Opening the Gate to Urban Repair: A Tool for Citizen-Led Design

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City planning in the United States suffers from opaque and unresponsive processes—egalitarian in name but in reality controlled and mediated by city officials and powerful interests, not residents. We explore methods for placing city planning directly in the hands of the people. For inspiration, we look to the democratization of knowledge production through citizen science, and examine how this trend can be paralleled in urban design. To that end, we give ordinary people pattern-based planning tools to help them redesign (and repair) urban areas. We describe a prototype for such a tool that leverages classic patterns to enable city planning by residents, and show through a series of Mechanical Turk experiments that this prototype allows ordinary people to create designs and communicate their intentions without design training or expert intervention.

CCS Concepts: • **Human-centered computing** → *User interface management systems*; User models; • **Applied computing** → Sociology.

Additional Key Words and Phrases: tactical urbanism; city planning; participatory design; grassroots activism; citizen science

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1 INTRODUCTION

> *In the best of all possible worlds, both the professional and citizen planner would be using the guide together, as they jointly set about drafting a neighborhood plan... This book uses a democratic, participatory planning approach, and the planner working without the people has perhaps picked up the wrong book!*
>
> *Neighborhood Planning: A Guide for Citizens and Planners*, Bernie Jones [41]

In theory, methods for engaging citizens in the urban planning process are highly egalitarian, placing strong emphasis on democracy and the equality of laypeople and professional planners. This is evidenced by the quote above from one of the leading manuals on participatory methods for neighborhood planning. Such approaches to participatory design are not confined to the realm of urban planning, but are also used in HCI and other fields with prominent design cultures.

However, many participatory methods are egalitarian only in their process. When implemented, such a narrowly circumscribed "participation" is insufficient to create egalitarian outcomes. Indeed, in city revitalization, it is often the case that good processes, such as participatory design, yield little beyond providing cover for the preordained decisions of city officials (see [20, 40, 75]). In past experiences with city planning, we, the authors, have witnessed firsthand city officials dictating

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constraints to planners *before participatory planning begins*, especially regarding budgets, and these constraints are often not shared with residents. Such constraints and objectives create preordained outcomes that are later justified by the planners [75]. For example, planners may be forced—due to budget, space, and other exogenous constraints—to select those community-member ideas that align best with official, hidden constraints.

Arnstein's ladder of citizen participation can be used as a guide to examine this divide between theory and practice [8]. Urban planning texts such as Jones's [41] would have us believe that participatory methods in urban planning are in the realm of "degrees of citizen power" somewhere between rungs six (partnership) and seven (delegated power) on Arnstein's ladder. The idea is that citizens are at least equals in the decision making process, if not holding slightly more power. This may be the intention, but it is often far from reality. Even the most sincere and well-intentioned planner cannot easily overcome the weight of bureaucracy and money. Predetermined budgets, the impetus to seek only the profitable, the interests of powerful and wealthy stakeholders, limited avenues for disadvantaged members of the community to weigh in, and lack of adequate time for eliciting deep citizen participation, among other challenges, are antithetical to a truly democratic process [74]. In our experience, the reality of participatory design in urban planning typically falls between rung four (consultation) and rung one (manipulation) on Arnstein's ladder. Our goal in this work is to allow citizens to break out of this limiting urban planning status quo.

An obvious remedy—direct citizen action—is at hand, but it too does not quite achieve the goal. Theoretically, direct citizen action is known as tactical urbanism (also known as guerilla or do-it-yourself (DIY) urbanism) [52]. However, as Douglas shows in [23], many tactical urbanists have extensive knowledge of urban planning theory and municipal codes, with quite a few of them actually holding day jobs in city government or urban planning. This highlights two problems with both today's urban planning and its DIY alternatives: 1) formal expertise is often seen as necessary *even in a DIY setting* and 2) official city-planning processes are broken enough that even those who work within the system seek to go around it.[1]

Thus, in this work, we seek a middle ground. We seek to give ordinary people tools that will allow them to achieve visceral communication of their goals and desires with planners and city officials. This cooperation will give citizens more control over their input; unlike participatory design processes, in our approach there is less room for citizen ideas and priorities to be abstracted away by planners or officials creating final designs.

For inspiration, we turn to the citizen science movement. Science is a field that was once ruled almost exclusively by experts with extensive training and formal degrees. However, the rise of citizen science has started to change this, democratizing access to the production of knowledge [65]. Citizen science started as a way for experts to collect and annotate data which they otherwise may not have been able to access—activities which would rate low on Arnstein's ladder of participation in the totality of knowledge production [8]. However, citizen science has recently begun expanding to include projects that allow citizens to engage in the full knowledge-production process from forming hypotheses to crafting experiments and analyzing results [64, 73]. Technology has played an important part in this shift, with technological tools guiding ordinary people to collect and access data and carry out processes in ways that were once unavailable to them (see for example [47]).

With citizen science's democratization in mind, we consider the very first step in the urban revitalization process—creating a new design for a space. Typically, once space is identified, experts use resident feedback to produce a final design. Usually this feedback is abstract, in the form of

[1]We acknowledge that this perspective may be specific to the U.S. and that it is possible that in other countries the urban planning processes in place today are less bureaucratic and more egalitarian.

priority lists, sketches, or highly abstract designs. Thus the job of the experts is to make concrete these abstractions.

We allow people to bypass the designer and create their own 3D designs for urban repair projects without the need for expert assistance.

Our work makes the following contributions:

(1) We examine how the foundations of "democratization" in the literature—previously applied in citizen science—inform or contrast with the design of systems for grassroots urban planning and revitalization.
(2) We prototype *PatternPainter*, a design aid for urban repair projects, which allows 3D elements to be placed within a scene to easily visualize designs. We use as an exemplar the scenario of designing an urban parklet (small park) in an abandoned lot, a common challenge in urban areas across the world.
(3) We demonstrate PatternPainter's efficacy through a series of experiments performed on Amazon's Mechanical Turk. Our experiments show that the prototype system can by used by people with little to no prior experience or training and no expert intervention to effectively communicate designs for urban repair in the context of an abandoned lot.

Beyond these concrete contributions, our results show that ordinary people can produce meaningful designs for an urban repair scenario with little training given the right tools, which we believe has implications for other design-oriented fields.

In the rest of this paper, we first introduce Alexander's classic planning tome *A Pattern Language*, which served as a major source of inspiration for this work. We then review related work in citizen science, showing how the democratization of these fields parallels with urban planning. In Section 4 we discuss the design and implementation of the PatternPainter tool, and how it differs from other available urban planning software. We then evaluate the software using a series of Mechanical Turk experiments and discuss the results. Finally, we conclude with a discussion about lessons learned from the experiments and areas for future work and investigation in this domain.

Positionality Statement. We include this statement to give context regarding the authors's backgrounds and how they might have affected the lens through which urban planning and participatory design are viewed, as well as the design of the PatternPainter tool. Despite our best efforts to maintain neutrality of aesthetic while designing the tool, some of the design decisions do represent to some extent the aesthetic perspectives of the authors. The first author is a white female who was born and raised in a small, rural town in the Mid-Atlantic U.S., in which both resident-led and local government sponsored events and festivals are a common and important part of the community structure. The second author is a non-white male from the Western U.S. with family ties to and significant time spent in the Global South, and who has extensive experience personally implementing successful tactical urbanism-style projects and also seeing failures of participatory design processes. These experiences and perspectives have led us to conclude that there is a need for the CSCW community to apply its understanding of computing in such settings to improve the cities around us.

