

Parametric Design Strategies for Collaborative and Participatory Urban Design

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Abstract. *Due to the complex nature of urban space and the multitude of interests vested in it, urban design can be described as a complex system. Various disciplines are involved in the analysis and development of urban space. In this respect, collaboration is key in creating socially and physically sustainable urban design. This paper, using a student workshop as a point of departure, discusses the potentials of parametric design as a methodological approach in collaborative urban design between disciplines and with non-professionals.*

Keywords. *Parametric design; collaborative design; participation; urban design; Esri CityEngine.*

INTRODUCTION

Democratic involvement of different stakeholders in urban design has been studied for decades. A large variety of collaborative and participatory design and planning formats, such as design charrettes, future workshops, and planning weekends, have seen the light of day (Batchelor and Lewis, 1985; Wates and Knevt, 1987; Zadow, 1997; Kelbaugh, 1997).

In the wake of these studies, different collaboration and participation formats have been developed. But as several planning theorists have pointed out, differences in thinking and language between professionals and laypersons represent a communication barrier (Forester, 1980; Friedman, 1973). Non-designer professionals and non-professional stakeholders alike typically lack the capacity to fully understand the spatial implications of planning and design decisions, unless they are demonstrated by the use of relatively detailed architectural models, whether physical or virtual. This, however,

typically presents steep demands in terms of time and resources.

A dilemma exists in the opposites of influence and understanding. While design is still open in the early phases of a design process, the level of detailing is typically low. Hence, the implications of design may be difficult to comprehend for non-designers and laypersons. But as the level of detailing increases, thus allowing for a better understanding of the design, the design tends to close and can no longer be changed without substantial implications for time, money and resources (Steinø, 2010).

Hence, an approach which responds to these problems and dilemmas is desirable. When time and resources are scarce, it must be expedient and effective. In order to overcome the communicative gap between professionals and laypersons, it should be possible to convey ideas about urban space between these two groups. And in order to overcome

the influence/understanding dilemma, the ideal approach must provide a level of detailing high enough for laypersons to engage, even at early stages when real and substantial changes to the design may still be possible.

Parametric urban design is a potentially powerful tool for collaborative and participatory urban design processes. Rather than making one-off designs which need to be redesigned from the ground up in case of changes, parametric design tools make it possible keep the design open while at the same time allowing for a level of detailing which is high enough to facilitate an understanding of the generic qualities of proposed designs.

Yet, in any collaborative or participatory urban design process, some aspects – or parameters – are more likely to be more relevant to deliberate than others. And they are not likely to be the same for different design cases. In one case, density and building style may be topical, while in another case, environmental issues or the distribution of different building programs may be relevant issues to analyze and negotiate.

This paper argues that a parametric approach to collaborative and participatory urban design holds great promise with respect to rendering the design process more effective and more informative. Parameterization of design principles, in other words, may overcome many of the problems of closed design systems and facilitate participation. By way of parametric design tools, stakeholder participation can be conducted with more detail and in less time and with less resources.

The first section of the paper gives a theoretical discussion of the notion of collaborative design and the challenges of collaborative urban design processes from the perspective of a parametric design approach. The second section introduces the potential of a parametric approach to overcome these challenges for collaborative and participatory urban design. The third section presents a case study in the form of a student workshop and some *a posteriori* reflections and refinements of the workshop results. The fourth section discusses the case study in the

light of collaborative and participatory urban design. The paper concludes with some perspectives for further research on parametric design as a tool for collaborative and participatory urban design processes.

COMMUNICATION IN COLLABORATIVE AND PARTICIPATORY DESIGN

With technological developments in service of construction, management, transportation and communication, urban space becomes increasingly complex both in its creation and its use. Therefore, many different professionals are involved in developing urban space. In democracies, urban design processes typically also involve a wide array of laypersons. Such laypersons can be stakeholders like property developers, residents, local retailers, NGOs, and others with an interest in urban development. Hence, urban design becomes increasingly collaborative – as professionals from many different backgrounds need to work together – and increasingly participatory – as non-professional stakeholders are involved in urban design processes.

Due to the complex nature of urban space, as well as the multitude of vested interests in urban space, urban design can be described as a complex system. As Schön (1983) has pointed out, professionals cannot remain on the “high grounds” of their professionalized knowledge when operating within a complex system. They need to exit the autonomous methodological and knowledge structures of their professions and venture into the “swampy lowlands” where problems are fuzzy and confusing and cannot be solved by way of unilateral technical approaches.

