THE DIGITAL PALETTE: A SURVEY OF CURRENT SOFTWARE INTEGRATION IN LANDSCAPE ARCHITECTURE CURRICULA

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ABSTRACT
A digital palette of tools is fundamental to the practice of landscape architecture. Software programs are embedded in academic curricula, graduating from a single course in years past to permeating nearly all courses and design projects. These contemporary digital workflows, however, are not in competition with traditional analog representation. Instead, there is a new paradigm where digital tools augment and expand what is possible in the design process (Cantrell, 2014). It is in this new paradigm that academics must make choices about which drafting, modeling, rendering, and publishing software to integrate into curricula. This research seeks to capture the current state of design software in Landscape Architecture curricula. It builds off previous survey data on this topic (Steffens, 2005; Summerlin, George, & Fulford, 2017; George, Summerlin & Fulford, 2019) and integrates new conversations around emerging technology like drones, virtual reality, and artificial intelligence. The survey examines three major questions for academics:

1. What specific software packages are LAAB accredited programs teaching in their courses?
2. What emerging technology is being introduced and integrated into the curriculum?
3. What challenges and opportunities lie ahead as faculty intentionally integrate software into the design curriculum?

Beyond simply noting if a software program is discussed, this research seeks to capture the depth to which each software package is covered in courses. This was executed through a Likert scale associated with each software package. This added texture to the survey provides a truer representation of software usage in accredited programs. Additionally, this research highlights niche software packages that have gained traction nationally in recent years and allows for speculation of future trends both regionally and nationally. Altogether, the findings provide an updated snapshot of the state of design software in Landscape Architecture curricula across the United States.

Keywords
Computer Software, Curriculum, Technology, Teaching, Landscape Architecture

1 INTRODUCTION

The practice of landscape architecture boasts a rich heritage of tools and methodologies for representing landscapes. While historically dominated by analog mediums such as pencils, pens, markers, and watercolors, in the last several decades computer software has become ubiquitous across various stages of the design process, prompting educators, particularly those instructing on digital representation tools, to regularly evaluate the specific software within their curriculum (Cantrell and Michaels, 2015). Several surveys have been conducted to gauge the prevalence of computer software in professional landscape architecture offices, providing valuable context for academic curriculum decisions (Calabria, 2012; Steffens, 2016; George, Summerlin & Fulford, 2019). However, the decision on what software to incorporate into teaching is not solely reactive to current professional practices; academics must also anticipate future trends and equip students with emerging digital tools to navigate changing expectations. Just as surveys on software utilization in professional contexts offer insights, an examination of software taught in academia serves to inform curriculum design for educators and also assists practitioners in making informed decisions for their firms.This article discusses the results of a survey conducted on the software being taught and the extent of its integration within accredited landscape architecture programs across the United States. Additionally, the article provides a contextual backdrop of software integration within academia. The survey results offer a comprehensive snapshot of software used by broad consensus, while also shedding light on more specialized software utilized by select programs. These findings aim to inform both academics and practitioners about the current landscape of software instruction within landscape architecture curricula, as well as help these parties anticipate emerging trends in software education.

1.1 Technology Integration in landscape architecture academia

The widespread adoption and integration of computers and software within both landscape architecture educational and professional spheres in the United States is still a relatively recent phenomenon, having begun in earnest since the 1980s and largely culminating over the past decade. AutoCAD was introduced in 1982, a milestone marked by its rapid proliferation as evidenced by a million copies in circulation within just over a decade (Walker, 1994). This growth prompted Julius Fabos's to predict a future "paperless office" in 1983 (Tai, 2003). While the anticipated paperless office failed to materialize, the ongoing integration of software instigated long-running conversations about the evolving role of computer software in landscape architecture (Tai, 2003). The next major shift in design technology was the advent of widely accessible digital 3D design software. Advanced 3D modeling software had been in development for some time, but in the late 1990s, a series of several 3D modeling programs began to be released, most notably 3D Studio Max in 1996, and Rhinoceros (Rhino) in 1998. However, it was SketchUp that brought widespread 3D modeling to the profession. Originally developed in 1999 by Last Software, SketchUp was purchased by Google in 2006 who would subsequently go on to promote it as a free and uncomplicated software package for 3D modeling, prompting rapid adoption (Lallawmzuali & Pal, 2023).

The first comprehensive survey conducted encompassing all the accredited landscape architecture programs across the United States at the time explored the utilization of computers within their respective curricula (Palmer, 1994). Reporting indicated that over eighty percent of programs required an introduction to GIS technology in their planning courses, making GIS software (ArcInfo, MAP II, and MacGIS) the most common software taught in academia at the time. Approximately three-fourths of students were required to learn about the use of computers for design graphics with AutoCAD, LandCADD, Photoshop, and Freehand listed as the software applications used for this instruction (Palmer, 1994). Concerns revolved around computing capabilities and the substantial time investment required for mastering software applications, raising worries that such endeavors could potentially detract from essential design instruction (Palmer, 1994). In the 2000s, scholars began highlighting educational implications, notably the challenge students would face in securing employment without a blend of conventional and highly technical skills (Tai, 2003). Concurrently, the declining cost of computers precipitated a shift, with many design programs mandating purchasing personal computers for use that facilitated an expansion of students' opportunities to develop proficiency in software and other technical skills as learning shifted out of the confines of university labs, thereby extending student exposure and enhancing their capabilities (Tai, 2003). With increased skills has come an expectation, or assumption, of increases in efficiency and expanded capacity. For instance, the use of parametric modeling has been observed to increase efficiencies in design time, accuracy, and quality (Amoroso, Ashari, & Pedersen, 2022).

