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Inclusive Interactive Simulation: Stakeholder Empowerment in Design

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Abstract. Solution generation in transdisciplinary engineering is increasingly buttressed by computational modeling and simulation tools implemented by highly skilled experts. As powerful as these tools may be, they tend to exclude non-technical stakeholders from the solution design process. With this concern in mind, we discuss the method, implementation, and preliminary results for an experiment designed to measure the efficacy of "inclusive" computational modeling techniques that allow non-technical stakeholders to participate more actively in solution generation. In the experiment, we asked individuals to play the role of an empowered citizen who must choose the final and best design for a real estate development in their city. Participants accessed a browser-based digital design tool to view, edit, and create building scenarios. Ultimately, we asked participants to specify a single solution as their final choice, while also reporting their levels of satisfaction and confidence regarding that choice. We found that non-expert participants are quite willing to exercise their own personal discretion to make decisions, even to the point of overriding or ignoring existing professional recommendations. This work may have important implications for technology-enabled participatory design processes in transdisciplinary engineering.

Keywords. Decision Support Tools and Methods, Democratization of Design, Rapid Prototyping, Methods for Transdisciplinary Engineering, Interactive Simulation for Engineering, Boundary Objects, Urban Design, Solution Design

Introduction

Transdisciplinary projects often strive to incorporate broad stakeholder participation. The word 'participation' merits careful definition. In the context of design, participation implies a dichotomy of interaction between at least two groups: professionals who conduct a design process, and those who are allowed to participate in that process. We often refer to the former group of professionals as engineers or designers, while the latter group of participants might consist of users, clients, or stakeholders. For this research, we refer to either side of this dichotomy using the above terms interchangeably. Arguably, participation is a necessary and implicit quality of transdisciplinary engineering, as professionals and stakeholders must reconcile objectives and requirements across multiple domains.

Furthermore, we should clarify the nature of stakeholder involvement that constitutes true participation. Specifically, we believe that participation implies a certain degree of shared power and shared responsibility between engineers and stakeholders.

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This is quite different than merely inviting a stakeholder to voice their opinion. Rather, we embrace a definition of participation that seeks to empower stakeholders with decision-making responsibilities.

There is a good deal of literature that reviews the potential benefits of participatory design, as well as methods for implementing participatory processes. However, we are concerned that existing participatory design methods are not keeping pace with the rapid development of digital design tools used in many engineering fields. Power over design has become increasingly concentrated in the hands of engineers who happen to be trained in the use of specialized tools or software. The gap in technical skills between stakeholder and engineer have made true participation harder to achieve. Increasingly, design alternatives are ultimately created, modeled, and simulated within arcane digital tools that are detached from the process of participation. Stakeholders may spend a token afternoon chatting around tables with post-it notes, but they might feel rightly skeptical about their chance of having any real influence over a digital design process that has become far removed from their own abilities. To achieve genuine participation in transdisciplinary design processes, engineers need to consider how their tools of practice interface with stakeholders. Specifically, tools and processes should empower stakeholders, allowing them to influence designs and make decisions in an authentic way. In prior work, we designed and built a novel digital design tool called Open Simulation User Interface (OpenSUI) with this goal in mind (Figure 1). OpenSUI allows engineers and stakeholders to co-create digital models in a sandbox-like environment that is specified in advance by an engineer [1,2]. Design configurations are left malleable, so that stakeholders may exercise their own discretion. As a demonstrative case, we built a model for designing the form and use of a real estate development project. However, much work needs to be done to demonstrate the efficacy of such tools.

