Employing Generative Technology in Urban Design: An Aid or a Threat?

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Abstract: In the field of urban design, many designers laud generative tools for their insightful power, especially given the complex urban issues that we face today. For many, these tools are especially helpful in wading through, distilling, and prioritizing the large economic, social, and environmental datasets that are available for urban sites and for revealing proposals not typically considered in non-generative urban design processes. Some think that generative tools have the power to shift the fundamental role of the urban designer but at the same time, there are concerns about the potential loss of designer agency. This study is based on the premise that it is necessary to critically evaluate emerging tools like those employed in generative design before they are widely adopted into mainstream practice. Thus, with this work, we studied the role of one generative tool – Spacemaker[1] – to better understand the potential challenges and benefits of integrating these techniques into design workflows. We found that, in its current form, this tool cannot replace the detailed work of designers but can, instead, assist them to think outside of the box and with mundane, repetitive tasks. Furthermore, we found promise in a more hybridized future with a co-created design process.

Keywords: Generative design; artificial intelligence; computational design; urban design; spatial analysis

1 Introduction

With the emergence of academic computers in the 1950s and personal computers in the 1980s, the architecture, engineering, and construction (AEC) industry experienced significant advancements. Up until the last decade, though, most of these computational improvements have not drastically changed the design process; rather, they primarily helped make the act of traditional drafting more efficient. Then, in the late 2000s, with the rise of parametric tools, the role of computers in the AEC industry began to shift. Instead of focusing on the act of expediting tedious tasks, these new tools allowed designers to design systematically by setting up a platform for them to develop sets of parameters and adjust the values manually to produce design outputs (GANE 2004). Since then, generative tools have emerged and have steadily risen in popularity within the AEC industry. These tools go a step beyond parametric design by allowing computers to produce hundreds or even thousands of design options semi-autonomously, using designer-set parameters as a base and artificial intelligence (AI) as an engine (NAGY et al. 2017).

In the field of urban design, many designers laud generative tools for their insightful power, especially given the complex urban issues that we face today. For many, these tools are especially helpful in wading through, distilling, and prioritizing the large economic, social, and environmental datasets that are available for urban sites and for revealing proposals not typically considered in non-generative urban design processes (LEACH 2022). Some think that

[1] Please note that since conducting this study, Spacemaker is now Autodesk Forma. For clarity and consistency purposes, it will be called Spacemaker throughout the text.

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generative tools have the power to shift the fundamental role of the urban designer – from that of a sole creator to that of a choreographer, co-creating instead of producing (NOYMAN et al. 2020, LEACH 2022, MEHAFFY 2008). But what does this mean for designer agency? Are generative tools in the field of urban design taking over the role of the designer? Are they capable of producing the same quality of outputs as non-generative processes?

And while generative design technology has been widely available for the last five-ten years, there have been limited studies comparing generative tools with traditional design tools. Thus, this study explores the role of one generative tool in urban design to find out how this design process compares to non-generative design processes. Our goal is to help readers better understand the potential challenges and benefits of integrating generative design techniques into their urban design workflow.

2 Methodology

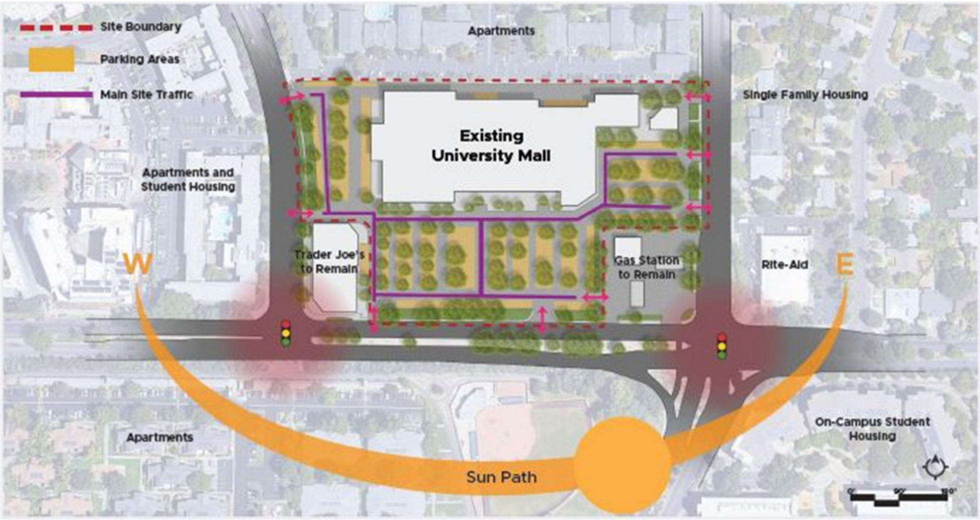

Fig. 1: A diagram showing the existing conditions of the site located in Davis California. The site is located north of the University of California, Davis campus and currently houses a mall, a grocery store, a gas station, a stand-alone restaurant, and a surface parking lot. It is flanked by three major roads and by single-family, multi-family, and student housing.

