YOU WIN, I WIN! LET'S BE NEIGHBOUR AND DESIGN TOGETHER!

A digital platform to mediate residential housing design

○ Lo Tian Tian*1

Keywords. : Collaboration; Gamification; Housing Design; Digital Platform; User-Oriented.

1. Introduction

At present, 'a house' is mostly just an apartment unit within a high-rise building. To meet high demand, housing units has been simplified to prefabricated, mass-produced 'containers' for shelter and living. However, values and needs differ widely across cultures. Differences also exist in spatial needs

The industry is currently in such a top-down operating state that occupants usually cannot have any input into the design process; they can choose only from predefined options; selecting the one most suitable for them. Although every family is different with diverse needs, housing units are usually categorised quite generally into studio apartments, and 3-room to 5-room apartments. Instead of design responding to family needs, the opposite situation is the norm: the family must adapt itself to the units' design. This results in many mass housing designs reacting ineffectively to multi-faceted social needs, 'forcing' people to live in identical units designed and prefabricated for efficiency and affordability (Gao, et al., 2015).

2. Design Participation and its Technology

This research proposes that the main reason for housing failing to provide for the needs of the people, is the exclusion of the people who will live in the building from the design process. Participation is, therefore, the central topic of this research. In the past, architects spent time with house-owners, discussing their needs and preferences before a design was built. Now, high-rise occupants are not just one family but hundreds living together in one building. Occupants' needs are surveyed and studied, but occupants are not involved in design. The experts make all the decisions and try to design the best 'one-fits-all' apartment based on the study results. John Habraken suggested that such a housing model is outdated and a new model required for the future (Luthi & Schwarz, 2013); one which includes the participation of the occupants.

Participation of homeowners in the multi-family residential building do exist. such as Frei Otto's Ökohaus project (Eco-home) in Berlin, Germany, Next21, in Osaka, Japan and Lucien Kroll's La Mémé student accommodation in Belgium. These three examples took at least a year just to engage the homebuyers. Although these examples are not high-rise apartments, they are all multi-users housing typology. The charm of participatory approaches is clear, yet its practice is seldom undertaken. The problem lies in the time and effort required for such a process. This research identifies that the development of a participatory process has great potential to be adopted into a high-rise scenario. The main obstacle is the management and coordination of a wide variety of occupants. This research, therefore, identifies the need to increase the efficiency of design participation in creating flexible yet cost effective mass housing, and that a digital platform could be a solution.

Technology advancement has pushed architecture design to the digital era. Parametric modelling tools have allowed building designs to come in any form and shape, as long as the architects can justify it. Building Information Modelling (BIM) has allowed close collaboration between building stakeholders, and vastly improves the efficiency of building construction. Yet the inclusion of homebuyers in the design process is yet to come about. Prefabrication has produced considerable change, but mostly in improving cost savings and accuracy, spurring more housing of this typology. Still, there is a handful of research that tries to develop a digital system to improve the design outcome and engage the homebuyers such as the "Barcode housing system" (Madrazo et al., 2009) that allows the prospective occupants to adjust their plan layout according to their needs. However, the systems developed either fail to engage the homebuyers directly, or contain too many constraints - obstructing the desired variety. Most importantly, the designs were not high-rises. There is a challenge in developing an integrated system for homebuyers. How to develop a system that is comprehensive enough to include most housing design details for an immersive design experience and a practical outcome, with a process that is sufficiently simple for anyone to engage with intuitively?

3. The Proposed Digital Platform

Comparing the existing systems, a significant similarity can be identified; the digital systems only serve as an information bridge between the homebuyers and the architects.