‘Two cultures’ (Snow, quoted in Portugali, 2000) exist alongside each other in this fuzzy landscape. Hard, quantitative knowledge of professional experts meets soft, qualitative knowledge of non-professional laypersons. Because of the complex nature of urban design problems, they cannot be decomposed into tasks which can be distributed and solved individually by different professionals but must be solved collaboratively (Achten, 2000).

And collaboration requires communication.

Given the constraints of time and resources which always exist in urban design, a communication format must be devised which is responsive and offers sufficient detail for non-designers to be able to make informed decisions about urban design. While conventional design techniques require much design work to be redone whenever a design is altered as models or drawings must be redone to various degrees, a parametric design approach allows for a high level of detail during the early stages of design, thus allowing for a higher level of understanding among laypersons while the design is still amenable to change.

PARAMETRIC DESIGN AS A TOOL FOR COLLABORATION

There is a limited but growing number of approaches to parametric urban design. While some are analog and do not rely on parametric design software (Steinø, 2010), most make use of more or less dedicated parametric design software, ranging from general parametric design software such as Grasshopper for Rhino (Beirão et al., 2011; de Monchaux et al. 2010) to specialized parametric urban design software such as CityCAD or CityEngine (Pellitteri et al., 2010). Steinø et al. (2013) define four different approaches to parametric urban design:

1. Parametrics is used in urban design to relate analytical data parametrically to 3D models in order to provide information for design
2. The power of parametrics is used in urban design as source of artistic inspiration for novel design
3. Parametrics is used in order to analytically address particular needs or constraints in the course of design
4. Parametrics is applied in the form of rule-based design

The work presented in this paper falls within the fourth approach.

When it comes to rule-based approaches, the field is dominated by a few research environments

such as ETH Zürich (e.g. Aschwanden et al., 2008; Halatsch et al., 2010; Kunze et al., 2012), TU Lisbon/TU Delft (e.g. Duarte et al., 2007; Beirão et al., 2008) and Universidade Federal do Rio Grande do Sul (e.g. Turkienicz et al. 2008; Paio & Turkienicz, 2011). While Duarte and Beirão make use of different software solutions, Halatsch and Kunze are focused on CityEngine, partly in supplement with different simulation software, such as EcoTect (e.g. Halatsch et al., 2010).

There is strong consent among researchers as to the design potential of a grammar-based or a rule-based approach to urban design. The alignment of a grammar/rule-based approach to urban design with the logics of planning laws and building code is also agreed upon. However, when it comes to the relevance of parametric urban design to collaborative and communicative urban design processes, only few statements seem to have been made. One exception, though, is a conceptual participatory framework proposed by Jacobi, Kunze and others (Jacobi et al. 2009; Kunze et al., 2011).

For effective and seamless collaboration among professionals and laypersons, there is also the need for a digitally supported platform with an interactive interface and real-time simulations. As our interest in parametric urban design lies mainly in its application to collaborative and participatory urban design processes, we are primarily occupied with accessibility and ease of use in our choice of platform, and less with the systemic scope and limitations of different software. While these aspects are truly important in a real-life application, they are not restrictive in order to test the approach in principle.

Our choice of CityEngine for our work, hence, is due to its relative ease of use. It should be noted, however, that this is true only for architects and designers with computational design skills. In order for this particular software to be more widely accessible to architects and planners, let alone other professionals and laypersons, the way in which one interacts with the software must be made subject to further research in order to develop (a) more intuitive interface(s).

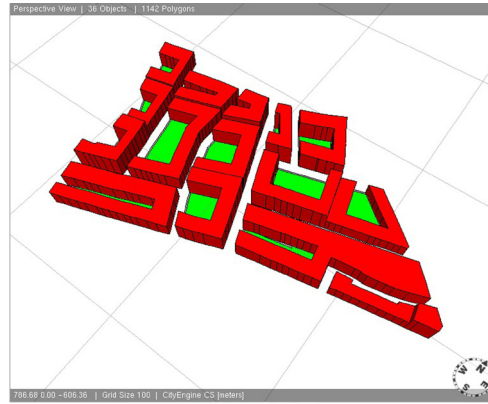
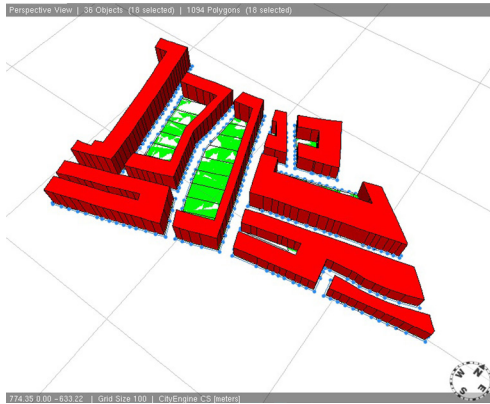


Figure 1
Workshop example: Attempts to create different scenarios for block development with u-shaped block with interior garden spaces for the project site.