2 A PATTERN LANGUAGE

In this section, we briefly introduce the classic planning tome *A Pattern Language* by Alexander *et al.* The book served as a major source of inspiration for this work. The inside jacket reads, "At the core of these books is the idea that people should design for themselves their own houses, streets, and communities...it comes simply from the observation that most of the wonderful places of the world were not made by architects but by the people," aligning perfectly with our vision of a more bottom-up, citizen-led approach to urban planning and repair [5].

At the book's heart is a language of 253 patterns, which the authors note can be used "...to work with your neighbors, to improve your town and neighborhood. You can use it do design a house for yourself, with your family; or to work with other people to design an office or a workshop or a public building like a school." The authors define a pattern, "The elements of this language are entities called patterns. Each pattern describes a problem which occurs over and over again in our environment, and then describe the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice."

Theoretically, anyone could take Alexander's language and put together a design for a whole region or a single room. However, the book's size (1100+ pages!) and structural complexity are barriers. Most people do not have the time or energy needed to dive deeply into the book. Thus in using it as our inspiration we are able to extract the relevant pieces and present them to potential users in an easier format. One of the things we appreciate most about the language is that it offers a framework that is both rooted in expert planning principles *and* offers significant flexibility for customization and creativity. This balance is key as we do not want to force a specific aesthetic or vision on the user. On a similar note, we also like the variety in the patterns. There are patterns that are common and well-tested. For example, it is well documented that trees (pattern 171) contribute immensely to the livability of a community [11]. However, there are also patterns that are less commonly accepted, and perhaps even controversial in some cases. For instance, for lifelong urbanites the idea of animals (pattern 74) living outside of a zoo or farm might be unthinkable, and sleeping in public (pattern 94) is usually seen as something to eradicate rather than something to embrace.

In Section 4, we describe in more detail how Alexander's work directly influenced the design of PatternPainter.

3 RELATED WORK

The rising popularity of citizen science in recent years has led to a growth in the number of projects available to citizens. Several taxonomies have been developed to classify this growing number of projects. These taxonomies typically classify project by the different levels of engagement they offer to participants [73, 80, 95]. Like Arnstein's ladder [8], Shirk et al. develop a spectrum of five classifications ranging from contractual (participation only in data collection) to collegial (participation in all stages of the project and related knowledge production) [80]. Their study, along with others (see [65, 73]), shows that in general, citizen science projects tend toward the contractual end of the spectrum [80]. Qaurooni et al. coin the term "crowd science" for projects at this end of the spectrum and use "civic science" to describe projects at the opposite end [73].

Qaurooni et al. relate this dichotomy to the struggles of the participatory design (PD) community, "in realizing 'genuine participation'." [73]. Participatory design has a long history of struggling with what constitutes quality engagement and how to realize it [19, 43, 91]. These challenges include, but are not limited to, how to include the voices of socially dis-empowered populations [34], the monetary costs that PD activities can add to projects in resource-strapped communities [68], and issues of transparency and accountability [63, 76]. We position our work as part of this struggle, in particular the struggle to give more autonomy to grassroots groups within the community. Teli et al. present this dichotomy between top-down and bottom-up led PD using the terms, "**institutioning**, which describes engagement with institutions, and **commoning**, which describes engagement with grassroots communities and by extension alternative economic frameworks that challenge the status quo" [91]. We position our work within the "commoning" paradigm. In particular, as a tool to help achieve the redundancy of design researchers, which Teli et al. note "can be a desirable outcome" [91] when the goal is creating self-sustaining, grassroots change.

While Qaurooni and co-authors focus on PD in broad terms, we narrow the focus to look specifically at efforts in urban planning and repair. In the following, we will show that their dichotomy of “crowd” versus “civic” found in citizen science exists in the HCI and CSCW communities’ urban planning and repair work, and that there is a similar bias toward the “crowd” end of the spectrum.

3.1 Citizens as Sensors

A majority of citizen science projects position citizens as sensors. They collect and annotate data or perform other simple tasks, but their role does not go beyond these cursory functions [16, 72, 92]. We see a similar trend in HCI applications for urban repair [44, 49, 53]. For instance, Mahyar et al.’s CommunityCrit system enables citizens to voice their concerns and opinions about community issues via crowd-sourcing technology [53]. This kind of system may broaden the scope of who is able to voice their concerns when compared to traditional public meeting, but the data ultimately still ends of up in the hands of gatekeepers (the local government in this case) who get to decide which concerns get addressed.

In [49], Le Dantec et al. show how planners and other stakeholders use route data submitted by cyclists via a mobile application in workshops about the improvement of local cycling infrastructure. Speaking about the data, which for most cyclists was a proxy for traditional, in-person participation, they note, “The consequence of this shift was a kind of authority without agency, where the intentions of the cyclists who submitted the data were subordinated by whatever in-person argument was being made with that very same data at the charrette” [49]. In other words, the cyclists were not able to clarify or dispute conclusions being drawn using their data at the meetings. This raises questions as to whether or not route data is enough to ensure the priorities of the cyclists are met in the final plans.

A great deal of research in the realm of “crowd science” applications centers on how to motivate participants and sustain engagement [16, 39, 72, 92]. This is also true of research in HCI for urban planning [4, 29, 44, 70]. One strategy often used to increase engagement in both areas is gamification: citizen science [15, 16, 72], urban planning [45, 70, 71, 87].

We do not mean to claim that any of this work is inherently bad—far from it. “Crowd science” has played an important role in helping scientists gather and annotate data, particularly in a world where “big” data reigns supreme and science funding is continuously being slashed [3, 56]. Similarly, crowd-sourced urban planning data can be an excellent means of broadening the scope of participation [49, 71]. This is particularly important in our contemporary moment as municipal budgets fall [97] and research shows that those citizens who show up to traditional meetings are not typically representative of the population at large [24].

However, as Le Dantec et al. allude to in [49], there are still issues of accountability and transparency in how (and if) the data is used in producing final plans and outcomes. In the case of [49], we do not see what happens beyond the charrettes and stakeholder meetings, whether the publicly expressed desire to include citizen data and participation is realized in the decisions about where to place new cycling infrastructure.

