MASS PARTICIPATORY DESIGN ON THE WEB

A Voxel-Based 3D Modelling Approach

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Abstract. The traditional participatory design approach has its physical limitations regarding the number of workshop participants and visualisation tools used. In order to get the input from more people and to enable three-dimensional design visualisation, an online web-game is developed as a mass participatory design tool. For the purpose of this research, a specific social issue regarding the "Not In My BackYard" (NIMBY) attitude in Singapore was chosen as a vehicle. The results from a small pilot test group of a prototype shows that the participants find this approach engaging. The game also has a potential in terms of recording participants' design and attitude inputs.

Keywords. Mass Participatory Design; Citizen Participation; Web-game Design; three.js; WebGL.

1. Introduction

Participatory design is an effective approach for solving community-based design problems. The designer can facilitate the discussion and contribute their design expertise while people from the community can offer their knowledge about the site context. A traditional workshop-based approach typically uses drawings, plans and other two-dimensional visualisation tools.

One example that managed to use traditional participatory design workshops at a large scale was a city-wide project in Vancouver, Canada, in 2015. The CityPlan Vancouver project was carried out over a period of two and a half years, involving 100 000 citizens (Rosol 2015). The project has generally been regarded as being very successful.

However, such traditional approaches suffer from two main drawbacks: limited scalability and limited support for spatial exploration. The scalability issue stems from the fact that face-to-face workshops have inherent limits regarding the number of workshops that can be held, and the number of participants that are able to join those workshops. Scaling up the participatory process, as was done in Vancouver, is often prohibitively costly and time consuming. The spatial exploration issue stems from the fact that physical plans and models commonly used in participatory design workshops mainly support two-dimensional planning.

PROJECTIONS, Proceedings of the 26th International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA) 2021, Volume 2, 31-40.

In high-density cities, the most innovative solutions often require 3D solutions that are spatially complex (Pietsch 2000).

This research proposes to overcome these drawbacks by leveraging online digital tools that allow participants to explore alternative design options. Al-Kodmany (1999) has highlighted that: "Used on their own, the traditional non-computerized tools lack the capabilities for sophisticated analysis, display, and visualization that enable the public to make more informed decisions". One issue with such tools is that they are often too overwhelming and intimidating for the general public to use. For participatory design, any such tools should be as simple and as unintimidating as possible (Al-Kodmany 2001). However, this often results in digital tools being used solely for the visualisation of design options. For example, a well-known case-study is the participatory design project led by the University of Glamorgan, on the proposed development of a wind farm in South Wales (Berry et al. 2009). The workshops included various GIS visualisations that show how the windfarms would be visible in the landscape. While these digital tools were successful in allowing citizens to understand the visual impact of the wind farms it did not allow the citizens to modify or change the design.

The aim of this research is to allow participants to create their own designs, thereby giving feedback on the types of spatial configurations that could be acceptable. We believe that innovative spatial configurations may be able to ameliorate various types of social tensions that may exist in high density urban environments. Configurations may involve stacking different types of programs. From a planning perspective, we suggest that it would be useful to be able to gather data on different types of configurations that citizens would find desirable. This data could then be used to inform the planning of future urban environments. Furthermore, if such tools can be developed as online games, they could potentially be accessible to a much larger number of citizens, in contrast to the limiting context of a traditional participatory design set-up. Games as a medium offers immersive problem-solving experiences where players can learn not just facts, but also multiple ways of seeing and understanding problems (Squire 2008).

A number of researchers have developed online participatory design tools specifically for allowing citizens to develop their own designs. The most well-known example is the "Qua-Kit" urban modelling tool developed by Anonymous (2016, qua-kit.ethz.ch/about). The tool allows participants to do a simple massing of 3D components on a base map. Qua-kit records the configurations submitted by the participants and other participants can then view and leave reviews on them. Qua-kit allows for a quick exploration of urban planning iterations, however, the unconstrained modelling approach used in this tool was still found to be rather complex for usage by the lay-people.

Another interesting tool is Block'Hood, an architectural simulation videogame developed by Jose Sanchez (2015). The game aims to educate players on the concept of trade-offs in city planning, with a focus on sustainability. The goal of the game is to design a sustainable city that is ecologically interdependent, testing the players' resource management skills. This game was studied for its simple voxel-based modelling approach which can be adapted for the context of this research.

In this research, we have developed an online web-game that addresses the aforementioned limitations of a traditional participatory design workshop. The game uses a voxel-based 3D modelling approach that is easy for citizens to use, but that nevertheless allows complex spatial configurations to be created. The focus of the game is to develop spatial configurations that resolve various potential social tensions and conflicts between different programs, including residential housing, worker dormitories, markets, restaurants, and parks. The game allows citizens to develop and explore their own design ideas within the constraints imposed by the game environment.