While researchers have been interested in the impact that technology has on the creative process and workflows, there has been a concurrent effort to assess what technology is being used. Palmer (1994; 1997) conducted some of the earliest studies on the integration of technology into the profession. Steffens (2017) conducted repeated surveys of practitioners regarding their use of software over a decade starting in 2004 which illustrated a burgeoning growth in the number of different programs being used in practice. This proliferation of software options poses several problems related to learning, cost, and interoperability, and both practitioners and educators prefer a focus on a select few programs (Yan, 2014). Steffens 2008 survey identified AutoCAD, Photoshop, and SketchUp as the three most important software packages for hireability. A 2014 study of 3D modeling software (Yan, 2014) found that SketchUp was by far the most commonly used 3D modeling program, with 93% of practitioners reporting using it, and 86% of educators. Other works indirectly document the adoption of technology, for instance, the technical credits in Amoroso's (2015) work highlighting exemplary digital illustrations are dominated by SketchUp and Rhino.

Another question that has persisted is identifying who is responsible for identifying and integrating the most likely new technology that will benefit the profession, namely is it the role of practice or the academy to pioneer new software? Many of the earliest digital technologies in design were either developed or integrated in academia, such as SketchPad and 3D modeling software. Frequently, expectations for academia and practice as identical. Meadows (2021) survey found that Photoshop and AutoCAD are the two most important software taugt and practiced, and SketchUp is the most popular 3D modeling software. However, there is often a misalignment between what is being taught in education and what is being used in practice, sometimes dramatically. Yan's (2014) research highlighted this where 91% of educators use GIS, but only 38% of practitioners, and 61% of educators use Rhino, but only 13% of practitioners. While not as pronounced, Meadows (2021) found similar misalignments between Illustrator and Rhino.

The last decade has also witnessed a discernible shift in technology utilization, characterized by a transition from sole reliance on laptop and desktop computers to include a host of additional hardware and mobile technologies. Notable among these is mobile computing, virtual reality (VR), unmanned aerial vehicles (UAVs), and artificial intelligence (AI). There has been significant interest in VR as a visualization and design tool within the profession, as 27% of firms reported using VR in 2019, with an additional 42% intending to adopt VR (George & Summerlin, 2019). While VR is being utilized in practice, researchers have noted that this use is limited to select use cases and that there are several bottlenecks preventing its broader use throughout the design process, including cost, complexity, hardware demands, collaboration difficulties, a lack of native integration with major industry-standard software, and landscape architects conservative approach to technology adoption (Lombardo, 2018; Hill, George, Johnson, 2019; Galar, Kumar, & Seneviratne, 2020; George, Fernandez, Summerlin, 2022). UAVs have also seen significant adoption in landscape architecture, with 42% of firms reporting they were using drones in 2019 (George & Summerlin, 2019). UAVs have been particularly useful for LIDAR and photogrammetry capture (Hahn, 2013; Milligan, 2019) and collecting terrain and imagery data from inaccessible sites (Rekittke, Paar, Lin, & Ninsalam, 2013; Blauer, 2019), and efficient aerial photography (Toomey, 2015; Kullman, 2017). AI tools erupted beginning in 2020 with the release of ChatGPT 3 and then Dall-E 2 in the subsequent year. There has been immense interest in the use of AI as measured by the amount of research that has been produced, but as of now there has been limited formal research on how widespread the adoption of AI is in either practice or education (Fernberg & Chamberlain, 2023).

1.2 Research objectives

This study assesses the software and emerging technologies that are currently being utilized in LAAB-accredited landscape architecture programs in the United States (ASLA, n.d.). This is valuable to educators in providing an understanding of what is currently being taught and to be able to assess changing trends in technology education. This will inform educators when making decisions regarding technology teaching and investment strategies. The survey had three primary objectives:

1. Identify the specific software being taught and target proficiency levels;
2. Identify emergent technologies that are being integrated into teaching practice;
3. Identify strategies used to deliver technology training.

2 METHODS

The construction of the survey was based on a previous survey (Summerlin, George, & Fulford, 2017) given to academics. The survey was 26 questions in total and grouped software into seven different categories based on the primary function of the software: drafting software, geospatial software, 2D rendering software, 3D modeling software, supplemental 3D modeling software, desktop publishing software, and mobile applications. Software included in the survey was based on questions from the 2016 survey, with the addition of software frequently written in by respondents, and through conversations with academics and practitioners. Each category also included write-in options for respondents to include software that was not pre-listed in the survey, allowing researchers to capture all potential software programs. A similar strategy was used to identify emergent technology, which resulted in the inclusion of AI. The study was approved by the Mississippi State University Institutional Review Board (Protocol ID: IRB-23-598).