Take the Hoover traffic triangle project in South Los Angeles as a cautionary example. The triangle was an unloved piece of land home to two bus stops between 23rd and 24th streets on Hoover Street, set to be revamped into a park-like plaza by the city’s streets department [88]. Citizens clearly expressed through surveys and during participatory workshops that their main priority for the revamp was ample shade (see one example of a citizen generated design in Figure 1). However, the actual revamp—a product of 2 years of planning and $600,000 in expenses—had absolutely no shade. Despite the added seating, lighting, and colorful concrete play areas, the

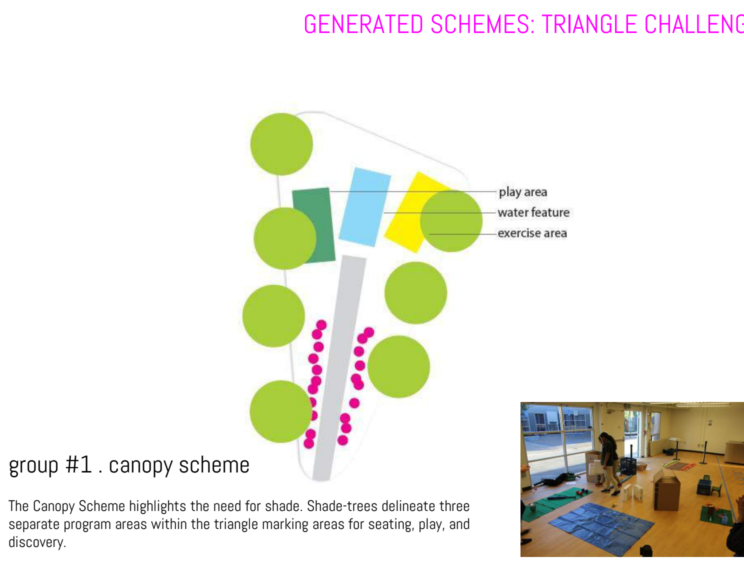


Fig. 1. A plan developed by residents at a participatory workshop for revamping the Hoover Triangle, a traffic triangle in Los Angeles on Hoover Street, between 23rd and 24th Streets. The plan, like others developed during the workshop, clearly indicates that shade was a priority for residents [88]

plaza was essentially unusable without protection from the intense Southern California sun. So commenced "Phase 2", to revamp the revamp and add the much-needed shade at additional cost to the local taxpayers who had been very clear about their needs from the beginning [89].

The sub-field of "digital civics" (see for example [10, 19]) has taken on these issues of transparency and accountability. Digital civics works to "understand the role that digital technologies can play in supporting relational models of service provision, organization and citizen empowerment... and the potential of such models to reconfigure power relations between citizens, communities and the state" [94]. This is valuable work, and we acknowledge that official channels are often necessary. Official channels are important for things like completing large infrastructure projects or providing services en masse such as comprehensive regional public transit. However, there are many instances in which these channels could be bypassed, placing the power directly into the hands of small groups of motivated citizens. We choose to focus on this more bottom-up, grassroots methodology for urban repair.

In the next section, we show how citizen science has begun to democratize, putting the power for knowledge production into the hands of citizens. We show how this parallels movements in grassroots urban planning and discuss how our work fits into this realm.

3.2 Beyond Citizen Sensing

Thanks to the work of Pandey et al. [64, 65], Qaurooni et al. [73], and others, citizen science has started to democratize, using technology to give citizens the power to produce knowledge directly—what Qaurooni et al. call "civic science" projects.

Some projects such as Hevelius, a tool for remote neurological assessments, are designed to induce collaboration between citizens and experts for joint knowledge production, but for the purposes of this paper, we are more interested in projects like Gut Instinct, which guides citizens to create and test hypotheses on their own without expert intervention [65]. Other examples of this trend include COSAMED, a system for citizen-led clinical trials [66], and the DIYbio movement, in which ICTs and open source hardware are designed to allow non-professionals to engage in research and experimentation in the biological sciences [28] (e.g., monitoring local water quality [42] and testing the DNA of genetically modified foods [47]).

We see similar trends emerging in the urban planning and repair setting with the rise of technologically-mediated systems (including social media) for grassroots organizing and action around urban issues [33]. Examples include work on fighting evictions and gentrification in Atlanta [9], and dealing with issues surrounding food such as community food sharing [32] and urban foraging [22].

Most aligned with our work are systems that leverage the power of communities and encourage them to engage with their urban surrounds. For instance, Mosconi et al. study the Italian social streets movement, which uses hyper-local Facebook groups to engage communities in offline activities, including but not limited to the kind of placemaking activities our work looks to encourage[59]. Sasao et al. have also made strides in the area of engagement outside of official channels with the use of systems to engage people in microtasks for community upkeep and collaborative social activities in existing community spaces [77–79].

Another prime example is the BlockbyBlock system [55]. It was created by a community member to allow neighbors to collect data on local code violations or instances of neglect (e.g., overgrown lawns or trash left at abandoned properties), and then encourages them to take action to help their neighbors to mitigate these issues [55]. One interesting aspect of the BlockbyBlock system is that users have the option to send the data to local authorities *or* to take a citizen-led approach. This choice about how to handle issues is incredibly important, as it gives the group a chance to promote trust among neighbors, while penalizing those property owners who might exploit the neighborhood.

Our goal is to promote the same kind of neighborhood cohesion, trust, and social capital as the projects described above, but in contrast to these efforts, our goal is to encourage a more comprehensive overhaul of abandoned or similar urban spaces, beginning with the process of creating and sharing designs. In the next section, we introduce PatternPainter, our tool for citizen-led redesign of urban spaces such as abandoned lots.

4 PATTERNPAINTER

When building our prototype system, we were motivated by the following primary goal:

To create a system that allows ordinary residents to produce designs for urban revitalization projects, effectively communicating their design ideas to their fellow community members without the aid of a professional designer to guide the process, and with little to no training in system use.

This led to the creation of *PatternPainter*—named for Alexander's book, the inspiration for our work, which is introduced in detail in Section 2. In the rest of this section, we first discuss our design choices. We then discuss the technical implementation of PatternPainter. Finally, we discuss how PatternPainter differs from other available urban planning programs.

4.1 Design

Typically, during a participatory planning workshop, residents, led by professional designers, create abstract representations of what they would like to see in the project [41]. Spatial thinking is not usually directly exposed to residents in the planning step; planning is typically done on a map, akin

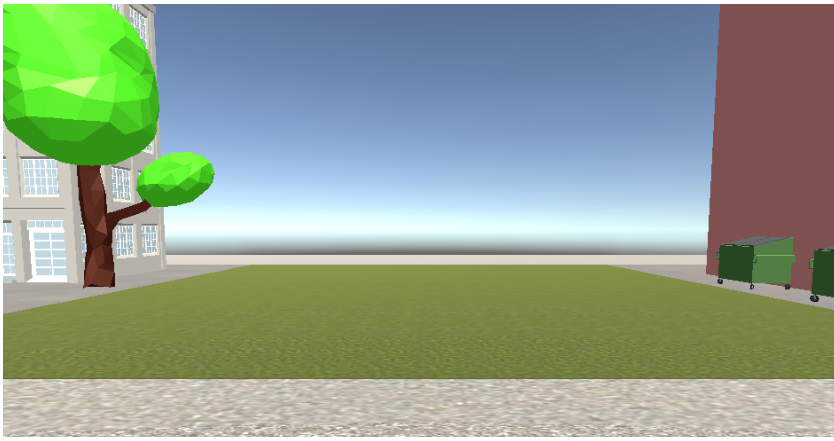


Fig. 2. The scenario for PatternPainter: an empty urban lot ripe for repair.

to a floor plan or street layout, and done in a meeting room or via online questionnaires, removed from the physical space in question [36, 62, 67, 75]. Although some efforts have been made to start incorporating additional technologies like 3D visualization and even virtual reality in the process, these technologies are typically used either entirely by or with the help of a facilitator [18, 48] or are too complex and expensive for use by small scale community groups [84].