Section 2 describes the proposed design scenario and section 3 describes the implementation of the first version of the game. Section 4 presents the results from a pilot study while section 5 discusses the limitations and future work.

2. Design Scenario

A social issue in Singapore has been adapted as a vehicle for this research. NIMBY, which is short for "Not In My BackYard" is a term coined in the 1970s and it refers to "the protectionist attitudes of and oppositional tactics adopted by community groups facing an unwelcomed development in their neighborhood" (Dear 1992). NIMBYism in Singapore is not new. With its high population density, Singapore has no choice but to build unpopular facilities near residential areas. In the past decade, there have been numerous NIMBY cases in Singapore, usually regarding the construction of nursing homes and foreign worker dormitories. NIMBYism often arises from the lack of proper communication between the two parties involved in the development: the residents and the developer.

A study conducted by Sirianni (2007) highlighted that a well-designed participatory planning process could curb NIMBYism as it increases mutual understanding between the two parties involved. Therefore, the aim of this research is to create a game that will allow participants to develop an understanding of how 3D spatial planning can resolve many NIMBY issues. Urban proposals that incorporate programs such as nursing homes or worker dormitories can result in various mutually advantageous solutions that would benefit all the residents.

The web-game developed for this research is a simple town building game with complex rules. It has a simple interface where participants will be able to build a 3D configuration by selecting a module, placing it into, or deleting it from the neighbourhood. The interface is made to be as intuitive as possible to make sure that it can be understood by anyone. However, the computational rules behind the scoring system require a certain level of complexity in order to capture various relationships and trade-offs relating to NIMBYism and city planning.

An imaginary site that represents a typical Singaporean neighbourhood has been designed as the game environment, see figure 1. After accounting for a 10m building set-back from the road, the site consists of a 90 x 90m buildable plot for the game. This plot is further divided into 9 x 9 grid of 10 x 10m squares as this grid size was found to have a good scalability in the context of Singapore's built environment.

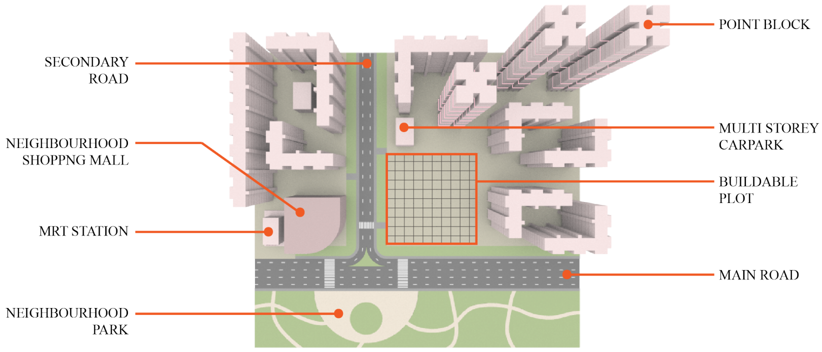

Figure 1. Game environment details.

In the proposed web-game, players are faced with the challenge to develop a plot of land with different programs. There will be some inherent conflicts between these programs and players can then explore different types of spatial configurations to minimise the conflicts and maximise the benefits. Some of these conflicts can be built into the UI/UX of the platform while some others can be a written description. Additionally, the building constraints and goals can be incorporated in the UI/UX of the platform, such as by not allowing participants to submit their iteration before they have fulfilled certain requirements.

The in-game conflicts will mainly be based on the concept of trade-offs:

1. Trade-offs based on resources: Participants will be given a fixed number of modules of different programs (housing, education, F&B etc) that they will be able to build on the buildable plot. For example, the housing program includes residential, worker dormitories and nursing home modules. Building more dormitory modules means less residential and nursing homes modules can be built.
2. Trade-off based on critical mass: The more people who live in the neighbourhood, the more facilities the residents get to share and enjoy together. NIMBY facilities such as worker dormitory modules are denser than residential units such that there will be an incentive to include more dormitories in the neighbourhood in order to unlock bigger facilities such as a food court.

Participants will not be given a single numerical score for their iteration. Instead, several different 'share-holders' are identified and each of them will have their own scores. For example, building many nursing home modules but no playgrounds will give a high satisfaction score for senior citizens but a very low score for children. These scores will only be shown to participants after submission so as to not affect their decision making while playing the game. For each participants, the scores serve as a personal check on the NIMBY attitude. These scores and their related numerical data indicate preferences and attitudes of the participants, and hence will be useful for planners, see table 1. Planners can customise the limitations implemented in the game to test for different participants' attitudes. For example, a group can be tasked to build a minimum number of worker dormitories while another is free to build what they want.