To jumpstart the study, our two-person research team first selected an urban design case study site in Davis, California. The site, called University Commons, sits just north of the University of California, Davis campus and currently consists of a single-story mall, a small grocery store, a gas station, and a large surface parking lot (Fig 1). Upon analyzing the site, we noted a number of current shortcomings that could be improved with future proposals. First, the site prioritizes automobile movement and has an inefficient parking layout. All of the current structures are single-story and low-density, with only one program each. There is no shared public space onsite and there is no street frontage along the main road that runs adjacent to the University of California, Davis campus, and limited street frontage along the two north-south corridors.

To improve upon these conditions, the city council approved a proposal for redevelopment that features ground-floor retail, podium parking, and upper-floor housing. In this proposal, the developer used the following parameters: 412,500 SF/38,322 m^2 (264 units) of residential, 150,000 SF/13,935 m^2 of retail (including the existing grocery store), 246,000 SF/22,854 m^2 of parking, 7-story (80ft/24m) height limit, and a Floor Area Ratio (FAR) of 1.56.

For our study, we used these same parameters to generate design alternatives. We spent one week exploring options through a non-generative urban design process and we spent one week exploring options through a generative design process. In both cases, we followed the same general procedure – we formulated parameters to guide the development, we produced design options, and we evaluated the options to move forward. To aid with the last step of evaluation, we developed a design goal rubric (Tab. 1). The rubric considered eight criteria and included five ratings. We evaluated proposals by going through the criteria and assigning a rating for each. We then added up the ratings to determine an overall score for each proposal, ranging from a minimum of eight points (if poor in all categories) to a maximum of 40 points (if excellent in all categories).

Table 1: A design goal rubric used to evaluate designs

	1 **Poor**	**2** **Unsatisfactory**	**3** **Satisfactory**	**4** **Good**	**5** **Excellent**
Street frontage	No buildings on perimeter	Few on perimeter	Some on perimeter	Most on perimeter	All on perimeter
Circulation and flow	Significant restrictions	Moderate restrictions	Some restrictions	Few restrictions	No restrictions
Number of buildings	<1 or >5	2	3	4	5
Average building height	1	2	3	4	5
Building coverage	<100,000 SF or >140,000 SF	100,000 SF – 110,000 SF	110,000 SF – 120,000 SF	120,000 SF – 130,000 SF	130,000 SF – 140,000 SF
Gross Floor Area	<350,000 SF or >600,000 SF	350,000 SF – 412,500 SF	412,500 SF – 475,000 SF	475,000 SF – 537,500 SF	537,500 SF – 600,000 SF
Number of entrances	<1 or >5	2	3	4	5
Outdoor space	None	Minimal	Some	Moderate	Significant

For the non-generative urban design process, we took our site analysis findings and our provided site parameters, and began sketching out quick ideas by hand. To do this, we printed an existing base map in plan and iterated with layers of trace, focusing primarily on building footprints, circulation, and open space allocation. Through this process, we identified three potential options, drafted our ideas using AutoCAD, a computer-aided design software to create measured drawings (AUTODESK n.d.) and created basic building massing in Rhino, a freeform modelling tool (MCNEEL n.d.). In many respects, this process mirrors a non-generative urban design approach where "the designer studies the design problem, internalizes all of its constraints and objectives, and then uses their skill and experience to craft a single design solution, or a handful at most" (NAGY et al. 2017). We then applied our design goal rubric to our three options, which ended up receiving scores of 32, 32, and 35 (Fig. 2).

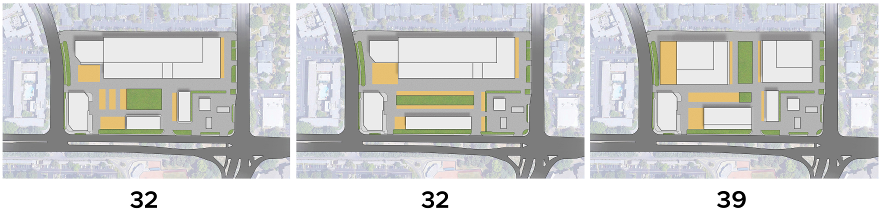

Fig. 2: A scoring of three design options created from a non-generative urban design process. For this part of the study, our team manually developed urban design ideas using site analysis, sketching, and computer drafting and modelling. We then applied our design goal rubric to our options to create scores.