Figure 1 shows an example of this kind of abstract design from a participatory workshop for the revitalization of a traffic island in South Los Angeles. Professional designers then produce detailed renderings of a final design. With PatternPainter, we chose to eliminate the abstraction and engage residents in spatial thinking to allow users to create designs directly in a 3D rendering of the space. We based this decision on research into 3D visualization versus alternatives. Research shows that when given a choice people generally prefer 3D visualization to 2D for spatial navigation tasks, among others [12, 83]. More importantly, studies of various spatially-based tasks have found that 3D visualization is, "most useful for tasks that require understanding of the general shape of 3D objects or the layout of scenes" [86], as well as in complex, spatial-decision making tasks [50]. Since presentation of the parklet layout is the primary goal of PatternPainter, 3D visualization is ideal. Furthermore, anecdotal evidence suggests that using 3D visualization can help people picture themselves in the scene [13]. We feel this is important for PatternPainter to help increase community buy-in for the suggested upgrades.

We selected an example—turning an abandoned lot into a small park (a parklet)—as the task around which we designed the system. Abandoned lot revitalization is one of the simplest urban repair projects, but is known to have a statistically-significant impact on crime rates, mental health, and social connectedness of communities [37, 60, 85]. As a target user, we consider the resident who walks by the lot each day, who would like to see the lot cleaned up and turned into a community space, who might even participate in a cleanup if they knew how to begin. Such a user might ask themselves: "where do I start, just clean up the trash, plant a few trees, put in a bench or two?" These are the questions PatternPainter aims to help residents answer. The PatternPainter scene is set with an empty lot. The "un-repaired" lot is shown in Figure 2. For the initial tool, the research team came up with a list of items that could be added to the scene. These items were inspired by some of Alexander's patterns that deal with uses for public space and community organization; for example, shopping street, accessible green, local sports, teenage society, and vegetable garden [5].

Fig. 3. The PatternPainter user interface displaying scenario B2 with a partially completed design.

4.2 Implementation

We built PatternPainter using the Unity game engine [93]. The scene was created using a combination of public domain images and free assets and textures from the Unity Asset Store. The 3D models and UI graphics are a combination of public domain images, free assets from the Unity Asset store, and free models downloaded from Sketchfab [81].[2] We chose to use Unity, which is freely available for non-commercial use, and to source free models, as we wish the software to remain as accessible as possible. The user interface, showing scenario B2, can be seen in Figure 3. As we will discuss in the next section, the scenarios were added as part of our evaluation, and are not intended to be part of the final tool. Game objects can be added to the scene using the object menu located at the bottom of the interface and manipulated using a number of mouse and keyboard controls. The camera position and rotation can also be controlled with keyboard input. A help menu describing the various controls can be displayed by clicking the help button in the upper left-hand corner of the interface. The game was exported to javascript using the WebGL build feature in Unity and hosted on an AWS web server.[3] Upon submission of a scenario, a screenshot of the scene is saved to the server.

4.3 Why PatternPainter?

Finally, we address what PatternPainter offers that is not available in other systems. There are already a number of software systems for urban planning, many of them much technologically richer than PatternPainter. However, there are various barriers to adoption that we feel make these previous systems unsuitable. One of the guiding principles in HCI and CSCW is an awareness of the intended user, and our intention was to design a system for all, not just those with a certain technical or design literacy or with a certain socio-economic status. Based on our literature review, we found that previous urban planning systems exist on a spectrum: professional software, open-source software, and video games co-opted for planning. With professional systems, the most substantial barrier is cost. A one year license for ArcGIS Pro, one of the most popular programs for professional planners, starts at $700 [26]. This is clearly antithetical to the "cheap and fast" mantra of tactical urbanism, and out of reach for many of the communities that could most benefit

[2]We will include attribution for the models and images in our public tool release.

[3]A fixed scenario can be tried here: http://ec2-3-129-22-64.us-east-2.compute.amazonaws.com/BuildB. Enter any text for the mechanical turk ID.

from urban revitalization. Even the personal version, including only a subset of the features in the professional version, is $100 per year [26]. Even if a community could afford professional planning software, another major barrier is expertise. Planning students take entire courses dedicated to learning this kind of professional software. Unless a neighborhood has a resident with experience in geographic modeling, geo-databases, and other relevant skills, actually using the software to produce meaningful plans would be extremely difficult. Open source urban modeling systems mitigate the issue of cost, but most still require significant technical and geographic expertise [58]. For example, Borning et al. worked on the popular open-source urban modeling system UrbanSim to create a module to simplify the use of indicators (values used in assessing the quality of urban spaces), but even in simplifying the system their target was still professional planners and modelers, not the ordinary resident [15]. Thus, we felt that our system needed to be even simpler to use than the current open-source solutions.

The use of city building games such as SimCity and Minecraft in planning education and participatory workshops is an emerging trend [2, 57]. One such game, Cities: Skylines has an extensive API that has been used to create realistic models of real cities [1, 21]. While we are inspired by the interface and capabilities of such games, there are a number of drawbacks that make actually using one of these games as a base for our project infeasible. Despite recent research to make creating real city models easier in Cities: Skylines, expert knowledge is still required to format the GIS input on which the model is based and to manually fine-tune the model after data has been imported [61]. Basing our tool on an existing commercial game would also mean that users must own a copy of the game and understand how to play it. By creating a simpler, web-based model we can host the tool cheaply and make it free for use. It also allows us to make the entire tool open-source.[4]

5 EVALUATION

In this section, we first describe how we arrived at our evaluation plan—a series of experiments performed on Amazon Mechanical Turk. We then describe each of the two experiments in detail.

As we were beginning development of our prototype system, the COVID-19 pandemic hit and our city implemented a strict lockdown. As everything moved online, it became clear that we would not be able to test our prototype in person as we had originally hoped. At the time, we were looking into several organizations doing work around grassroots advocacy and implementation of urban revitalization and repair projects whom we hope to partner with for an evaluation, but had not yet made contact with any organizations. However, as these, often resource-limited, organizations also saw their projects shut down and worked to move their advocacy online, we felt that we should not impose on their already limited time and resources with a proposal to test our prototype until we had done some initial validation ourselves.

This left us with three options for reaching participants: using our personal networks, using our university's population, and using a crowdsourcing system like Amazon Mechanical Turk. We chose not to use our personal networks because having a personal connection to our test subjects might bias the results. We also chose not to recruit participants through our university because this would bias toward a so-called WEIRD population [51]. In particular, the 'E' seemed problematic to us, as university students are potentially be much more technologically savvy than the general population, as university students in the U.S. are generally required to use numerous technological platforms in the course of their education, even before Covid. Since our target population may not have this kind of education. The remaining viable option given the restrictions at the time was

[4]PatternPainter code can currently be obtained upon request, and will be publicly released soon.

crowdsourcing, and we chose to use Amazon Mechanical Turk as we had prior experience with the platform.

