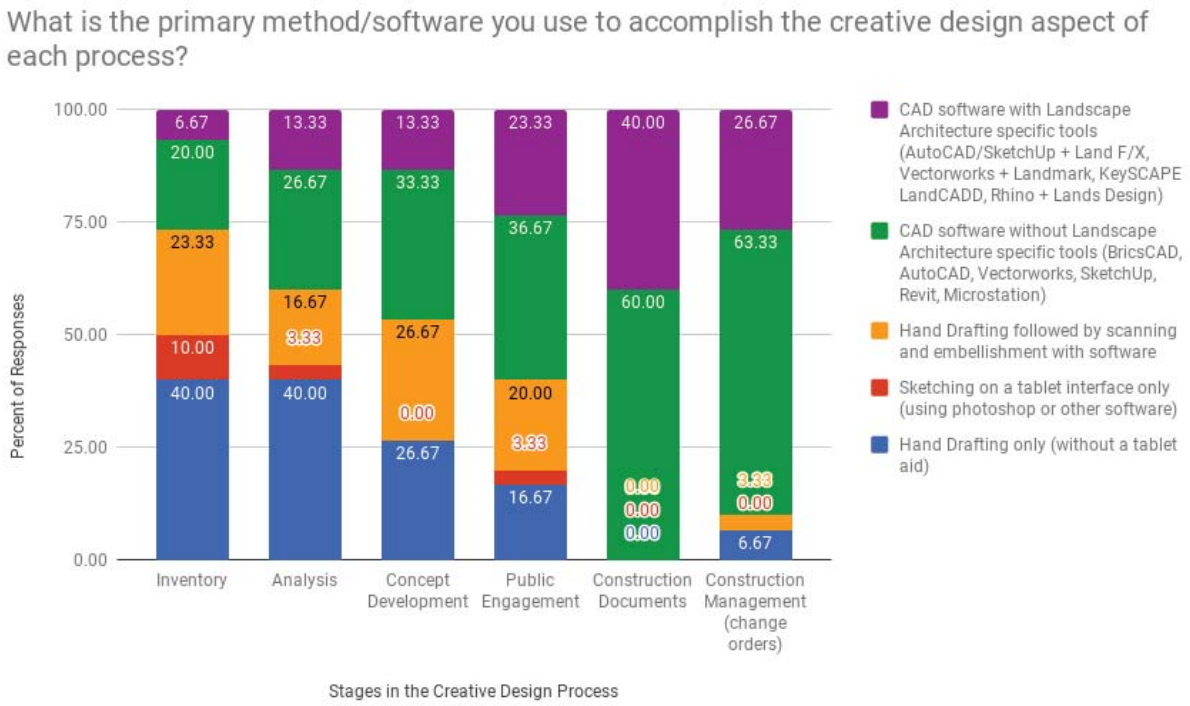

Figure 2. Comparison of Drafting Systems Used in Each Design Stage (2018). Diagram by the author

When asked to self-reflect on their workflow for the landscape design process, 70% said they don't think or don't know whether it's the most efficient available. On the question of why they haven't achieved their ideal workflow, the highest response at 50% was that respondents felt they did not have enough time to research or learn new methods or software, equaling the 3 other concerns of software cost, simple inexperience, and the fact that the technology doesn't exist yet combined at 15%, 20% and 15% respectively.

When asked which method is best for an efficient landscape design process, 47% responded as BIM(L), 30% responded CAD/BIM(A), and 23% said hand drafting (almost all involving technology to embellish). However, 43% also said that BIM(L) is the most difficult method to learn/train. Only 13% said that BIM(L) is best to collaborate with other disciplines, with most preferring CAD/BIM(A) at 53%.

CAD and BIM(A) methods are seen to impede the creative design process more than BIM(L). When asked which process is best to communicate creative design intent, 66% of respondents reported that hand drafting is best, with most of those respondents asserting that embellishing with software is even better than hand alone.

Respondents were asked whether hand drafting, CAD/BIM(A), and BIM(L) are required for the landscape design process. A majority believed CAD/BIM(A) to be required, but notably there were more unsure responses to BIM(L), indicating that this is more of an unknown subject in the profession. By this point in the survey, more respondents were starting to suggest that hand drafting is not required at all in the landscape design process, although as indicated at the beginning of the survey, many of those respondents still use it anyway.

Respondents were asked whether landscape architecture and design students are learning the right methods/software to enter the profession. The answers were nearly evenly split between yes, no, and unsure, and the question generated the greatest number of long-form answers to clarify. Strong opinions were given on whether students learn the right tools, and whether that even matters. Many said they themselves had not learned enough technology in school, citing how different firms use such different tools. As stipulated in a notable (anonymous) comment, "Students have the time to explore new and novel methods that aren't constrained by hourly billing and profit margins. The issue is whether firms students end

up working for are stifling this creativity and workflow innovation." This brings to bear the question: What can firms do that simultaneously respects the profit margins that allow them to work, and permit effective creativity, in order to ultimately give value to the landscape design process while moving forward with new BIMv2 design requirements?