Questions for the software portion of the survey utilized a 5-point Likert scale, from 0-4. A response of 0 indicates that the software is not being taught in the curriculum. A response of 1 indicates that students are being introduced to the software and its capabilities. A response of 2 indicates that students are shown a few techniques for specific tasks. A response of 3 indicates that students can integrate several techniques into a design workflow. A response of 4 indicates that students are proficient in using the software for discipline-specific use. This Likert scale provides two types of information. First, is the software being taught in the program? Second, what is the target level of proficiency for instruction?

Respondents to the survey were selected using a targeted approach to identify the most appropriate faculty member at each LA Program to complete the survey. A first round of solicitations was done through contacting the program or reviewing faculty teaching and research profiles on the program webpage. When this strategy failed to produce a response, a follow-up request to take the survey was sent to the program administrator. Because the survey is meant to be representative of the individual programs, only one survey request was sent to each program in order to avoid duplication of data. Survey requests were sent to every LAAB-accredited or candidate landscape architecture program listed on the ASLA website. All rounds of the survey were completed by March 2024.

3 RESULTS

Responses were received from 48 of 76 programs that were solicited, representing a response rate of 63%. The results are presented using a modified box and whisker plot, where the box is defined by the 10th and 90th percentile, and the whisker shows the highest and lowest recorded results. This approach aids in highlighting both outliers and broad consensus.

3.1 Software results

The results of the survey are presented within the six software categories defined in the methodology: 2D drafting (Figure 1), 2D rendering (Figure 1), desktop publishing (Figure 1), geospatial (Figure 2), 3D modeling (Figure 2), supplemental 3D modeling software (Figure 2), and mobile applications (Figure 3). The results in each category are ordered by mean, from highest to lowest. Across all categories, the most taught software are, in order, Photoshop, AutoCAD, InDesign, Illustrator, ArcGIS, Rhino, Lumion, Google Earth, SketchUp, Grasshopper, and Land F/X (Figure 4). These all had an average above one, meaning that students are at least introduced to the software capabilities.