Once we determined how to reach participants we had to design an evaluation in line with the platform. The goal of our evaluation was not to replicate a real world setting, because we recognize that there are unique challenges that come with working in a participatory design setting [30, 31]. For instance, we realize that issues such as place attachment will be relevant in situated settings [54]. Our goal instead was to focus on the efficacy of the system, to prove that it could be used by ordinary people without outside help or extensive training to produce meaningful designs for public, community spaces. This will allow us to approach community groups for future testing with the knowledge that our proof of concept is sound and instead focus on tailoring the system to meet their specific needs.

Our previous work with Mechanical Turk impressed upon us the need to have a validation mechanism for tasks to ensure participants paid proper attention. Furthermore, we would not be able to observe users interacting with the system or solicit semi-structured feedback in the moment. This led us away from a traditional usability survey. Instead, we designed a series of scenarios and metrics to impose more structure on the evaluation and allow for replicability and generalization across participants. We discuss the scenarios and metrics in detail next.

We recognize that there is some tension in using a global platform like mTurk with essentially anonymous participants given our goal of empowering local, grassroots organizations. However, we believe that mTurk is a viable way to test the general usability of the platform from an individual perspective. Recall our goal was to build a platform that could be used by anyone without the need for extensive training, so that it could be used by community members who may not have urban design training. Our experiments were designed specifically to test this usability aspect. As mentioned, we recognize that there will be aspects of the design which may need to be adjusted for use by a group in a real, local place. However, given the local circumstances when the research was being performed, we felt that this approach to testing the usability of the system was the best choice.

5.1 Scenarios and Metrics

In order to add replicability to our experiments and for comparison across participants, we came up with a set of 12 design scenarios. Like the objects we had added to the initial system, the scenarios were inspired by some of Alexander's patterns for community space [5]. The scenarios can be found in Table 1. These scenarios became the basis for the first experiment. We used standardized language across the scenarios, positioning them as community requests. (Although tactical urbanism projects may often bypass official channels, it is still important to consider the community's needs, not just the wishes of a single individual.) Several of the scenarios are also somewhat similar. For instance, A2 (theater) and B4 (live music performances). These scenarios with similar purpose were included, because our goal was to test the communication powers of our prototype. Similar scenarios would allow us to test the granularity of communication.

The next question was how to evaluate the efficacy of the designs for each scenario. We needed a way to compare the designs for each scenario as well as to measure how well the designers were able to communicate the purpose of each scenario using PatternPainter. Thus, we decided to come up with a quantitative measure of qualities we felt were important for community spaces based on our reading of urbanism and planning literature (i.e., [5, 40, 46]). We came up with the eight metrics, which are listed and described in Table 2.

Although all of the metrics describe general principles of a well-designed community space, some metrics fit certain scenarios better than others, and should therefore be more evident in those scenarios. For example, scenario B3 (a place for children and families) should exhibit high levels

Group A	
1	The community wants a space where elderly residents can gather for leisure activities.
2	The community would like to turn this lot into an area where outdoor theater productions can be held during both the day and evening.
3	The community would like to see this lot across from the town hall transformed into a place where residents and local leaders can meet one another informally.
4	The community would like to use this space for a community garden.
Group B	
1	The community would like to see this area transformed into a space to hold a local farmers market.
2	The community wants to make this lot into a recreation space that can be used after school by local teens.
3	The community wants to use this lot as a space where parents can take their children to promote healthy habits.
4	The community wants to turn the lot into an area where they can gather and host live music performances.
Group C	
1	The community wants to turn this space into a park with plenty of shade and places to sit and relax.
2	The community would like to see this lot turned into a park that local families can use with their children.
3	The community wants an after school location for children to study.
4	The community would like to use the lot to set up a monument to their loved ones who passed away from accidents.

Table 1. The 12 scenarios used to implement and evaluate PatternPainter. The scenarios are based on various uses for public space outlined in Alexander's pattern language [5]. They are divided into three groups for evaluation purposes.

Metric	**Description**
Shade	Are there shady spaces for people to spend time?
Play	Are there activities available for children or young people?
Comfort	Are there places to sit and relax?
Safety	Are there places to supervise children playing, is there lightning for nighttime activities, etc.?
Access to Nature	Are there elements of nature such as trees, flowers, gardens, or animals?
Recreation	Are there activities available for adults?
Entertainment	Could the area be used for performances, dancing, outdoor dining, etc.?
Sociability	Would people enjoy gathering here to spend time with friends?

Table 2. The eight metrics used to evaluate the designs produced by PatternPainter. Each design from part 1 of the experiments was rated on these metrics on a scale of 1-7 on these metrics during part 2.

of play and safety, and possibly also recreation. The first author and two other members of the research team independently chose what they believed to be the top three metrics representing each of the scenarios. The top metrics, as shown in Table 3, are those that all three team members chose in the top three. This resulted in a set of one or two top metrics for each scenario.

Scenario	Top Metrics
A1	Comfort
A2	Entertainment
A3	Comfort, Sociability
A4	Access to Nature, Sociability
B1	Recreation, Sociability
B2	Sociability
B3	Play, Safety
B4	Entertainment, Sociability
C1	Shade, Comfort
C2	Play, Safety
C3	Comfort, Safety, Sociability*
C4	Comfort, Access to Nature

Table 3. The top metrics representing each scenario as determined by the research team.
*For scenario C3, there was no metric agreed upon by all three members of the research team. The metrics given were agreed upon by two of the three members.

5.2 Experiment 1: Designs

In the first experiment, participants used the tool to design community spaces based on the scenarios in Table 1. The scenarios were broken into three sets to avoid over-taxing the attention of our participants. Each participant was given one of the three sets of scenarios, which appeared in randomized order. For any considerations regarding climate or weather participants were instructed to assume the lot was located in Los Angeles, California, due to its fairly consistent year-round climate.

Before beginning the scenarios, for practice and validation, participants were asked to replicate the scene shown in Figure 4. This ensured participants were familiar with adding and manipulating objects within the scene. Participants who failed to replicate this test scene were rejected from the task. For this experiment we used participants who were located in the US and had achieved "master" status to ensure high-quality data.[5] The experiment was designed to take under half an hour, and participants were paid $6.00 USD for completing the task.

Eighty-four participants completed the experiment—28 per sets of scenarios.

5.3 Experiment 2: Validation

The second experiment was used to evaluate the designs created in the first experiment, which would determine how well users were able to use PatternPainter to communicate the intended uses for the space given in the scenarios. Participants were told they were rating designs for revitalizing an abandoned lot in Los Angeles, California. Participants were asked to rate the designs on the eight metrics, listed in Table 2, on a scale of one to seven, as well as to briefly answer the following questions for each design: *Please provide a brief description of how the community would use this space. Who would use it? What would they do? What is the purpose of the space?.*

[5]In early trials where the master status was not required, we found people would simply leave a jumble of objects on the screen. Due to the nature of online experiments, it was impossible to tell if it was a problem with the tool or if the workers simply were not making an effort to complete the task well. We suspected the latter, but making such assumptions would have biased the data. Master status is conditional to continued review, and therefore incentivizes workers to take tasks more seriously.