For the generative urban design process, we began by selecting an existing platform to use. A few of the platforms we considered included Scout (SWEARNGIN 2020), Delve (SIDEWALK LABS n. d.), Finch (FINCH n. d.), Giraffe (GIRAFFE TECHNOLOGY n. d.), Archistar.ai (ARCHISTAR n. d.), Digital Blue Foam (DBF n. d.), Conix.ai (CONIX n. d.) and Project Refinery (AUTODESK n. d.).[2]

In the end, we moved forward with Spacemaker, because of its primary focus on urban design projects, since it was cloud-based and was available for testing at the time of the study, and since it had the ability to generate design options using similar parameters to what we had for our site. The program, geared towards real estate developers, architects, and urban designers, seeks to maximize the potential of building sites by allowing users to define initial parameters and generating a range of proposals based on these rules. Once generated, users can filter these options, compare stats for each, and save favorites. In our study, we used three initial parameters – building coverage, rentable area, and gross floor area – analyzed hundreds of options (Fig. 3) and eventually selected three, which received scores of 29, 30, and 37 (Fig. 4).

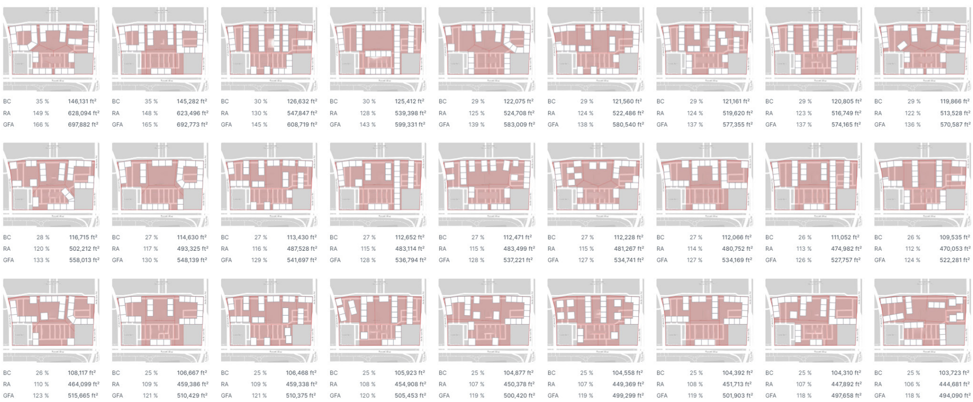

Fig. 3: A selection of generative design outputs that the team created. Once generated, the team applied the design goal rubric to develop scores for the various options.

[2] Note that this study was completed in the spring of 2022; thus, this list reflects what generative design tools were available then. Many AI tools that are available now were not available then for testing.

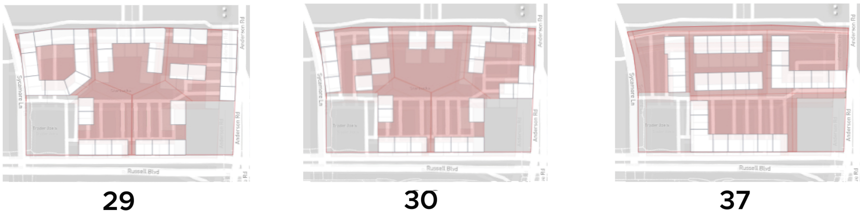

Fig. 4: A scoring of three design options created from the generative urban design process. While unrefined, these three options illustrate how generative design tools can develop unexpected, out-of-the-box ideas.

3 Findings

In analyzing the outcomes of our two design processes, we ultimately found that generative design tools like Spacemaker have the potential to bolster cross-disciplinary collaboration between a range of project stakeholders including architects, engineers, real estate developers, municipalities, and residents. This is partially because most of these tools are cloud-based, updated in real-time, and user-friendly. The tools can democratize the design process – traditionally reserved for professionals – and support more participatory planning work by acting as mediators between different stakeholders. Generative design can also produce solutions not typically considered by designers due to a reduction in human bias and to the sheer number of options created (LANDES 2022); these unexpected outcomes, sometimes called "happy accidents" (CAETANO et al. 2020) can change the ways in which designers approach a site. Additionally, generative tools can handle a number of complicated parameters at once and can evaluate sites at a high level of detail, which is difficult to do in a traditional workflow (LANDES 2022). Furthermore, given its adaptable structure, designers can quickly test design hypotheses and iterate using generative design tools without having to rebuild from scratch every time. Ultimately, this can save money in the early design phase of a project.