CASE STUDY: COMPUTATIONAL DESIGN WORKSHOP

The object of our case study is a workshop held at Istanbul Technical University on December 14-17, 2012. In the workshop, the CityEngine software was used as the design tool, and the object of the design was a contested urban space, subject to urban renewal. A key aspect of the workshop therefore, was to develop different design scenarios and to use parametric design software to communicate the scenarios spatially, and to mediate between them.

In the course of the four-day workshop, senior computational design students were asked to develop different design strategies for an urban renewal area and subsequently to script design scenarios which reflected the strategies. The students worked from different stakeholder perspectives and three different approaches were adopted; a scenario for a conservative approach for maximum conservation, a scenario for a radical approach for maximum transformation, and a scenario for a hybrid approach negotiating different spatial and land use interests in between these two extremes.

During the workshop, the students had to continuously consider how to script their design ideas in CityEngine. As the mediation between different design scenarios were an important component in the workshop, they also had to consider which aspects of their design to parameterize, i.e. to be able

to subsequently modify. Technically, the example is made by way of a single script where select parameters have been changed. Despite the very narrow time frame of four days, they were actually able to develop different scenarios, despite the fact, that they had never worked neither with the software before nor with the notion of parameterization for the sake of testing different scenarios.

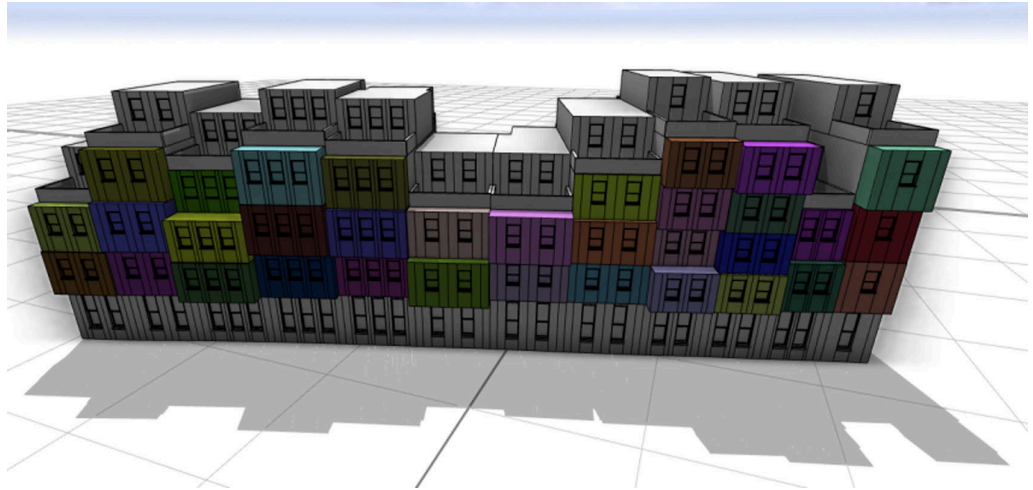
As shown in Figure 1 through Figure 3, the results of the workshop ranged from keeping historical lot sizes and street build-to lines while offering larger green backyards (conservative scenario), over reinterpreting the facade schemes of historical buildings (hybrid scenario), to a total reinterpretation of public and private space and building morphology (radical scenario).

In order to further elucidate the potentials of a parametric design approach, some additions were made to the hybrid scenario after the workshop. With respect to three different aspects of the scenario, these further additions help illustrate

1. a successive replacement of buildings which maintain the character of the area (Figure 4),
2. the insertion of public squares/green areas in the historically dense area (Figure 5), and
3. a study of different variations in the facades of new buildings (Figure 6).

Successive replacement of individual buildings is a dynamic process which can be difficult and time

Figure 2
Workshop example: Attempts to create different scenarios for building facades with different colours and protruding elements.



consuming to visualize by conventional means. By a parametric approach however, it is very simple to incorporate a replacement ratio into the script, indicating the relative amount of historical buildings to be replaced by new ones (Figure 4). In this example, buildings were selected randomly. Controlled by a constraint map, buildings closer to the intersection of the major street going through the area and the boulevard along the south perimeter of the area were more likely to be substituted than buildings in

the rest of the area.