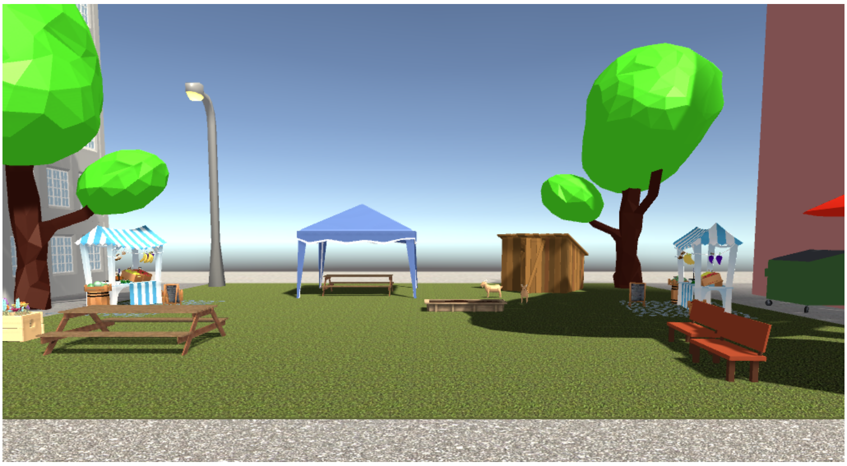


Fig. 4. The practice scene, which participants in experiment one were asked to replicate. The scene purposefully includes a variety of objects at different locations as well as some that are rotated from their initial position in order to familiarize users with all of the different object controls.

The surveys were constructed as follows. Each survey consisted of 15 designs. The first three were for practice and were taken from initial pilots of the experiment that were not included in the final data set of designs. These were the same across all surveys, but were given in randomized order. This was followed by one design from each scenario, 12 in total, also shown in random order. This resulted in 28 different surveys, one for each complete set of scenarios collected in Part 1.

The surveys also contained four attention checks that asked participants to choose a specific rating. Participants who failed two or more checks or entered nonsense text responses were rejected. Five responses were collected for each of the surveys, meaning every design from Part 1 received five ratings.

Participants were restricted to users located in the US, but due to the ability to implement robust attention checks, were not restricted to participants with "master status". Participants who completed the first experiment were not eligible to complete this second part. The survey was designed to take about 20 minutes, and participants were paid $4.00 USD.

In the next section, we discuss the results of both the quantitative and qualitative sections of the survey.

6 DATA AND RESULTS

In this section, we present the results of the experiments, using both quantitative and qualitative analysis.

6.1 Quantitative Analysis

As mentioned, the quantitative data was gathered by asking participants to rate each design on the eight metrics found in Table 2 (shade, play, comfort, safety, access to nature, recreation, entertainment, and sociability). There were 28 designs for each of the 12 scenarios, and each design received five ratings for each metric. We averaged these five ratings to obtain a mean rating for each metric on each scenario. Table 4 shows the average rating out of seven for each metric, for each scenario. Note that given the relatively small sample size we do not perform any significance testing. For each scenario, the metric with the highest average is in bold, while the metrics chosen

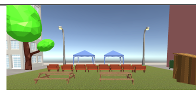
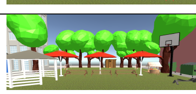
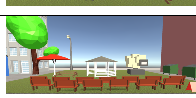
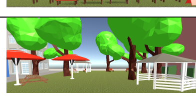
	Example Design	Shade	Play	Comfort	Safety	Nature	Rec.	Entertain	Social
A1		5.00	4.45	***5.18***	4.82	4.74	4.67	4.76	5.13
A2		4.46	4.18	5.14	4.93	4.49	4.74	*5.12*	**5.36**
A3		4.88	4.47	*5.13*	4.79	4.61	4.70	4.89	***5.56***
A4		4.50	4.30	4.47	4.52	***5.02***	4.67	4.42	***5.02***
B1		4.88	4.39	4.93	4.87	4.65	*4.77*	5.06	***5.38***
B2		4.49	5.14	4.67	4.92	4.66	5.15	4.92	***5.38***
B3		4.70	***5.54***	5.07	*5.02*	4.68	4.97	4.66	5.19
B4		4.47	4.35	**5.37**	4.92	4.58	4.53	*5.09*	***5.37***
C1		*5.15*	4.69	*5.37*	4.93	5.11	4.77	4.95	**5.47**
C2		*4.70*	***5.82***	5.03	*5.13*	4.90	4.90	4.65	5.41
C3		5.14	4.56	*5.44*	*4.92*	5.00	4.74	4.92	***5.62***
C4		4.72	4.55	*5.12*	4.77	*4.71*	4.94	4.86	**5.26**

Table 4. The average rating (out of 7) for each metric for each of the 12 scenarios. **Bold** denotes the metric with the highest average. *Italics* denotes the metrics the research team chose as most representative for the scenario. Matching of the bold and italics indicates that participants successfully communicated the scenario's purpose in their designs.

as most representative for each scenario by the research team (see Table 3) are in italics. Thus the metrics in both bold and italics represent a line up between the research team and the designs.

In nine of twelve cases, the metric with the highest average rating lines up with a metric the research team picked as most representative of the scenario. The three exceptions are A2 (outdoor theater), C1 (park with plenty of shade), and C4 (a monument to lost loved ones), which all rated highest on sociability. However, in all three of these cases the metrics chosen by the research team were among the top three. This allowed us to be confident that users were able to communicate the essences of the scenarios through the designs they created on PatternPainter.

It is worth noting that for nine of twelve scenarios sociability was the most highly rated metric, and no scenario had an average rating less than five (of seven) on sociability. This tracks with our goals for the PatternPainter system. While the specific use case for the space is varied across the scenarios, all of them are intended as a community gathering space, and sociability captures this general purpose. It is also notable that across the entire table, the highest average rating is 5.82 of 7, while the lowest is 4.18. This indicates that all eight characteristics represent most of the scenarios to some degree, which tracks with the fact that all eight metrics were derived from general principles for the design of good community spaces.

While these quantitative results may indicate the efficacy of our prototype system, we also analyzed the qualitative responses. This allowed us to better understand which scenarios were communicated most effectively, and explore other themes that emerged in the responses.

6.2 Qualitative Analysis

The qualitative data was gathered by asking participants to describe each design in terms of by whom it would be used and for what purpose (*Please provide a brief description of how the community would use this space. Who would use it? What would they do? What is the purpose of the space?*).

Due to issues with language fluency of the participants, we did not analyze all of the qualitative data. The data was reviewed for clarity by the first author; we are native English speakers. A response was retained for analysis if it was deemed to sufficiently answer the prompt and could be understood with minimal effort to interpret odd or incorrect grammatical structures. There were three common response types that were discarded:

- **Single word or very short answers.** These responses were considered insufficient to fully respond to the prompt. Examples: “park” or “children playing”
- **Lists of one or more of the eight metrics.** These were also considered insufficient to fully respond to the prompt.
- **Indecipherable grammar.** Example: “The place is park reception arrangement of people of this place. uses of peoples. the place is very nice.”

As mentioned, there were 28 surveys with 5 responses each for a total of 140 responses for each scenario. Of the 140 responses we retained 47 responses per scenario. Zero of the five responses were retained for survey 11. For the other 27 surveys, we retained between 1 and 3 of the 5 responses for each one.