Table 1. Types of scores and their relevance.

Type of score	Description	Implication
Ratio based score	Scores based on the ratio between various variables e.g., the ratio between Singaporean Residents and Foreign Workers.	Indicate how comfortable participants are with a certain compromise in living arrangement.
Proximity based score	Scores based on how close some modules are to another e.g., the proximity of residential units to green spaces versus the proximity of dormitory units to green spaces.	Indicate the facilities participants are comfortable sharing with other parties.
Count based score	Scores based on the number of modules built in the neighbourhood.	Indicate the type of facilities participants want from new developments.

3. Prototype Implementation

In order to test the proposed method, a prototype version of the game, called "Sharing a Backyard" was developed. The game was implemented as a web application that could be accessed in any web browser. The main software library used behind the development of Sharing a Backyard is three.js. Three.js is a cross-browser JavaScript library and application programming interface (API) that allows users to create and display 3D models and animations in a web browser using WebGL renderer. The numerous 3D models used for the game are first built using Rhino and Blender. glTF file format is chosen for the final export as it allows for faster and more efficient use in 3D games.

Figure 2. From left to right; samples of residential, park and worker dormitory sub-modules.

In this prototype version, three types of modules are included, namely a residential module, a foreign worker dormitory module and a park module, see figure 2. The residential and dormitory modules are included to introduce a conflict of interest related to the social issue addressed in the context of the game. The park module is included as a neutral, public good facility. The design of the modules for Sharing a Backyard is made with minimal details to avoid imposing the idea of a model residential building and to avoid overloading the system. Using an abstracted design also allows participants to better relate the environment to their own neighbourhood.

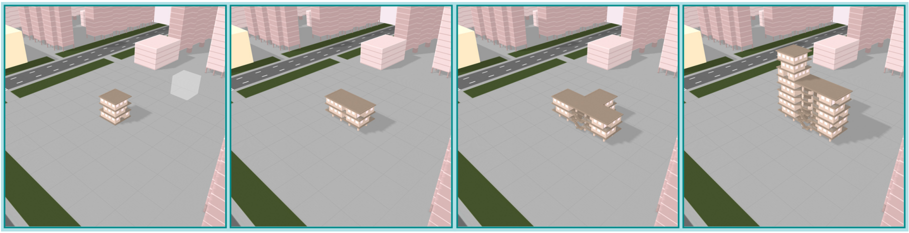

Figure 3. 'Mutation' process, cluster forming .

When a module of the same type is built next to each other, the modules mutate to form a cluster of connected modules, see figure 3. There are two types of module propagation, namely a planar propagation and a 3D propagation. The current dormitory and residential modules follow the 3D propagation logic, allowing vertical expansion, while the park modules follow the planar propagation logic. In order to create clusters of interconnected modules, the different method of propagation requires different numbers of sub-modules in a set. For planar propagation, six sub-modules are required in a set, while 24 sub-modules are required for 3D propagation. The logic of propagation is explained and tabulated below, see table 2.

Table 2. Planar and 3D propagation sub-modules.

Graphic	Number of Neighbours	Neighbour Type	Planar Code
	0		0
	1		1
	2	adjacent	2A
	2	opposite	2P
	3		3
	4		4

Graphic	Bottom	Top	Vertical Code
	ground	0	S
	ground	1	V
	1	0	R
	1	1	W
	0	0	R
	0	1	W

For planar propagation, six different types of sub-modules are identified based on the number of filled neighbours a voxel has and the location of the neighbours relative to the voxel. A numeral code is assigned to the sub-module for identification. These sub-modules are then programmed to rotate to face the correct position in relation to the location of neighbouring modules.

For 3D propagation, the same planar rules applies but with a vertical component added to the logic. A sub-module type is evaluated based on the voxels on the top and bottom of the said voxel. An alphabetical code is assigned to the sub-modules for identification.

The game interface contains a brief description of the design scenario, along with a few basic instructions on how to proceed to play the game. A task is given for the participants to build a certain number of each module type on the empty plot. There is a counter at the side of the screen to keep track of this. A brief explanation on the three different modules and the game controls are also given at the side of the screen.