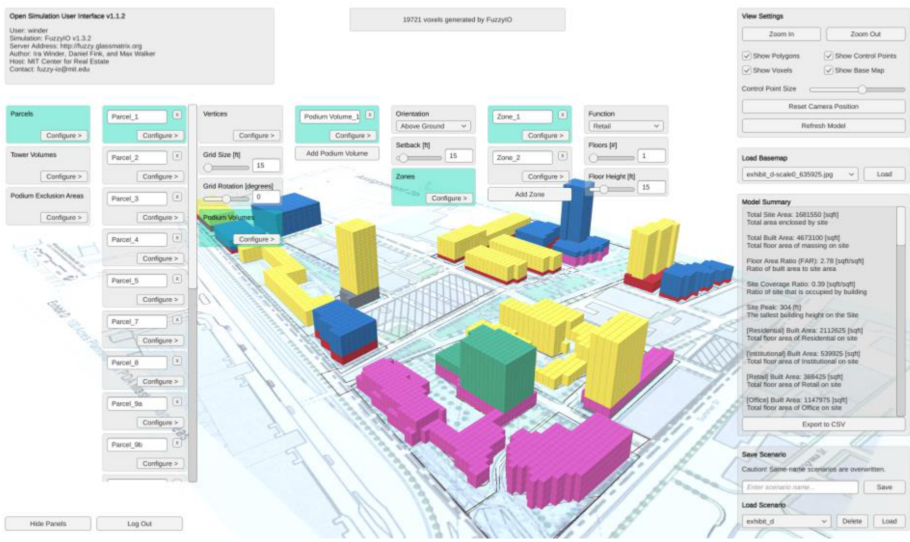


Figure 1. Screenshot of OpenSUI configured to enable urban design and modeling.

1. Objectives

We wish to observe and understand the experience of stakeholders in a participatory digital design process. Even though novel digital design tools can hypothetically give discretion and power to stakeholders, it is unclear whether stakeholders will desire or use this capability. For instance, when a stakeholder is given the option to simply endorse a professional's existing design, edit that design, or create their own design from scratch, we wish to understand which option they choose and why. Regardless of a stakeholder's decision, we also wish to know the extent of their satisfaction and confidence when they are ultimately asked to choose a final design. Finally, we also wish to determine how the provision of baseline, pre-generated scenarios can affect participation, for better or for worse.

2. Literature Review

According to architect John Habraken, ideas and methods concerning participatory design first emerged during the early 1960s as a response to demands in public housing [3]. Though Habraken himself doesn't identify as a transdisciplinary engineer, he holds many sentiments that a transdisciplinary engineer might relate to. Specifically, he recognized that "we [architects] cannot be responsible for everything, nor can we control everything." This seems like tacit acknowledgement of how something as complex as the built environment cannot be handled by a single profession. Relatedly, Habraken felt that architects were falling short of their obligations to offer true participation in design processes.

References to stakeholder participation across disciplines have become common in contemporary literature [4,5]. However, consistent definitions for what constitutes true 'participation' have remained elusive. Terms such as 'involvement' and 'engagement' often indicate paternalistic processes more concerned with public relations than empowerment [6,7]. When precedents do specifically refer to stakeholders as empowered, the term "design democratization" is often seen [8]. Curiously, some even explore the benefits of "hidden design," a process that purposefully keeps stakeholders in the dark [9]. Suffice to say, it seems that we are far from a golden age in stakeholder participation. Rather, it's possible that legitimate participation in design is in decline.

Prior work concerning novel digital tools for stakeholder participation is also abundant. However, much of this work focuses on technical implementation. While stakeholder participation is often mentioned as a motivating factor in the development of such tools, their specific efficacy as vectors for participation and empowerment is often presumed or taken as an a priori assumption. For instance, tangible interfaces for urban planning, such as the Tactile Matrix, CityScope, or Urp, are developed specifically to be user friendly and engaging [10,11,12,13]. While there is indeed evidence that such platforms may be useful in educational design exercises, it is yet to be demonstrated how such tools might empower stakeholders to have genuine influence over design outcomes. The mere act of making design tools user friendly does not necessarily empower stakeholders. Even worse, such tools might become playful distractions, far removed from how real design decisions are actually made.