From the study of existing tools (Lo et al, 2015), a digital

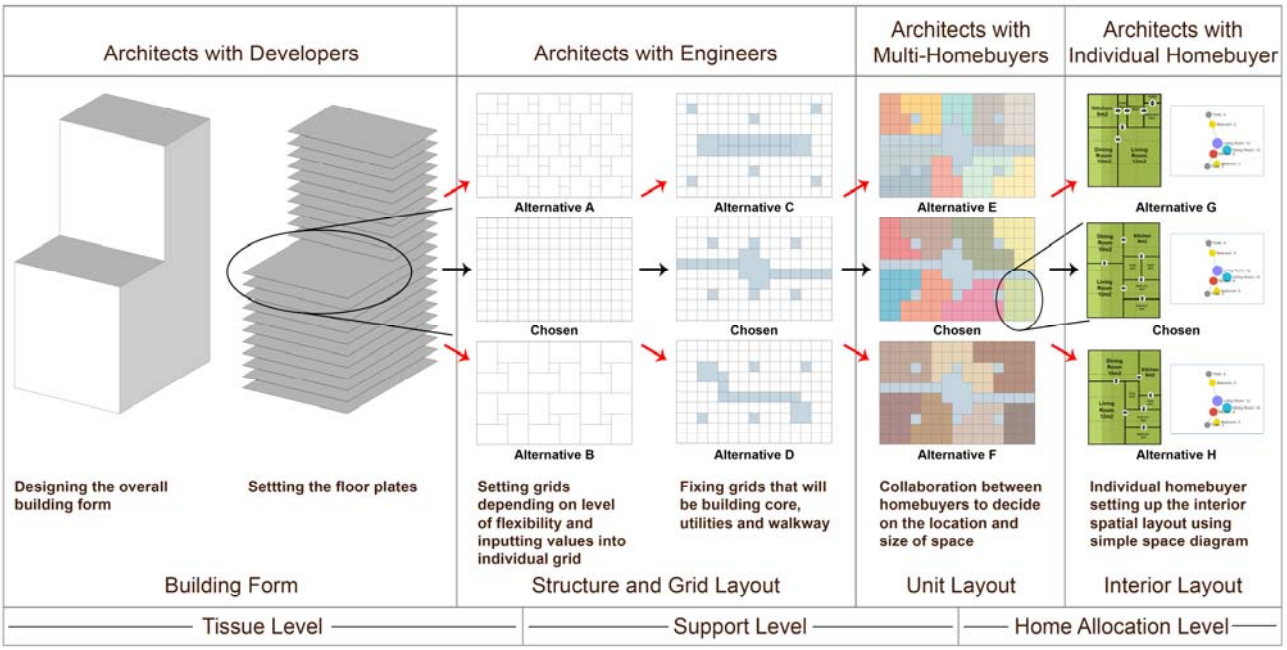

Figure 1. The design collaboration workflow with ModRule.

platform – *ModRule* was created. The name is short for 'modular rule' since housing units are usually modular in nature. Details of the system can be obtained in previous publication by the author (Lo et al, 2015). With the rules and parameters set by architects and regional planning requirements, units can be varied yet retain modularity. Factors identified in the observation of the design studio were integrated into the development. Some objectives of this platform were that design parameters could be better controlled, communication could take place within the system, and that data collection could be managed more efficiently. The most important aspect was user-friendliness; the simpler the control, the easier it is for the homebuyers. Controlling the design content maintains the richness required to keep homebuyers engaged with the process. By setting flexible rules and parameters, the modular system is able to generate a diversity of design options for every individual homebuyer.

ModRule divides the housing design further into five major components: spatial driver, structure frame, skin modules, inner partition system and utility system. These components can still be categorised into support and infill but these subdivisions allow for more design flexibility and for the architects to have control of every aspect of the design. Using a BIM methodology, components are not separated but rather linked together to correlate and maintain information throughout the process. The five components offer the possibility of selectively controlling information; information which can be published as open source for others to use or contribute to.

Within these five components, there are countless possibilities for participants to develop meaningful design outcomes. Two of these components, skin modules and inner partition system, allow sufficient flexibility for design solutions that respond to the design parameters set by the architects. To open up these two components for homebuyers' participation, the architects must design the other three components specifically to accommodate design variations. In other words, the architects have two critical operations: One, to construct the three components which include creating the basic building form, developing the structure frame accordingly, and setting the public space and utilities. And two, to establish the variation schema of the other two components. This includes laying out a range of skin modules and working out the arrangement of the inner partition system, allowing types of input parameters such as daylight, sky-view factor, accessibility, thermal radiation, cost, etc. In this situation a BIM model is necessary to manage information and connect the data of the dynamic open source model to the construction documents, without consuming extra resources. The challenge for the architect is providing a BIM model that can respond to the wide spectrum of data that results from the various design options generated by the homebuyers.