The first author conducted the textual analysis. The second author was available to discuss any themes that emerged. The data was analyzed both inductively (looking for evidence of the scenarios) and deductively (looking for other patterns that emerged) [27]. The inductive analysis consisted of marking those responses which directly or indirectly captured elements of the scenario. For example, a response directly capturing scenario B1 used the words “farmer’s market” whereas words like “buy” and “sell” were considered instances of indirect capture. We then deductively looked for other repeated themes, paying particular attention to instances where multiple participants proposed a common use for a space not specified by the scenario.

We judged success to be cases in which most participants were able to identify the key purpose of the scenario, directly or indirectly, from the given designs. Those that were communicated most successfully were A4 (community garden), B1 (farmers market), and C2 (park for families). For A4, 20 of 47 responses directly mentioned the phrase “community garden” while another 8 used words like “growing” and “planting.” In the case of B1, 19 responses used the phrase “farmers market” and another 16 mentioned “vending,” “selling,” or referenced a generic community market. For scenario

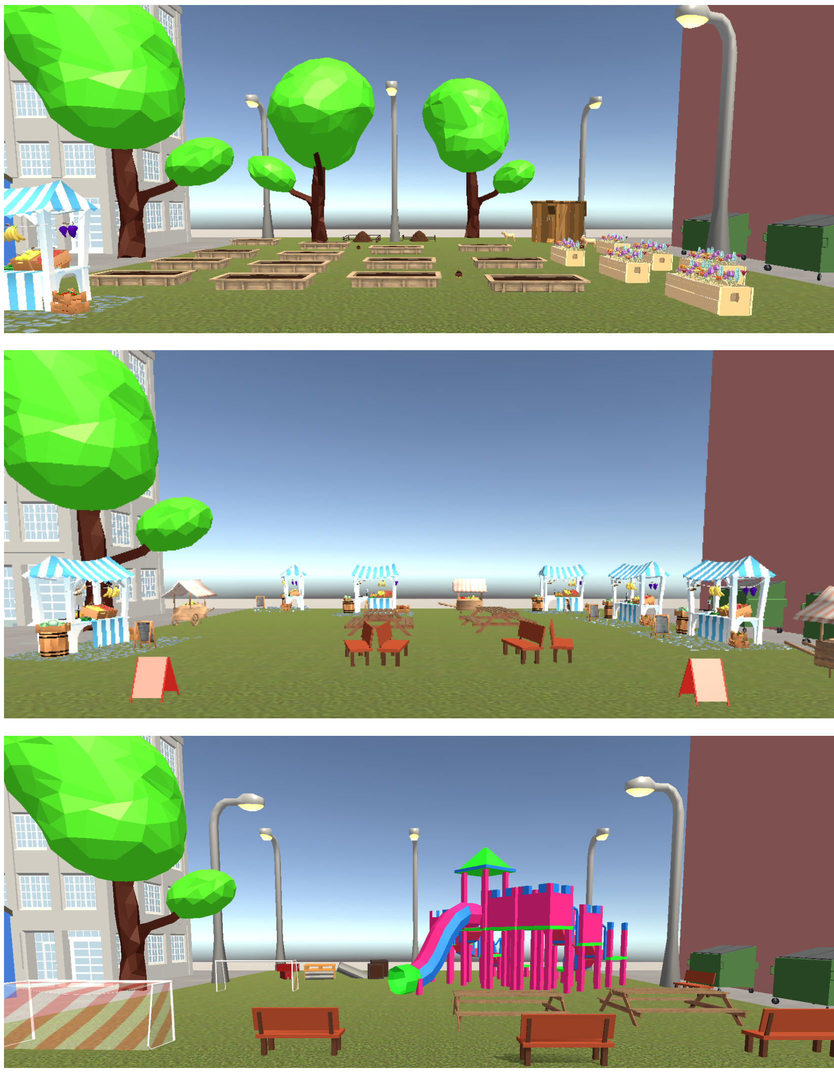


Fig. 5. From top to bottom: Examples of designs for scenarios A4, B1, and C2, which successfully conveyed the purpose and use to survey respondents.

C2, 12 responses indicated the space was for children without mention of families or parents, and 26 directly mentioned either families or parents and children. We believe that these scenarios were most successful due to highly recognizable elements associated with each scenario—garden and flowerbeds for A2, market stalls and food carts for B1, and a playground for C1. Figure 5 shows example designs for each of these scenarios featuring these items.

In contrast, we found that those scenarios that were the least successful were those with a very specific purpose, but without a specific set of highly recognizable and related elements. These were A1 (space for the elderly), B3 (promoting healthy habits), C3 (study space for students), and C4 (memorial to lost community members). While A1 was rated highly on comfort and sociability, which we believe would appeal to an elderly population, no response specifically mentioned this demographic. In contrast to a jungle gym, which is clearly intended for children, there is no analogous item that clearly signifies the elderly. The designs for B3 seemed to convey that the space was meant for children, and a few responses mentioned exercise, but the specific idea of intentionally promoting healthy habits was lost. Scenario C3 was largely seen as a picnic or dining area due to widespread use of picnic tables in many of the designs. However, knowing the intended purpose, it is easy to see how children might gather at these tables to study. No one captured the intended purpose of the spaces designed for C4, mainly surmising it was a space for relaxation or art exhibits, due to frequent use of benches and the presence of statues.

From these less successful scenarios, it is clear that some scenarios simply need additional context, but we do not feel that this undermines PatternPainter's usefulness. In a real-world use case, additional context would be provided with a design to help users communicate their intentions. Due to space and attention constraints, we only presented one view of each design in the survey. Ideally users would be able to show off a variety of angles or a allow 3D interaction with their designs. Users would likely also be present to explain their design concepts in person or could provide a written description with their design.

There is also some question as to how the 3D object models chosen for the software affected the designs. We consider scenario A2 (community theater) as an example. While many responses captured the general intention of an entertainment space for scenario A2, we might consider whether the designs would have been more successful had we included a stage as opposed to the tents and gazebos used to create a makeshift stage area in many designs. We discuss this issue in more detail in the next section, where we consider areas for improvement and expansion of PatternPainter.

Another key theme that emerged from the deductive analysis was that some of the elements were mistaken for other things. The goat was mistaken as a dog, the garden plots for sandboxes, and what was intended to be a miniature adventure park (see pattern #73 [5]) was mistaken for a skatepark by five respondents. (A dangerous one at that, as one respondent noted, "Those are probably dangerous though as they seem unfixed.") Several respondents were simply unclear about the statue element referring to it as, "the blocky things" and "THOSE MINECRAFT SHEEP STATUE THINGS." Figure 6 shows these four items in the context where they were mistaken for these other things.

In these instances, the unclear 3D models may have failed to communicate the correct context for the scenario. For instance, the second image in Figure 6 is meant to be a community garden (scenario A4), but the combination of a playground with the garden beds caused them to look like sandboxes. However, as mentioned previously, in real-world use cases context would be provided with designs to help mitigate such issues. Furthermore, having some models that are flexible in their use is not inherently bad, as it broadens the scope of objects available to designers, an issue which we will touch upon in the next section.