Overall, existing literature leads us to conclude that participatory design is a near-universally embraced concept across disciplines. However, much work needs to be done to articulate what is truly meant by participation. Furthermore, novel digital tools that claim to democratize design, encourage participation, or empower stakeholders need to be subjected to rigorous experiments and trials that demonstrate the efficacy of such claims [14,15].

3. Method

We devised a hypothetical urban planning design process, inviting individuals to assume the role of an empowered stakeholder in a participatory design exercise. Using a combination of surveys and instrumentation, we observe the behavior and thoughts of participants as they use a digital design tool to review and adjust pre-generated designs or create their own designs from scratch. Pre-generated solutions were created by an urban design professional in advance. Ultimately, we asked each stakeholder to choose a single design for implementation and report their levels of satisfaction and confidence. When given the opportunity to directly influence design decisions, we are interested in how non-professional stakeholders handle such responsibility. For instance, we might find that stakeholders lack the confidence required to make changes to a design that was made by someone they perceive as an ‘expert’ relative to their own standing. Alternatively, we might find that a stakeholder embraces their responsibility enthusiastically, either by editing designs or creating their own from scratch. Of course, we might also find a good deal of variation among stakeholders depending on their prior background and experience. We also created a variant of the exercise where participants are asked to create designs from scratch, without the aid of pre-generated designs. We wish to see if there are any noticeable effects on satisfaction or confidence when stakeholders do not have a baseline scenario to work from.

4. Experimental Design

To accommodate individuals working remotely, we implemented the experiment as a structured exercise to be completed online within a specified time limit (Figure 2). Specifically, volunteers participated by logging in to a browser-based interface designed and created for this research. First, participants are guided through account creation and informed consent. Then, after completing an entry survey, participants are briefed on their roles and responsibilities. After a short tutorial, participants are then given access to a digital design tool, that allows them to view, edit, and create designs. After participants are given a set amount of time to work freely, they are asked to select a final design and complete an exit survey.

Volunteers were solicited via open calls for participation on various mailing lists and social media. To some extent, participants were drawn from the social and professional networks of researchers, so some selection bias was a concern. However, invitations made it clear that all persons were welcome to participate regardless of background or experience, and persons with prior knowledge of the research were excluded.

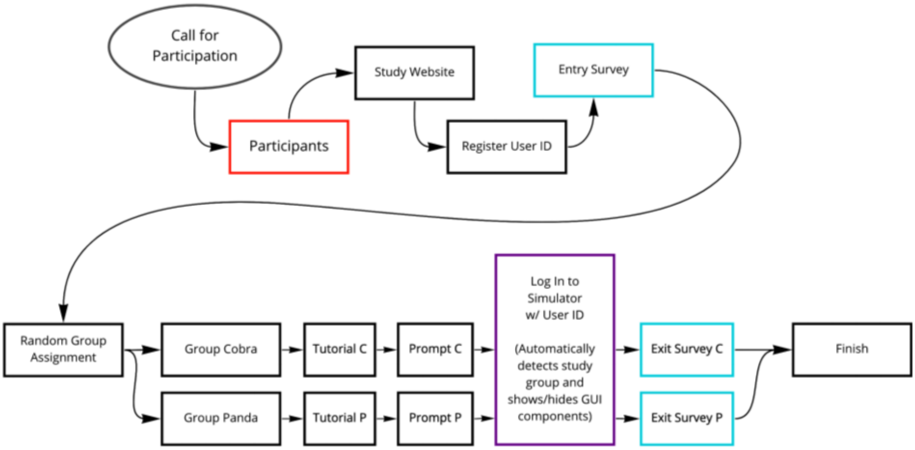


Figure 2. Progression of subject involvement in experimental design.

Conducting the experiment through a custom web interface had several benefits. Firstly, it allowed us to enforce a consistent and controlled experience for participants. It also allowed us to automate data collection and entry, as all user interactions were logged as digital fingerprints. We also used the system to randomly assign participants to one of the two treatment groups at the time of account creation. This helped us mitigate potential bias in our treatment allocation process.