The design process workflow using ModRule can be described as in the figure below (Figure 1). The figure demonstrates how the system can work for collaboration between homebuyers, and how the information it generates can work for other stakeholders too:

3.1. SYSTEM STRUCTURE

The technical aspects and functions of ModRule are supported

by setting rules and parameters crucial to end users. This is inspired by simulation game designs to provide an 'easy-to-learn' design process for the bottom-up collaborative approach. Using Java-Script-based code, WebGL, the proposed design tool can generate a wide variety of design options for individual occupants as well as negotiate conflicting interests and outcomes. The system can be simplified into three main modules: the 3D design module, the data management module and the real-time communication module (Figure 2).

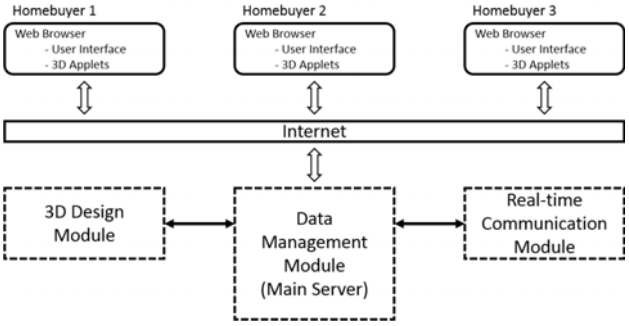

Figure 2. The system structure of ModRule.

The 3D design module first takes STL files as input and converts these into a triangulated geometric model. The model is then digitally manipulated by architects using an open structure that allows them to set design constraints and the level of design freedom. Physical and environmental parameters are mapped into the geometry accordingly, which then act as a 'scoring' system for users during the design process. The data includes user profiles and are stored in a data management module that uses 'redis', an open source, in-memory data structure store. For the communication module, Node.js is another open source code capable of providing scalable network. This system, therefore, utilizes Node.js to facilitate realtime design communication. Simple text-chatting remains the best form of physical communication, so this is implemented in the interface. Incorporating the three modules using WebGL provides the ideal solution to generate 3D geometry in a web-based interface for collaborative processes through the web and helps to increase the speed of communication - essential for decision-making during the design process.

3.2. GAMIFICATION

Gamification is not turning everything into a game. The purpose of gamification is not to pull us out of reality but rather to find what is fun in an activity that requires collaboration and engagement. They are not necessarily the 'serious games' such as those used as training and learning environments in military and educational examples. The focus of simulations in serious games is on testing the abilities of learners and on improving their skill sets in a virtual environment similar to real conditions. Game theory, in contrast, is used to mathematically analyse decision-making 'strategies' or individual 'choices' (Kelly, 2003), and gamification may be helpful to improve collaboration on 'a choice' and encourage involvement in 'a strategy' (Kapp, 2012). Also, points, badges and leaderboards (PBLs) are irrepressibly penetrating every aspect of our daily lives in tandem with the growing use of social media. PBLs are one of the most common game elements. However, they are not sufficient with regards to what games and game design can provoke. The approach is to gamify a situation by thinking like a game designer, which is different to being a game user. When using a gamified system, a player is still considered a user (Aydin et al, 2014). The term 'play' used in the following text is not just about playing a game but includes using an application, or engaging with a system.

3.2.1 Enhancing Interaction with the Tool

Going beyond Points, Badges, and Leaderboards (PBLs) drives Chou to develop the eight core drives of gamification. Most gamers or application users do not play the games or use the applications for the PBLs (Chou, 2015). It is usually the presence of elements of strategy, a means to spend time with friends and family, or simply the challenges and excitement they provide. The PBLs are instead a bonus as part of the gamification mechanics. Chou categories the eight core drives as the following:

- Epic Meaning & Calling
- Development & Accomplishment
- Empowerment of Creativity & Feedback
- Ownership & Possession
- Social Influence & Relatedness
- Scarcity & Impatience
- Unpredictability & Curiosity
- Loss & Avoidance

ModRule can be seen categorised as shown in Figure 3.