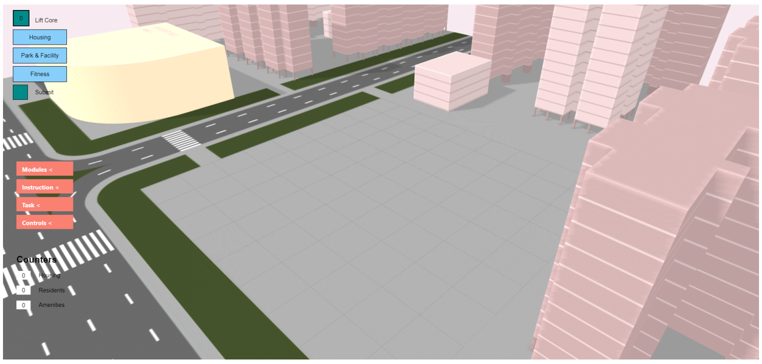

Figure 4. The latest user interface for ‘Sharing a Backyard’.

The image above is the latest interface of “Sharing a Backyard” and is slightly different from the one used for pilot testing, see figure 4. Some new updates have been implemented in the latest version:

1. A build limiter has been introduced to stop participants from building more than tasked.
2. New modules have been introduced including, “hawker center” (a typical neighbourhood food court in Singapore), elderly fitness corner, tennis, and basketball court. These are unlockable when the neighbourhood has reached a critical mass of a certain number of residents.
3. Resident count variables have been introduced, different sub-modules have different resident counts according to the size and number of housing units.
4. A saving mechanism has been developed for participants to submit their iteration in the form of an array of keys to the cloud. The developer side can then import the submitted files to the game to examine the participants’ iterations and scores.
5. A simple scoring mechanism has been introduced to evaluate participants’ iterations. These scores will be shown to participants after they have submitted their iterations.

The latest version of “Sharing a Backyard” can be accessed through:

https://annayenardi.github.io/SHARING_A_BACKYARD_CA/index.html

4. Pilot Study

A small pilot test involving even participants with various demographic backgrounds was conducted to confirm the feasibility and effectiveness of this approach. The group of respondents was relatively diverse with people coming from different age groups and occupations. It was interesting to see that different people come up with very different design strategies and iterations. Only the respondents with an architecture background massed the dormitory and residential modules in the same cluster. Others separated the two masses, often building the residential block higher to give the residential apartments better views. Some other iterations separated the dormitory and residential apartments while connecting the masses with roof gardens, saying that the garden was for the two parties to share. Some snapshots of the design iterations by the participants can be seen in the figures below, see figures 5-8.

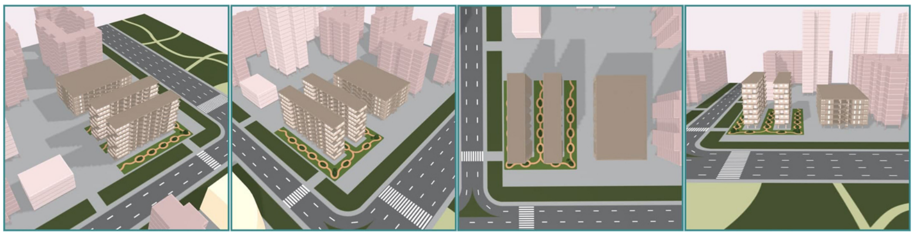

Figure 5. Respondent 1: 24 F, Singapore Permanent Resident, Product Designer.

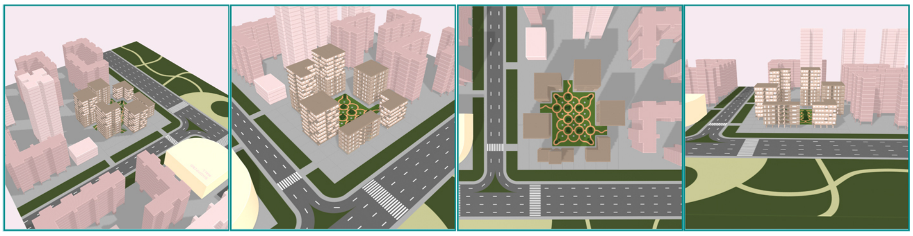

Figure 6. Respondent 3: 23 F, Singapore Citizen, Architecture Student.

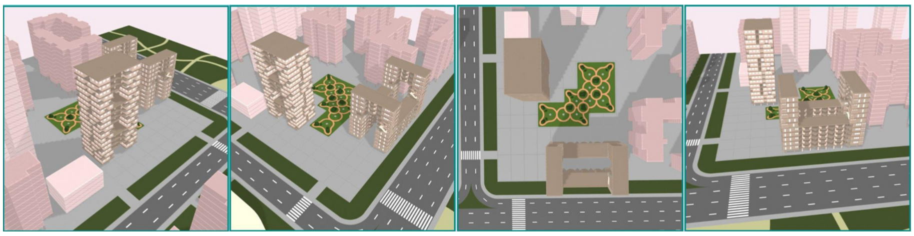

Figure 7. Respondent 4: 24 M, Singapore Citizen, Student / Naval Officer.