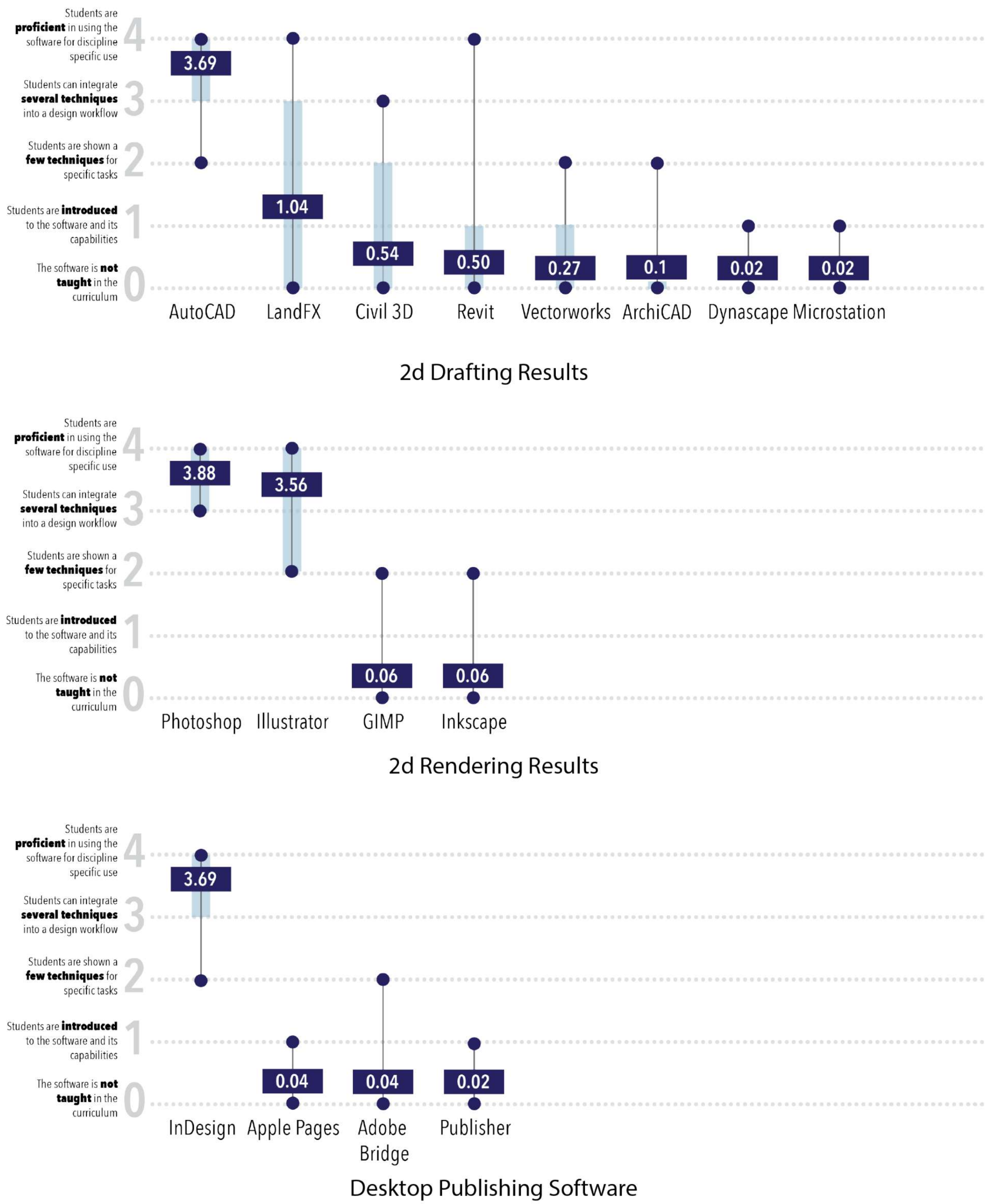

Figure 1. 2D Drafting, 2D Rendering, and Desktop Publishing Software Results

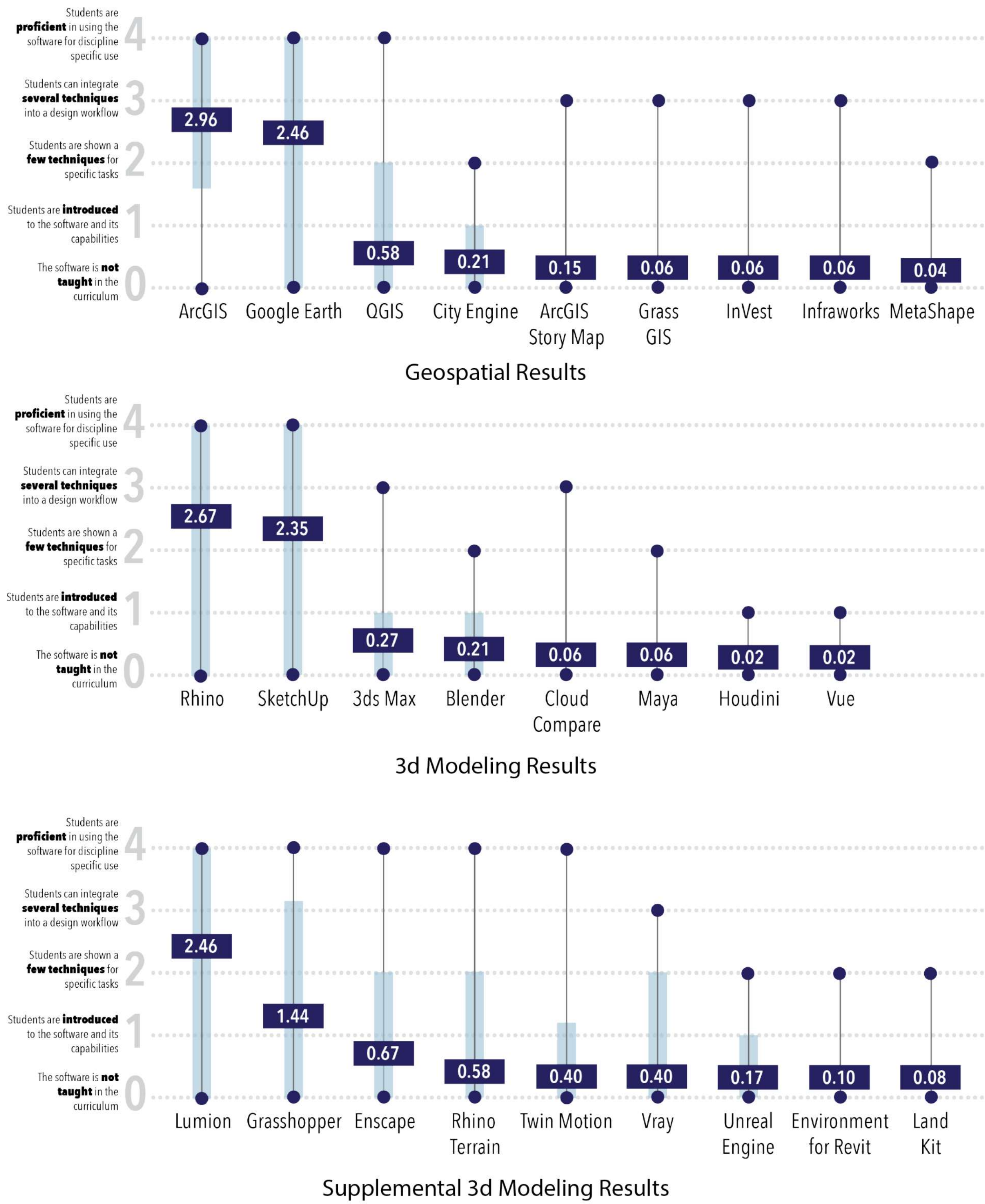

Figure 2. Geospatial, 3D Modeling, and Supplemental 3D Modeling Results

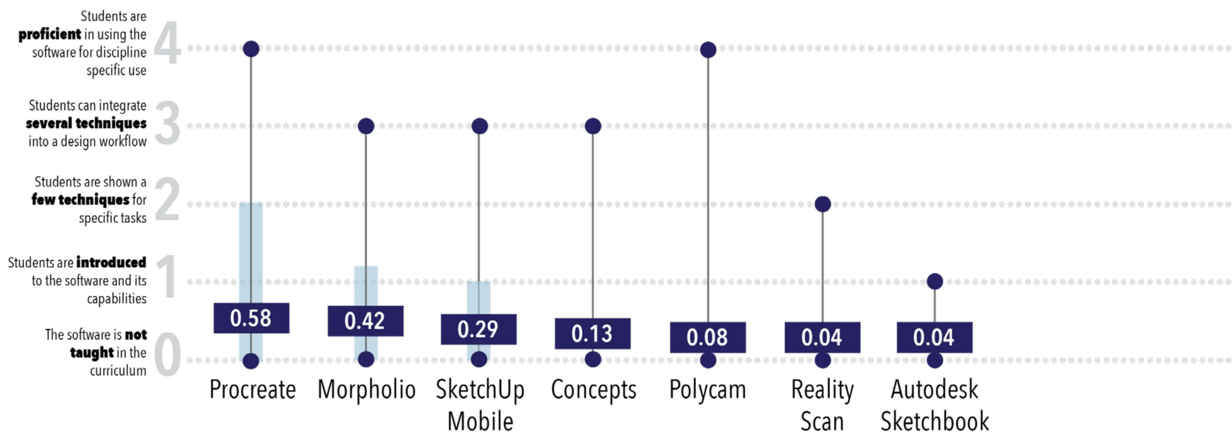

Figure 3. Mobile Application Results

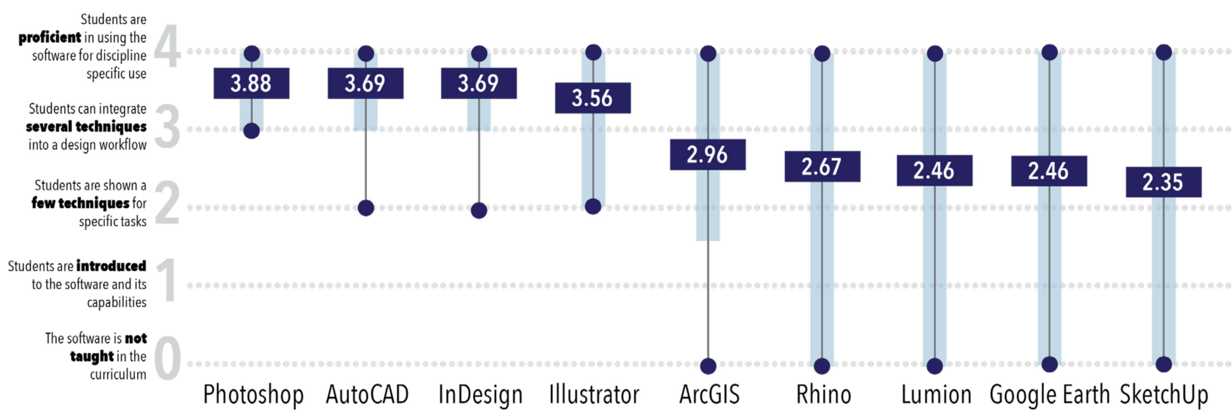

Figure 4. Top Software Results

3.2 Emergent technology integration results

In addition to software packages, emergent technology tools are presented in three categories: Virtual Reality Software (Figure 5), Artificial Intelligence Software (Figure 5), and a “catch-all” category titled Additional Software (Figure 5). The mean for all software in these three categories fell below a mean score of 1, meaning that, on average, these programs are only introduced to students. After Effects, Chat GPT, and Adobe AI were the leading software taught among these three categories feature emergent technology.

3.3 Technology instruction and operating system usage

In conjunction with capturing software taught in landscape architecture curricula, the survey also asked participants “Which method best describes how your faculty teaches computer software?”. 79% of programs indicated that they teach computer software in specific courses that primarily teach digital skills and techniques. 21% indicated that they integrate computer software into design or seminar courses that primarily teach non-digital tools. When compared to a 2016 study by Summerlin, George, and Fulford, these results show a greater number of programs teaching software in specific courses that primarily teach digital skills and techniques (up to 79% from 63% in 2016). The survey also asked faculty to estimate the percentage of students using PC vs. Macintosh operating systems. As a whole, respondents estimate that 70% of students are utilizing a PC and 30% are utilizing Macintosh.