4.2 Discussion

BIMv2, as a method of delivering a project, is growing into a requirement for the field of landscape architecture. Much research has proposed the merits of a BIMv2 workflow, but also on the pitfalls of landscape architects having to use tools that were not designed for them. Based on the results of this survey, the majority of landscape architects are not fully embracing BIMv2 tools, and far fewer are venturing into BIM(L) options using tools specifically designed for the profession of landscape architecture. This data suggests that the pressure on landscape architects to use BIMv2 is also pushing them into using BIM(A) tools that are not necessarily designed for them.

According to the responses, the primary barrier to landscape architects increasing efficiency and effectiveness in the creative design process is time. This could entail time to research new methods, or time to learn new methods. Many reported that technology impedes the creative design intent, but notably 5 of 7 BIM(L) users felt BIM(L) did not impede creative design. Most respondents pointed to BIM(A) and CAD-only methods instead as the greatest obstructions to effective communication, which suggests that many respondents who deemed BIM(L) as impeding effective creativity had not actually used that technology, and may have been fearing the unknown.

By contrast, BIM(L) was perceived as the most efficient method for the entire landscape design process above BIM(A) and CAD. This perception brings to light another common concern about becoming more efficient: upfront cost. If those not using the technology fear it to impede creativity, they may see that upfront cost as not worth the efficiency boost. With this comparison of perceptions, the aversions to BIM, and above that BIM(L), are largely unfounded.

The following ideas suggest a few means through which to break down the barriers to a BIM(L) workflow. First, it needs to be established that the use of common software is not a requirement for an efficient creative design process. Landscape architects are told that common software is needed but is not a requirement for all other professions. Ideal BIMv2 workflows have means of error checking, which, for landscape architectural designs, BIM(L) toolsets have but BIM(A) toolsets lack. This fact needs to be communicated effectively to other allied professionals. "SIM" and "LIM" have been put forth as possible acronyms, but any allied professional coming across either term would not understand them immediately, and thus the terms are not commonplace except among landscape architects. Creating a means of identifying all BIMv2 tools by the profession for which those tools are created would help allied professionals accept BIM(L) software within their BIMv2 workflow.

True BIM can only be defined as BIMv3. At the current technology stage of BIMv2, the available tools are segmented into disciplines. It does not make sense for the industry to continue to pretend that BIMv3 is currently possible, and consequently, force tools to be used in ways they aren't meant to be used—especially when there are tools available that accomplish landscape architecture tasks more easily. For landscape architects especially, manipulating tools meant for other disciplines to fit their needs only gives a benefit of easier collaboration with the architect—at the cost of effectively communicating the design intent and efficiency of work.

This segmentation needs to be recognized and acknowledged within the labels bestowed upon available tools. If software contains tools that accomplish primary tasks for a discipline, this fact needs to be acknowledged in its BIMv2 designation, as no currently available software can truly claim to contain tools specific to every design discipline. The commonly known and used drawing identifiers (A for Architectural, C for Civil, E for Electrical, I for Interiors, IR for Irrigation, L for Landscape, M for Mechanical, etc.) are ideal for this task. Software containing BIMv2 tools for landscape architects would be designated BIM(L). Architectural would be BIM(A), Civil would be BIM(C), and Electrical BIM(E). Each discipline's professional body itself could set parameters for the requirements needed to attain a BIMv2 designation for that discipline's core needs. This defined designation of BIMv2 would not only help landscape architects easily find out which software meets a contract's BIMv2 standards, but also help guide the software industry closer to BIMv3 status as various applications gain multiple BIMv2 designations, such as a BIM(A)(L) software or a BIM(C)(L) software. This method, even if only adopted initially by landscape architects, would be simple for allied professionals to understand, accept, and eventually adopt.

4.3 Conclusions and Further Research

The landscape architecture field is reluctant to adopt a BIMv2 workflow. This hesitance stems from an aversion to the available tools for achieving BIMv2. Most landscape architects surveyed were only adopting BIMv1 tools at best, with many opting for BIMv0. While users of BIM(L) tools reported that the tools facilitated collaboration, didn't impede creativity and were efficient, many more respondents adopted BIM(A) or CAD tools instead.

Further research is necessary to qualify the perceived efficiencies and effectiveness from the survey responses. The survey did attempt to offer a means to qualify or contrast the responses given by tying actual time spent on specific tasks to the process used. The responses received on time spent were of questionable accuracy and could not be compared, however, since many respondents do not work on the entire design process throughout the life of a project. Also, those using BIM(A) and BIM(L) tools tended to report much longer lengths of time spent on each design process (example: construction drawings), likely because they are able to take on more complex, larger projects. A more effective comparison for efficiency might be a case study analysis for two projects of similar scope by a single firm before and after transitioning between CAD and BIM(A) or BIM(L). A better comparison for tools that allow for creativity might be a study of award-winning designs compared with the tools and methods used to create them.

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