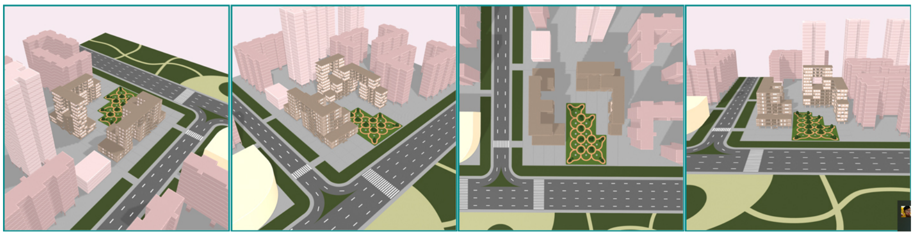

Figure 8. Respondent 7: 60 M, Singapore Citizen, Security Officer.

The mean rating for the game was 8.9/10, with 3 respondents rating it 10/10. This is a good indication that Sharing a Backyard has a potential to be an even more enjoyable game to play when it has more features. Making the game enjoyable to play is important, as it must be engaging for the participants if it were to collect meaningful attitude data and also raise awareness among the participants.

At the pilot-testing stage, the proposed method might not be so effective in changing participants' attitude towards NIMBYism. However, this can be attributed to the lack of avenues for the participants to get inspiration for their design. For example, several participants mentioned their strategy of building the residential volumes high for better views and property price which could have been executed better if they were to build the residential volumes on top of the dormitory volumes, yet they separated the two volumes. To address this limitation, the development of an online repository of previous designs can be considered. Participants can be shown a number of previous designs before they start building their own so that they can be more aware of the various creative spatial planning solutions that can be built in the game.

5. Future Work and Limitations

This research aims to develop a web-game as a participatory design tool which will allow a greater number of participants and better interface for 3D spatial planning. The web-game also has a potential to raise awareness among participants regarding the target issue, while at the same time, providing planners with meaningful data regarding spatial preferences. However, there is still a lot of room for improvement. First, the scoring system needs to be developed further. A more complex scoring system would be able to better estimate a participants' attitude towards the target issue. In the context of the vehicle of this research, it would be to estimate a participant's NIMBY attitude based on the submitted design iteration. More modules should also be included to create a more complex and realistic trade-off between the different programs.

The current version of the game only works on a desktop browser. Adapting this game for smartphone access is an important future goal. When coupled with a smartphone interface, the web offers the means to reach out to a lot more audiences than any physical workshops could. When a participatory design activity can be easily done from our personal smartphones, simply by scanning a QR code, anybody can submit their design entries anytime and anywhere.

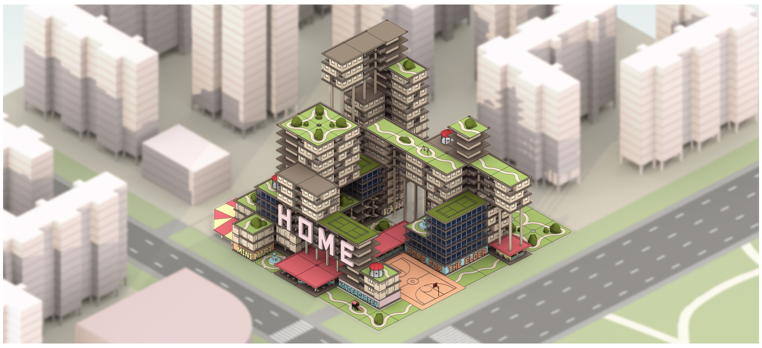

Figure 9. What 'Sharing a Backyard' is envisioned to be able to generate in the future.

There are some inherent limitations that arises from the choice of medium and interface of this web-game. First, the simplicity of the 10 x 10m grid result in a limitation of the size of the modules and hence the complexity of the overall design. Secondly, with a building game, there is a tendency for the participants to prioritise the overall aesthetic of the neighbourhood they are building instead of reflecting their actual preferences regarding the target issue which will result in inaccuracies in the data generated. Lastly, intangible qualities such as 'attitude' are difficult to measure and quantify. Therefore, more research would still have to be done in order to further investigate these issues.

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