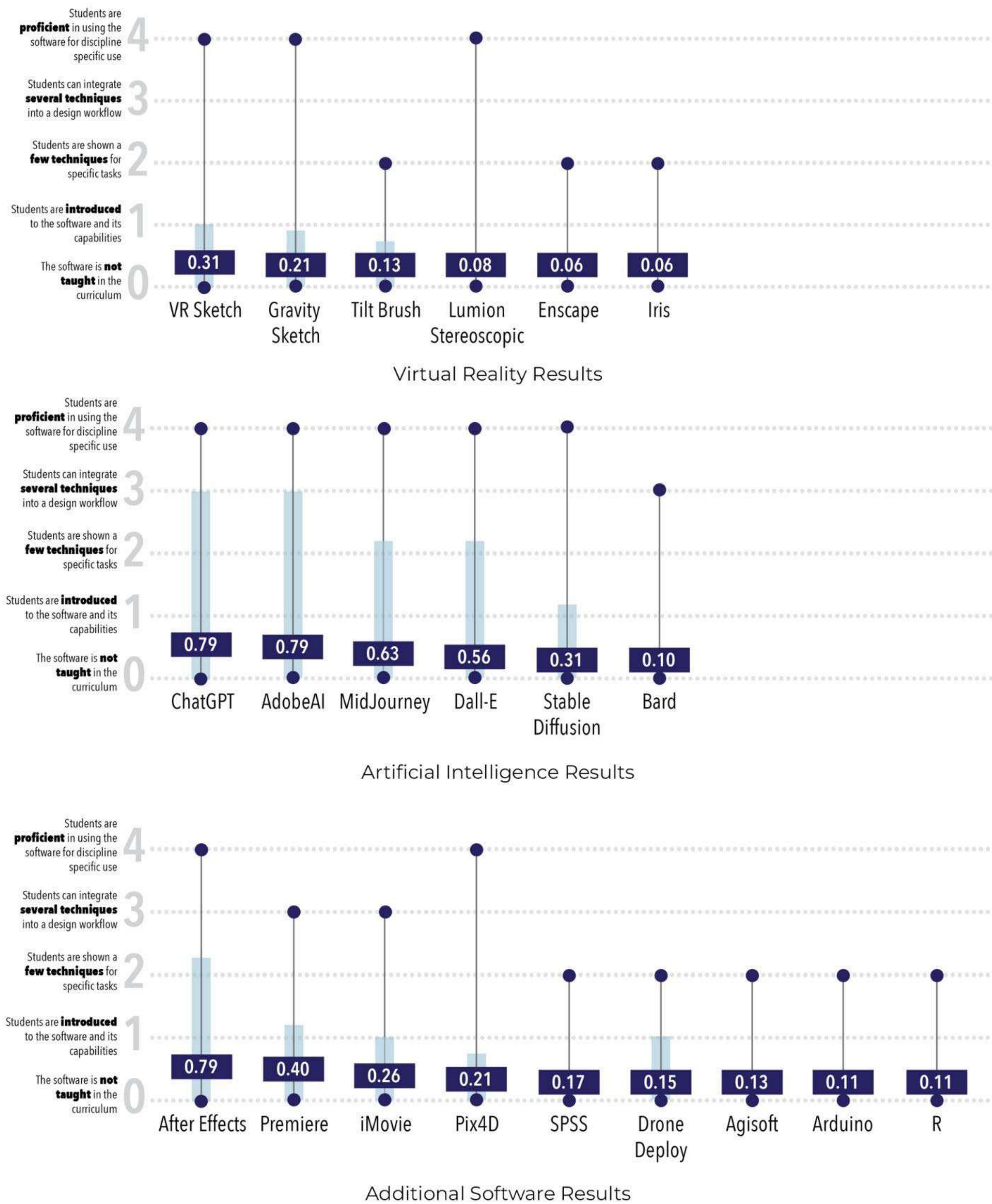

Figure 5. VR, AI, and Additional Software Results

4 DISCUSSION

The discussion delves into more nuanced observations from the survey results and is organized based on the same categories outlined in the survey methodology: 2D Drafting software, Geospatial Software, 2D Rendering Software, 3D Modeling Software, Supplemental 3D Modeling Software, Desktop Publishing Software, Mobile Applications, and Emergent Technology.

4.1 2D Drafting

Eight software were reported in the 2D drafting category. AutoCAD was the favored software by a large margin, with 71% of respondents reporting that they teach it to a high level of proficiency, and 98% reporting that they teach several techniques and the ability to integrate AutoCAD into their design workflow. This result illustrates that AutoCAD remains the dominant drafting software as reported by multiple earlier studies in both practice and academia (Steffens, 2016; Summerlin, George, & Fulford, 2017; Meadows, 2021). The next three most popular 2D drafting software are either other AutoDesk products or add-ons for AutoCAD. LandFX, a third-party plug-in for AutoCAD that offers some form of BIM capability, was the second most popular 2D drafting software, with a mean of 1.04 and 48% of programs teaching it and over a third teaching to at least a 2. Fifteen programs offer some instruction in Civil3D, with 12 reporting either a 1 or 2. Revit is taught by 16 programs and, of those, 12 only teach it to a 1 while three programs teach it to a 3 or 4. In recent years Revit has become more prominent, especially in practice (Meadows, 2021), and this result may be an early snapshot of Revit starting to gain traction in education. While only one of the programs currently teaching Revit to a more advanced level is in a college with architecture, we believe that future adoption of revit by LA programs is especially likely to occur in programs adjacent to architecture programs where there is more likely to be existing expertise that could be relied on. Vectorworks was listed fourth and is the highest non-AutoDesk drafting software and also fully BIM capable.

4.2 2D Rendering software

Adobe Photoshop and Adobe Illustrator were far and away the leading 2D rendering software taught in the programs surveyed. Photoshop, a raster-based rendering software, is primarily used for plan and section rendering and enhancements to perspective renderings, though its versatility allows it to contribute across a range of design documents. 88% of respondents (42 of 48) indicated teaching Photoshop to a level of proficiency for discipline-specific use (a survey level of 4). All remaining participants indicated that they teach Photoshop to a level 3, where students can indicate several techniques in their workflow. This level of consensus means that Photoshop received the greatest level of instruction across all software categories. This aligns with Meadows (2021) finding that Photoshop is the most important software overall.

Adobe Illustrator, a vector-based software, is a companion to Adobe Photoshop and used primarily for diagramming and annotations. While not as prevalent as Photoshop, survey respondents indicated that Adobe Illustrator was taught to a high level with 88% of respondents reporting teaching the software to a level 3 or 4, making it the 4th greatest level of instruction across all software categories. With Illustrator heavily taught in academia, Meadows' (2021) research suggests a misalignment between the use of the software in academia vs. professional practice.