Based on these experiments, it is clear that PatternPainter was able to help ordinary people create and communicate designs for re-purposing an urban lot. Furthermore, participants were able to do so with no formal training or outside facilitation, indicating that PatternPainter has a low barrier to entry. However, there are certainly areas for future work and improvement, which we discuss in the next section.

7 DISCUSSION

In this section, we discuss several areas for improvement and future work based on our experimental results. We also reflect on some feedback given to us by Chris Tallman, an expert designer with extensive experience in participatory design for urban planning [90]. Tallman was recommended to us as an expert commentator because he has experience both working within the classic participatory

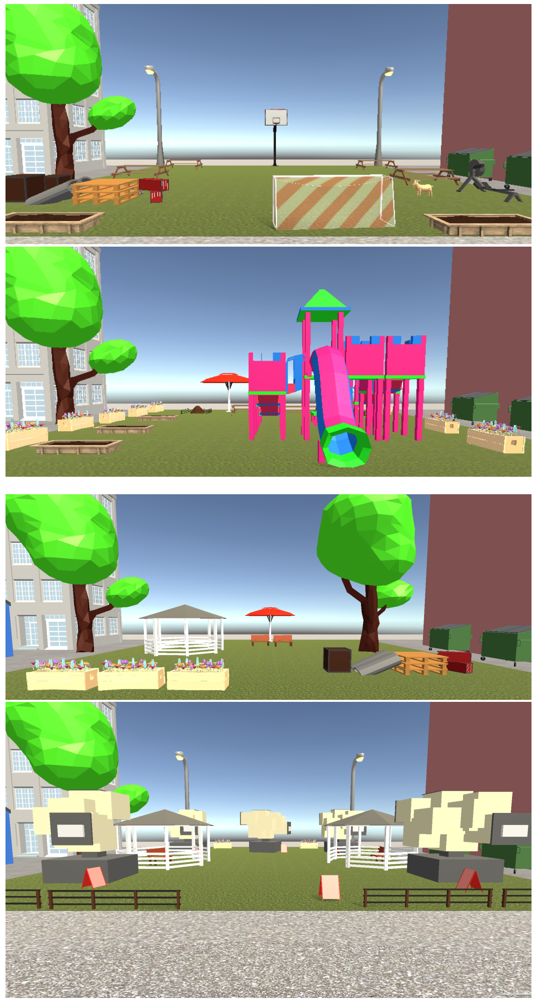


Fig. 6. From top to bottom and left to right, the models which were mistaken for other things: goat (far right side) as a dog, garden beds (far left side) as sandboxes, miniature adventure park (right side) as a skate ramp, and statues (throughout) were simply unclear.

system and also working on projects at the boundaries of the system from a bottom-up perspective. He gave feedback via phone and email after seeing an initial prototype of the PatternPainter system and reading a first draft of the paper.

Overall, our quantitative and qualitative analysis show that we were successful in creating a functional, easy-to-use system. Using PatternPainter and the limited set of objects provided, participants were able to create a diversity of designs for different neighborhood social spaces. This speaks to the tool's ultimate ability to allow community members to autonomously explore designs for community revitalization using a system tailored to local conditions.

However, we are also aware that bottom-up community led initiatives have their own set of unique challenges separate from the issues in classic participatory design [17, 31]. We expect that evaluating the system in the context of a complete urban revitalization project may lead to new insights and challenges. We hope to be able to complete this kind of evaluation soon.

As mentioned in the previous section, one potential issue is deciding what elements should be included in the system. We attempted to provide a sufficient array of elements to fit each of the pre-defined scenarios, but in the future users may want to use PatternPainter to brainstorm without a clear use case in mind. While we used Alexander's patterns as inspiration for the scenarios and elements, as Chris Tallman noted, "I was surprised at both how closely Alexander and company identified the armature of whole landscape patterns but more so by how many are missing." He then asked, "What order of complexity is there to having a tool where the user is walked through defining their own patterns?" [90].

Going beyond Alexander's language to capture more local knowledge as well as to solve problems that have cropped up in the almost 40 years since the book's 1977 publication is an important extension of the work. For instance, the disruption of public education due to the COVID-19 crisis has shown widespread inequalities in access to broadband internet, with many students unable to access online learning tools [6, 69]. This might lead to a new pattern: "Public Internet Access" that calls for public WiFi hotspots covering a city or region, and spaces to gather to safely use this infrastructure, so that all students can connect to online learning opportunities. We can only begin to imagine what myriad other patterns communities might define based on their unique circumstances and cultures.

However, this raises the related question of how to scale and support such a system. Our first step is to open source the system, which we intend to do with PatternPainter. This does not solve all the problems associated with scaling and maintaining this kind of system, but it is an enabler of further refinement and also helps the system to stay free. We are still considering this issue and other potential solutions.

Another suggestion of Tallman's was the inclusion of action items. He suggests thinking about the question, "What actions can you take today?" He proposes comparing the design with a database of tactical actions, and then listing suggestions that can be taken quickly and easily by community members. We think this idea is deep and empowering, as it is a first step toward activating community members to take on the next two phases of the design thinking process—prototype and test. This is the process by which crosswalks get painted, community gardens get planted, and neighbors become friends.

The idea of incorporating action items also alludes to the issue of creating sustained engagement in the projects designed by PatternPainter. As Tallman notes, "There are a vast number of popup community gardens laying fallow." Sustaining community engagement in local projects is an issue that has previously been studied in the context of HCI [82], and a problem we are also interested in addressing in future work. However, addressing it goes beyond the scope of this particular paper.

8 CONCLUSION

Leaving city planning to governments (particularly in the U.S. context) has yielded only crumbling infrastructure (in 2017 the American Society of Civil Engineers gave the U.S. a D+ for infrastructure [7]), slow and unreliable public transit [14, 25, 35], and a dearth of green space, particularly in areas of lower socioeconomic status [38, 96]. We believe it is time to put city planning and urban repair back into the hands of the people of each neighborhood. The blue-collar bus-rider should dictate the bus schedule, not the transit director who drives his SUV to work; the mother and child navigating broken swings and unshaded park benches should design the parks, not consultants flown in from out of state; and the urban gardener with no yard should be free to plant community food forests rather than leaving blighted lots behind the fences of a city's public works department. Based on the guiding principles of Alexander's Patter Language [5], PatternPainter is a first step toward helping residents take back the power for planning and repairing their communities. Based on our initial experiments to test its efficacy, the system shows promise in helping ordinary people create and communicate deigns for urban revitalization projects with little to no training in design of the system itself. This also has implications for the democratization of other fields which currently rely on design experts.

Our expert correspondent, Chris Tallman, responded positively to the PatternPainter prototype, and suggested a few features to further improve the tool. Based on these suggestions and our experimental evaluation, our aim for the near future of PatternPainter is to modularize the system to enable the open-source community to contribute modules for additional patterns, to integrate GIS to allow for location-specific plans, and to allow for other types of urban repair beyond abandoned lots. We look forward to getting out and testing the system in the real-world context as soon as possible. We are also planning to design tools to assist in other phases of the revitalization process beyond creating initial designs.

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