Subjects independently completed surveys and performed exercises over the course of 50 minutes. Each user had access to their own unique instance of a digital design tool, and no data was shared between users. Each user experience was an isolated exercise, and subjects remained unaware of other subjects' activities. Users' faces and voices were not available to any other users throughout the entire experience and were not recorded.

Figure 3. Image of the building site, provided to all participants.

Table 1. Design Requirements.

Building Requirements	**Amount**
Minimum Residential Built Area	50,000 square feet
Minimum Institutional Built Area	80,000 square feet
Maximum Floor Area Ratio (e.g. building density)	5.0

All participants were provided a consistent mission statement regarding a hypothetical site in the imaginary city of "Beaverton". Specifically, they were informed that a vacant piece of land had been donated to the city, and that they had been elected by their community as a trusted representative to finalize the design of a building upon the land (Figure 3). The participant was also given a small number of functional requirements, such as minimum areas for residential and institutional uses, as well as an overall maximum density (Table 1). Aside from specified requirements, other objectives and value judgements were left to the discretion of the participant.

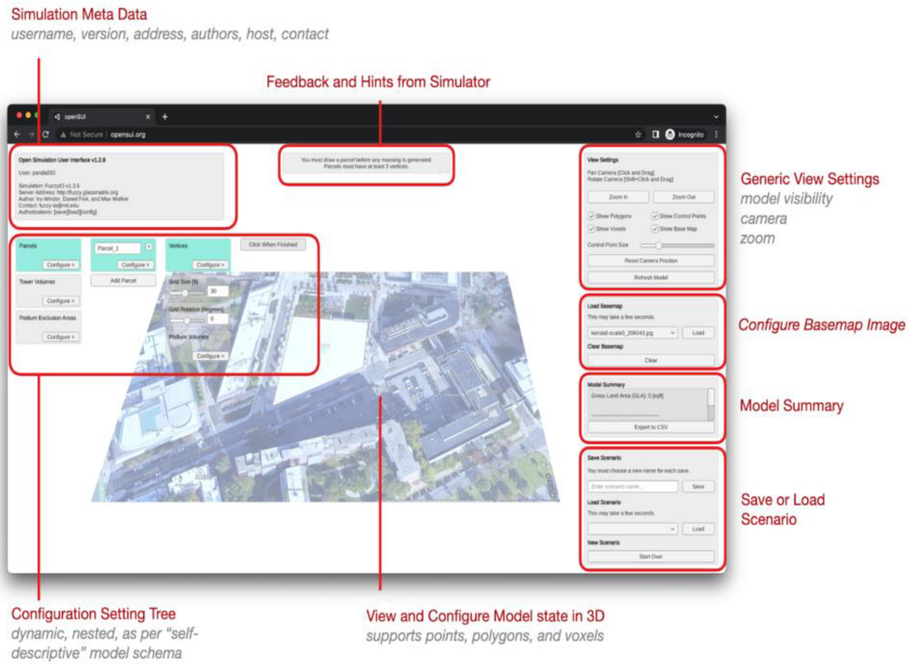
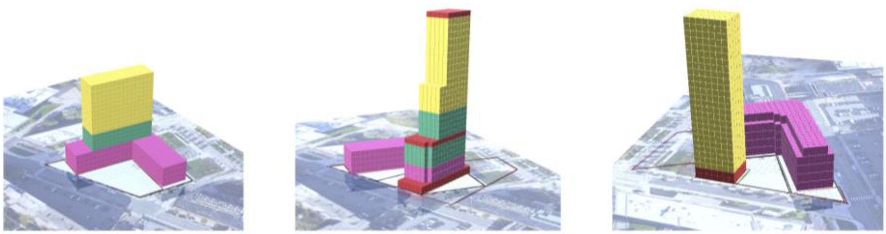


Figure 4. User interface components that facilitate creation and editing of urban design scenarios.