Two other software (GIMP and Inkscape) received only brief mention in this category, each with only 2 of 48 respondents indicating that they introduced the software to their students. Despite there being free alternatives to the Adobe software, survey results indicate very little traction from alternatives to Photoshop and Illustrator. As indicated by Summerlin, George, and Fulford (2016), Adobe's cloud-based subscription offers access to nearly all Adobe software, likely encouraging faculty to freely integrate a range of software into the design workflow.

4.3 Desktop publishing software

Adobe InDesign was the overwhelming consensus desktop publishing software among survey respondents. 94% of respondents indicated teaching it to a level 3 or 4, meaning that, at minimum, faculty introduced several techniques for the design workflow. With other Adobe software like Photoshop and Illustrator being entrenched in program curricula, integrating Adobe InDesign is logical. The interface and tools are similar and linking files between all three programs offers the ability to easily edit drawings and update them downstream. With the Adobe software subscription providing access to nearly all Adobe software, it also makes sense financially for students and faculty. What further entrenches InDesign in the desktop publishing category is that there is no clear competitor found in other academic and professional surveys on software in landscape architecture.

Across all categories, InDesign had the 3rd highest mean. While this underscores the importance of InDesign in program curricula, it also highlights the importance of presentation boards, booklets, and interactive PDFs in the design curriculum. The most obvious connection for each student is the design portfolio, an important tool for internship and full-time applications. Beyond portfolios, though, reports, manuals, and guidebooks have become more commonplace in academic courses.

4.4 Geospatial software

ArcGIS was the most integrated Geospatial software taught, with 46 of 48 respondents (96%) integrating it into their curricula. This seems fitting, given the long history of GIS in the profession and academia specifically. QGIS, a free open-source GIS alternative to ArcGIS, was also represented in this category with 25% of respondents integrating the software into their curricula. The software offers many of the same foundational mapping and analysis tools and works across both Macintosh and PC. While not nearly as robust as software like ArcGIS and QGIS, Google Earth was heavily integrated into program curricula with 42 of 48 respondents (88%) indicating that they taught the software in their courses. Google Earth Pro offers the ability to export aerial imagery and create geo-located data that can be exported to programs like ArcGIS and QGIS.

Geospatial software has a relatively strong presence in academia when compared to surveys on software integration in professional practice (Steffens, 2016, George and Summerlin, 2019). This gap is likely related to LAAB Standard 3-B, which guides program curriculum in several ways, one of which includes the “computer applications and advanced technologies” including “geospatial analysis” (Landscape Architectural Accreditation Board, 2024). Program curricula are intended to cover a wide range of practice types while design offices can be more specialized, meaning that this gap is to be expected and likely won’t change in future years.

4.5 3D Modeling software

Eight software were reported in the 3D modeling category, but half of these, Cloud Compare, Maya, Houdini, and Vue are taught at only two or fewer programs at a largely introductory level. The 3D modeling category is unique in that there is not a clear preferred program, as the degree to which Rhino and SketchUp are taught is very similar. Surprisingly, Rhino was slightly more prominent than SketchUp, with 44% of institutions teaching Rhino to a greater degree (compared to 40% for SketchUp), and 16% taught both programs to the same level. Both 3DS Max and Blender appear to be largely niche in their use, with the few programs that use them doing so only at an introductory level.

While previous studies (Yan, 2014; Meadows, 2021) have shown that Rhino is taught to a higher degree than is used in practice, this is the first survey to show that Rhino instruction has now surpassed SketchUp. Although SketchUp remains the second-most popular modeling software, a surprising 14 programs (29%) do not teach SketchUp at all, compared to just six for Rhino. Additionally, SketchUp had the highest standard deviation of all the software surveyed, further suggesting that its dominant position in LA education is in flux. In conversations with respondents, SketchUp is perceived as basic and limited in the geometry it can model, whereas Rhino is perceived as a robust 3D modeling suite, well-suited to modeling the organic forms in the landscape. This raises the question of the alignment between education and practice and who leads the way in adopting new software. A previous survey of practitioners found that a firm’s primary strategy to onboard new software and technology is through hiring (George & Summerlin, 2019). If this continues to hold, it could be expected that Rhino may become more prevalent in practice as an increasing number of entry-level designers come out of college having been trained to use Rhino.

4.6 Supplemental 3D modeling software

Where the 3D modeling software category features software primarily intended for poly-modeling, the supplemental 3D modeling software is intended to augment poly-modeling in a variety of ways. In many cases, the software is rendering-focused, though some focus on parametric modeling and terrain modeling.

Five supplemental 3D modeling programs are focused on rendering with Lumion being the most prevalent. 85% of respondents indicated teaching Lumino in their curricula, though it did have the 2nd highest standard deviation among all software surveyed in all categories. This could be because it has a shallow learning curve and, perhaps, some faculty only introduce the software and encourage students to self-teach through online tutorials to push them to a high level of proficiency. Enscape was the second most common rendering software taught among respondents (38%). Enscape, when compared to Lumion, is considered to be more nimble and less demanding from a computer processing and graphics standpoint, though it does have a smaller library of plants and entourage than Lumion. Twinmotion (19% of respondents) is a free rendering program and is increasingly popular in adjacent design industries. V-Ray (23% of respondents) and Unreal Engine (13% of respondents) were also mentioned as rendering-focused modeling software.