Despite its strengths, we found Spacemaker to have a number of weaknesses when compared to non-generative urban design workflows, perhaps due to its early stage of tool development. To begin, we found that the platform had limited parameters from which to design – building coverage, rentable area, and gross floor area were the primary inputs; furthermore, the program needed robust public data that may not be available in some places (ZHENG et al. 2021). It was also unable to manage more intangible inputs like beauty and comfort, which are often easier for designers to sense. Furthermore, the algorithm itself was difficult to predict; given the propriety nature of the tool, it was hard to understand the trajectory from input to output. In terms of project phase and project type, the tool was only helpful for early conceptual design and focused primarily on multi-family residential projects. As a result, the level of detail for the outputs was gross – just simple massing – and did not account for materiality, costs, or any sort of landscape-specific considerations. Additionally, while the output quantity was impressive, many of the proposals were unrealistic or too similar to one another (KIMM 2022) and the designer still needed to evaluate hundreds of proposals; thus, a robust design goal rubric was necessary. Lastly, we ran into a number of logistical issues with the tool. While we received a free trial for this study, the cost for long-term use of the tool could be prohibitive. The tool also requires some training to use and a reliable and strong internet connection.

As with all other generative design tools, Spacemaker will likely undergo significant improvements in the coming years as a result of rapid product development and refinement. Through this process, we hope that the tool is eventually able to: more seamlessly, quickly, and intuitively allow designers to evaluate outputs and modify them; generate outputs with a higher level of detail, especially in relation to landscape considerations; allow for a wider array of inputs.

Upon analyzing our various outputs and the two processes themselves – a non-generative urban design process and a generative urban design process – we shifted to a new approach of co-creating. We took positive aspects from various massing proposals to create a hybrid design for the University Commons site. (Fig. 5) To do this, we took a combination of unforeseen novel layouts (like what is shown in Fig. 4) and used them to develop our final design. This process of selection and hybridization was largely manual, with the team using the generative design outputs as inspirational fodder. The resulting design contained the valuable components and objectives we understood to be essential for the space and took a different perspective with the help of evaluating multiple options.

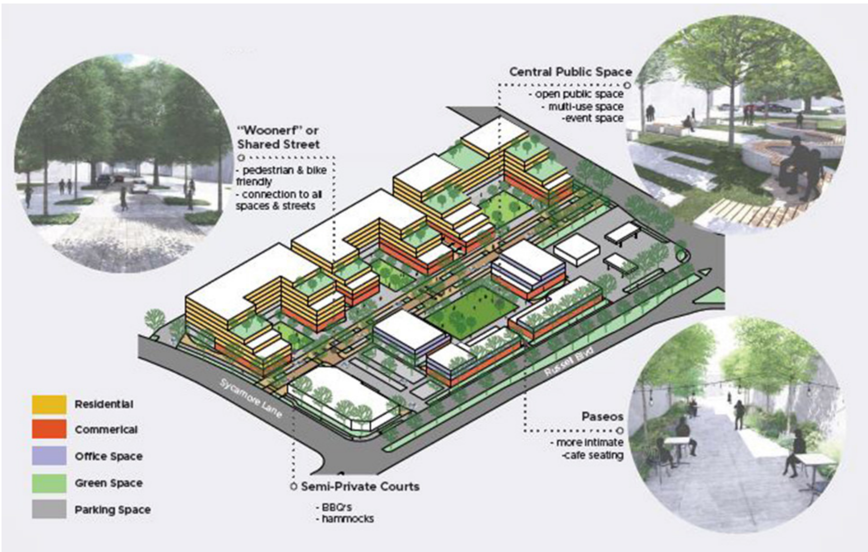

Fig. 5: Views of our final co-created proposal for the site

4 Conclusion and Outlook

A shift to co-creation is revealing when considering the primary research question driving this study – is generative design fundamentally changing the role of urban designers? From our perspective, the human designer still plays a critical and active role in the urban design process. And while we might have lost the notion of the sole genius – the idea that one designer can create a solution completely from scratch – but maybe that is not a total loss.

Perhaps generative tools like Spacemaker can actually enhance the work of designers by taking over mundane and repetitive designs tasks. And perhaps this could actually allow designers to spend more time on what really matters – design curation and choreography. As authors of this study, we see promise in a hybrid urban design process, using human designers for intuition and generative design tools for production. Yet, we acknowledge that this study reflects just one snapshot in time and our observations only hold true today; generative tools evolve so quickly that they must constantly be re-evaluated by a range of users. And while we do not know what will happen tomorrow or in five to ten years from now, we feel comfortable borrowing the words of Håvard Haukeland, the founder of Spacemaker: "We do not believe artificial intelligence will replace the architect, but it might be that architects who use artificial intelligence could replace architects who do not" (MOLTZAU 2019).

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