Floor Area Ratio (FAR)	4.7
Gross Land Area (GLA)	40800 sqft
Gross Floor Area (GFA)	270900 sqft
Floor Area [Residential]	82500 sqft
Floor Area [Institutional]	99000 sqft
Floor Area [Hotel]	30000 sqft
Floor Area [Parking]	59400 sqft

Floor Area Ratio (FAR)	4.79
Gross Land Area (GLA)	41300 sqft
Gross Floor Area (GFA)	288900 sqft
Floor Area [Residential]	57500 sqft
Floor Area [Institutional]	80800 sqft
Floor Area [Retail]	30100 sqft
Floor Area [Hotel]	52100 sqft
Floor Area [Parking]	68400 sqft

Floor Area Ratio (FAR)	4.12
Gross Land Area (GLA)	42300 sqft
Gross Floor Area (GFA)	241400 sqft
Floor Area [Residential]	87500 sqft
Floor Area [Institutional]	96500 sqft
Floor Area [Retail]	7000 sqft
Floor Area [Parking]	50400 sqft

Figure 5. Three pre-generated baseline scenarios exclusively provided to 'panda' group.

Participants were placed into one of two treatment groups. Both groups could freely use the digital design tool to create urban design scenarios (Figure 4). One treatment group, dubbed panda, also had comprehensive access to three pre-generated designs for the site (Figure 5). These designs were created in advance by an alleged professional. Participants in the panda group were free to utilize or ignore the pre-generated designs as they pleased. The second treatment group, dubbed cobra, was not given access to any pre-designed scenarios. Implicitly, they had no choice but to use the tool to generate their own designs from scratch. Otherwise, the amount of information, time, and tools at either groups' disposal was the same.

5. Results

We were able to successfully collect data from 14 participants from various backgrounds. Three of these individuals reported that they had some background in architecture, urban planning, or real estate, but only one participant reported that they considered themself to be an expert in one or more of those fields. Participants' prior experience with computer-aided design software was variable (Figure 6). We expected and even hoped for such diversity in our responses, as our users need not, nor should they, resemble professional architects or urban planners. Overall, sampled participants seemed like a potentially realistic mix of lay citizenry for the purposes of a participatory urban planning scenario.

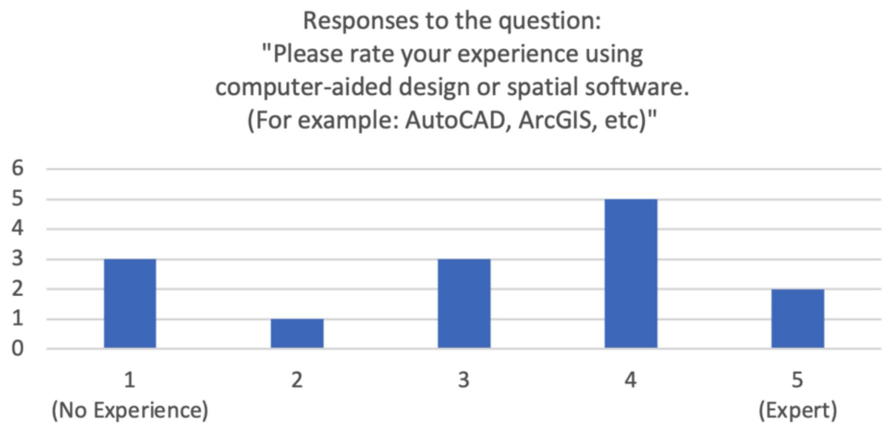


Figure 6. Self-reported participant experience using computer-aided design software.

Reported levels of satisfaction and confidence across participants covered a wide range of values (Figures 7 and 8). Satisfaction and confidence were highly correlated ($p = 0.005$), while CAD experience was correlated with neither satisfaction nor confidence. Levels of satisfaction and confidence between the two test groups were not significantly different according to one-way ANOVA test ($p = 0.79$). We feel that this is likely an indicator of insufficient sample size, but it could also indicate that stakeholder satisfaction in participatory design is not affected by the inclusion of pre-generated scenarios.