Behind Lumion, Grasshopper was taught to the second greatest degree in the supplemental 3D modeling category, with 63% of respondents teaching Grasshopper in some capacity. Grasshopper, a parametric modeling plugin for Rhino, offers the ability to create algorithms that generate form as a design or analysis tool. As a powerful plugin for Rhino, it could be argued that the emergence of Rhino as a leading modeling program is due, in some part, to the opportunities that exist with Grasshopper. Similarly, Land Kit offers parametric tools for terrain modeling, though only 6% of all respondents indicated teaching the software. Rhino Terrain (27%) and Environment for Revit (6%) were also mentioned by respondents.

As a whole, the supplemental 3D Modeling Software category has a wide range of options to integrate into program curricula, though Lumion and Grasshopper are the only two that are utilized in the majority of programs surveyed.

4.7 Emergent technologies

The last decade has seen the widespread commercialization of several important technologies that have been adopted by the profession, namely UAVs, VR, and AI. The adoption within academia of these three technologies varies, and it is too early in the adoption cycle of AI to judge the true impact that it is having. While nearly half of departments reported having VR students available to students, the total number of headsets those departments had varied widely from 1 to 25, with a median of 3 headsets. While half of programs have headsets, only a small minority report (23%) actively integrating VR into their curriculum. This suggests that departments see value in VR as a technology but the majority have not yet figured out how best to integrate it into their design workflows. This may be complicated by a relative paucity of powerful VR design tools, and what few quality applications do exist are barely being taught. Together this would imply that VR remains largely a technological curiosity in LA programs and that pedagogical research on the use of VR in design is needed to improve integration.

While almost two-thirds of universities reported having UAVs available for use, it was a similarly small portion (33%) that integrated it into their curriculum. UAVs are more challenging to fully integrate because of regulations and safety concerns, both of which probably contribute to the low integration. Despite these barriers, the fact that UAVs have a higher integration than VR might be attributed to the ability of UAVs to fill a role that has already been established in the design process, namely mapping, aerial photography, and remote sensing.

Despite barely two years of broad public availability, half of LA programs report integrating AI into their curriculum. This represents a significantly accelerated adoption rate compared to VR or UAVs. While AI is being broadly used, instruction in AI remains low, with a mean score below one for all the AI applications surveyed. The most prominent were ChatGPT and Adobe's AI, both of which are either free or included in students' existing Adobe subscriptions. The image generators MidJourney and Dall-E were close behind. Open-source Stable Diffusion has less than half the use of the leading image generators, but because of the potential it provides for users to train their own models and generally broader control over input and output criteria, it will be interesting to see if adoption rises as students and faculty increase their technical ability with AI.

5 CONCLUSION

The results of this survey indicate that Photoshop and AutoCAD remain the two most important software in LA education. Whereas SketchUp has often been listed as the third in previous surveys, it has now fallen to the ninth position and appears to have been passed by Rhino in 3D modeling software among academics. Will this trend in 3d software continue? It seems likely that Rhino will continue to have a strong presence moving forward, especially when considering the rise of Grasshopper, Rhino Terrain, and Land Kit. While SketchUp might continue to see a decline in prominence, it will likely always have a place in some programs. Adobe Creative Suite software dominates the top of the list, with Photoshop, InDesign, and Illustrator filling the first, third, and fourth positions. That the list is top-heavy with illustration and presentation software demonstrates the emphasis placed on aesthetics and the important role of that skill set in conveying design concepts. Additionally, the similarity of interface, tools, and lingo combined with the linking and updating across the Adobe software only strengthens their grip within the design workflow. This is likely to continue as no strong competitors are emerging in their categories.

The survey makes clear that there is an abundance of software that programs can choose from, and while there is generally broad consensus on the front-running software in most categories, several categories had important competing or companion software. The sheer volume of software also means that programs must strategically select what they will teach, and no program taught all of the software surveyed in any single category. Ultimately these decisions come down to several factors: faculty expertise, digital literacy of typical students within a department, and program values related to process, scale, design, and representation. Very few software will be the perfect fit for every department, and it can be expected that ongoing surveys will continue to find flux in the software being taught, especially for those outside of the top tier. One clear thing is that departments are recognizing that software is both important and complicated enough to merit specific courses dedicated to their integration. When compared to the previous survey examining how software is taught in the curriculum, departments are moving away from ad hoc instruction in other courses and into specific courses dedicated to software instruction. How software instruction is integrated into the curriculum and influenced by accreditation standards is an area for future research on this topic.

That rise of Rhino to supplant SketchUp indicates the use of even widely embedded software can change. Perhaps a program like Lumion, the leading Supplemental 3D Modeling software, will be passed by a software program like Twinmotion. Its similarly powerful rendering capabilities already have strong traction in Architecture programs and its connection to Unreal Engine only increases its potential and power in a design workflow. We can also anticipate increased integration of UAVs (drones), Virtual Reality (VR), and Artificial Intelligence (AI) in the design curriculum. Future work should expand to investigate what specific hardware and applications are being utilized with this emerging technology.

While the high response rate for this survey provides high confidence in the results, it is important to recognize that this survey represents only a snapshot in time. It is important to continue ongoing surveying to track these trends over time.

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