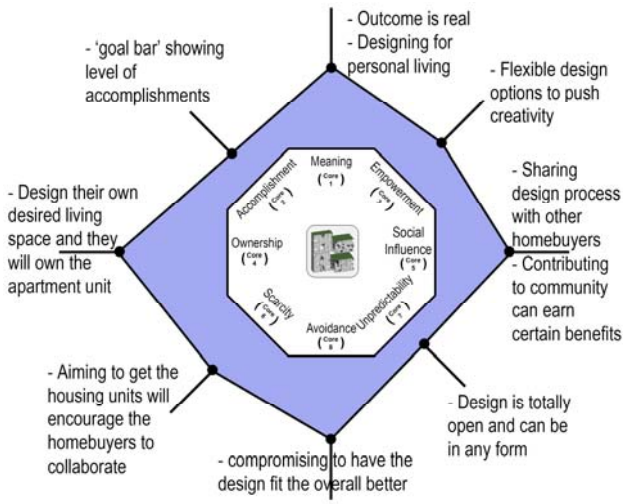

Figure 3. The level of implementation of the various core drives in ModRule, the further distance the points are from the centre means higher level of implementation to enhance engagement with homebuyers.

Looking deeper into the principle of the core drives, note that the method is not to incorporate the eight cores drives into the design system but to identify the elements of housing design that could be integrated into the design system to bring out these qualities. One such element could be simply giving the homebuyers more freedom to manipulate the space, for example by adding their own architectural components and materials. This gives homebuyers the opportunity to use their creativity to design their own living space but is only possible if the design process is simplified enough.

3.2.2 Simplifying the Design Process

This leads to the second objective: To simplify the design process in a way that homebuyers can interact with the system with ease. Although the eight core drives show how to motivate people to use a system, the approach to designing such a system is yet unclear. The most direct way is to examine how games are designed. Katie Salen and Eric Zimmerman wrote a book (Rules of Play: Game Design Fundamentals, 2003) to describe the fundamentals of game design. This research does not go into too much detail about the elements of game design, but studies the framework of the book around the idea of game design schemas.

The Rules schema is the formal element of the games which focus on intrinsic mathematical structures. It is a subset of Play schema, the experiential element which emphasizes the player's interaction with the game. The Rules are what define the Play but the Play constitutes communication processes which might not be controlled by the rules, and form the bigger domain of game design. The whole scope of game design is however, the Culture schema, the contextual element which highlights the cultural contexts of the game. It is this schema which sets boundaries for the types of gameplay and the meaning and value that the system provides. In this research, the context is the housing design process. The eight core drives of gamification is more relevant to the Play schema here. This leaves the most important part of game design, which could help identify approaches to developing a gamified tool of engagement.

Gamification development can adopt the three levels of game design rules:

- Constitutive rules are first. These are the abstract, core mathematical rules of a game. Putting it into a digital design context, this represents the essential algorithm within the system structure. They do not explicitly indicate how the users should enact these rules, but they reflect the underlying framework of the system that informs the operational rules, the second rules.
- The operational rules are the main 'rules of play' that users must follow when they are interacting with the design system. These rules directly influence the behaviour, input and output of the users and are usually printed out as instructions or manuals.
- Lastly, the third rules are the implicit ones. These are the 'unwritten rules'. They are the etiquette and behaviour of the users that usually go unstated. In game culture, these are well established as a form of 'sportsmanship'.

The aim is 'simplification', and it is about breaking down the design process into simple steps that enable homebuyers to get 'hands-on' more easily. The 'rules of play' provide a methodological direction for this approach.

To avoid the trap of developing the design tool into a game, the rules are adopted with a practical reality in mind. The constitutive rules can be used to prepare the structure of the design; which is to translate housing design into simpler geometry or formulas. This can be associated with parametric design where the design is based on parameters, rules and constraints, but simpler in this context. The operational rules must work closely with the core drives so that the homebuyers are motivated to use the design system. The implicit rules are a challenge as the understanding of homebuyers is required to make the system work. This can be developed overtime; observing the homebuyers interacting among each other and with the architects within the system to understand how these rules can be generated. There is, however, a provisional method that can provide this research with an initial approach which is explained in the next section.

3.2.3 Promoting Cooperation

From the study of the Group Forming tool (Ong et al, 2013), a simple bidding system is used to negotiate spatial ownership among the participants. The result achieved was more competition than collaboration. Since everyone knew from the start that the richest person will win, there was no motivation for communication among participants. This is where game theory comes into play. The third objective of promoting collaboration among homebuyers requires more than putting the homebuyers together within a system. It is necessary to adopt a method to manage the design communication.