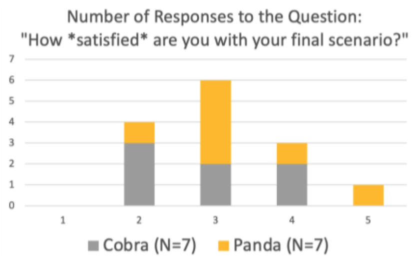


Figure 7. Distribution of participant satisfaction.

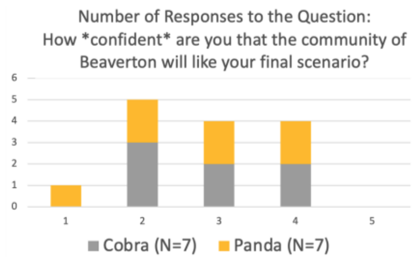


Figure 8. Distribution of participant confidence.

In the panda group, participants had multiple options to choose from when selecting a final scenario. Not only could they design their own scenario, but they could also choose a pre-generated scenario or modify it (Table 2). Of the seven participants in the panda group, five elected to disregard the existing scenarios completely, opting for their own original designs. The remaining two chose an edited version of a pre-generated design. No participants chose to implement a pre-generated solution in its original form. Even with this relatively small sample size, a Shapiro-Wilk test for normal distribution shows that the results are statistically significant ($p = 0.0017$). In other words, if stakeholders were just as likely to choose a pre-generated design as their own design, it is highly unlikely that we would see these results. Therefore, we predict that further participants would also favor designs that they themselves modified or created.

Table 2. Participants in the panda group overwhelmingly opted for their own completely unique design.

Responses to the question: Which best describes the scenario you ultimately chose? (Test Group: Panda)	**Number of Responses (N = 7)**
I chose Option 1, 2, or 3	0
I chose a modified version of Option 1, 2, or 3	2
I chose my own completely original scenario	5

6. Discussion

The results seem to suggest that digital design tools for participatory design can successfully empower non-professional stakeholders to make design decisions. When given the option to choose one of the pre-generated scenarios, we expected more participants to defer to the expertise allegedly embedded in those designs. Or, at most, we expected some brave participants to make small tweaks to those designs. We did not expect users to desire nor take on the responsibility of creating their own designs entirely from scratch, nor did we demand it from them. Nonetheless, we saw most participants exercise a great deal of discretion by creating their own designs entirely, when given the choice.

The inclusion of pre-generated designs appeared to have no measurable effect on stakeholder satisfaction and confidence, but it's still possible that they were influential in other ways. Discerning this influence would require a more nuanced analysis of design outcomes which we do not perform here. Regardless, the presence of the pre-existing scenarios did not appear to have a discernible impact on stakeholder satisfaction or confidence. This leads us to ultimately reconsider the fundamental value of pre-generating solutions in the process of participatory design in transdisciplinary engineering.

Other work has measured the tendency of designers to prefer their own ideas [16]. This work further reinforces that notion by suggesting that stakeholders acting as designers will also tend to prefer their own ideas, even when presented with direct knowledge of other, potentially better design alternatives.

7. Conclusion

In this work, we sought to test the feasibility and understand the impact of empowering stakeholders with decision-making capabilities during digital design. We formulated a novel experimental platform that allowed us to automate remote participation of subjects in a controlled design experiment. We found that participants are surprisingly willing to exercise their own personal discretion over decision decisions, even to the point of overriding existing professional recommendations. In fact, we found that the stakeholder participation was not largely affected by the inclusion of a professional's pre-generated recommendations. Though tentative, this work suggests new avenues of research that might inform how practitioners ultimately choose to incorporate their own expertise into participatory design processes. Rather than delivering concrete design scenarios, perhaps transdisciplinary engineers might consider delivering tools that allow stakeholders to create their own scenarios. Furthermore, we feel that these findings are just the beginning to many exciting discoveries that will be enabled by instrumented experimentation via remotely accessible digital design platforms.

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