Game theory provides an observable structure to examine

how the design system can be developed to mediate communication among homebuyers. By touching on the cooperative nature of game theory, this research can identify the factors necessary to motivate homebuyers to work with each other, even with their heterogeneous backgrounds and diverse needs. This may include methods to set design parameters and the engagement rules. The aim is to ensure that while the homebuyers are interacting with each other in the design system, they focus not only on their own interests but also those of other homebuyers and, more importantly, work together for the living community as a whole.

Modrule adopted the strategy of manipulating various parameters until all the spatial units have both pros and cons. For example, a unit on the top floor will have a great view, but also a high amount of sunlight. A unit on the bottom floor might be noisy, but have high accessibility to ground facilities. This occurs not only with respect to design issues but also in agreements within the community pertaining to lifestyle and mutual support. For example, if homebuyer 'A' offers to maintain the cleanliness of a given communal area, he or she will be identified as 'worth' more than homebuyer 'B' who contributes nothing to the community. In return, end user 'A' becomes eligible to receive some form of remuneration, such as 'discount per square area' or 'greater advantage in being chosen as occupants' as agreed in advance and set as part of the overall system parameters by the architects. The aim of setting these parameters is to stimulate homebuyers to work together strategically to achieve win-win situations with one another. The parameters are set in such a manner that this is possible, and so that if some factors are compromised a better benefit is available to reduce the sense of loss.

3. Conclusion

This research brings new knowledge towards understanding the network structure of ModRule and how it helps towards coordinating the design participations of the homebuyers. The system ModRule is just a digital tool to enable the participation process. It is elements such as gamification, simplification of the design process and bringing in rules of play that add on to the digital platform to complement the design process and bringing about closer relationships between homebuyers and architects through collaboration. This body of research argues that for apartment design to be more 'collectively productive', engagement between the homebuyers, and with architects, cannot be ignored. This research also identifies that digital platforms can provide fast and efficient means of communication, and that housing design involves many complex design components and operations that can be overwhelming for homebuyers. Gamification concepts were introduced and integrated with the platform to explore and strategize the collaboration approach. This research found that developing a collaboration technique of this type reinforces the role of architects in creating the built environment, by working closely with homebuyers to reflect their social needs.

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Summary:

Urban development and densification are increasing rapidly; this fact has been globally reported. According to a 2014 United Nations report, the world population will increase by 25% in the next three decades. This significant growth means urban density will also increase drastically, creating an increase in high-rise apartment living quarters to cater for the population growth. Subsequently, the development of housing has been advancing - especially around construction techniques which are becoming more efficient to meet the demand of fast-growing urban populations.

This paper proposes that simply supplying housing is no longer sufficient to address the requirements of citizens. Denser living environments result in increased dissatisfaction, especially among those living in high-density housing. This research looks specifically into enabling homebuyers to voice their needs and design their living space. In this context, the social paradigm of high-density housing has not progressed much. There is still more a notion of supplying the needed quantity and homebuyers accepting the housing without question. Homebuyers, the main users of the housing, are often absent from both the planning and design process. Recent studies have shown that participation in their community is one of the key themes towards social sustainability. Many public participatory projects and platforms only allow participation in large scale urban developments and planning processes. There is a significant lack of initiatives that include homebuyers in the context of high-rise, high-density housing.

The aim of this research is to explore how a computational tool within a virtual environment can facilitate and support design collaboration and interactions – not only between architects and homebuyers, but among individual and collective homebuyers too. The methodology of this paper is to examine the problems of participatory communication and how these could be addressed with a synergistic digital system. Then, a novel platform is introduced. It is designed and developed by the author to promote and facilitate collaboration between architects and future occupants (end-users) during the preliminary stage of mass housing design. In this design-framework the architects set the parameters of the system, while allowing the end users to set their space requirements, budget, orientation, sky view factor and others, as a means to define their desired way of living. It is a web-based housing design system that allows stakeholders to design their living space collaboratively and immersively in a virtual environment.

Throughout the research development, gamification techniques were introduced and adopted to further explore driving factors and to enhance design interactions. The target audience of this research is homebuyers, who are laypersons in architectural design processes and techniques. Gamification is, therefore, an effective technique to simplify the design process and enable homebuyers to immerse themselves in a collaborative design process. Virtual Reality is used at the final stage to immerse homebuyers further into the design environment and give them clearer feedback about their design decisions. The understanding of the research outcome provides insights into the digital relationship between the bottom-up, participatory design approach and the top-down, architects-oriented design approach.