Whether the area should contain one or more public squares/green areas is a matter of comparing scenarios with and without these features. This calls for a trigger effect, by which the software either generates a square/park or buildings. A Boolean switch was incorporated into the script and controlled by a constraint map indicating the areas in question. In this example, two areas were picked which could potentially be converted into open spaces. Each

Figure 3
Workshop example: Final rendering of scenario for radical transformation showing solitary tower blocks with randomly generated combinations of private and public spaces.



area had two possible sizes which were triggered by different values in the constraint map. Hence, it was possible to render three different scenarios; either with two small open spaces (not shown), two bigger open spaces (Figure 5 right), or with no open spaces at all (Figure 5 left).

The extent to which new buildings in an urban renewal scheme maintain the scale and architectural character of the area is a matter of width, height and facade design of the buildings. In order to illustrate how this can be evaluated by means of a parametric approach, two building typologies were developed, each of which could be altered with respect to width, number of floors and color within a select color scheme. The script was designed so that building heights and facade colors could be set either uniformly or randomly. Also, the two building typologies could be mixed randomly from 0-100. In this way, scenarios of one typology with identical colors (not shown) could be compared to scenarios of one typology with mixed facade colors (Figure 6 left) or to scenarios of mixed typologies with different color settings (Figure 6 right).

The dynamic potential of these examples exceeds the scope of a conference paper. However, we hope to have illustrated that the capacity to alter different settings and see the results in real time, albeit constrained by what has been parameterized in the script, has the potential to enhance the communicative aspect of urban design. Also the fact, that the level of detail is affordable by this approach, is very promising. Even if details require more scripting, this is still significantly easier and faster than by conventional design.

DISCUSSION AND FURTHER RESEARCH

The work presented in this paper is a preliminary stage for a planned research project on parametric design tools for collaborative and participatory urban design. Although still in its very infancy, a number of precursory reflections can be made. Given the fact that not much work has been done in this field, there is a limited literature to lean against, even if many authors point out the potentials of a para-

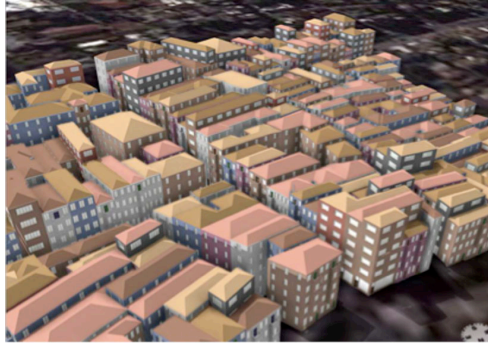


Figure 4
Successive replacement of buildings.

metric approach to collaborative and participatory urban design.

Being relatively new to CityEngine ourselves, giving a computational design workshop based on CityEngine was an absolute experiment. As men-

Figure 5
Insertion of public squares/
green areas.



tioned, the time frame of the workshop was very narrow. It is therefore all the more encouraging that the students actually managed to create meaningful results, as this was also a test of whether CityEngine – apart from all its promises – might actually be a useful software environment for our work.

In addition, the subsequent refinements done to one of the workshop scenarios showed that (near) real-time alterations to different parameters – although not achieved within the format of the workshop itself – are actually possible. The responsiveness of the system is central in order for it to be a meaningful tool in a real-life setting for collaborative and participatory urban design. Yet on this point the case study is obviously inconclusive, as simulation within an educational setting with role play lacks the varied response of actual collaborators and participants.

Many other aspects of developing a parametric design tool for collaborative urban design also require further investigation. Parameters relevant to different urban design scenarios and their possible interrelations should be studied. The interface for interaction with the parametric design tool is likely to be an important aspect. A tangible interface – possibly in the form of model blocks or game pieces – may offer a more haptic and thus intuitive way for non-designers to interact with models than the sliders offered within the CityEngine software. Further aspects would be the integration with GIS on the one hand, and simulation software on the other.

The most important aspect, however, is how the tool will function in practice, in the hands of those involved in urban design processes. The most important insight, therefore, must be gathered through involvement in real-life collaborative and/

Figure 6
Study of different variations to
the facades of new buildings.



or participatory urban design processes. Rather than developing the tool “in the lab” and subsequently test it “in the field”, we believe that an interactive process of developing and testing in close interaction with professionals and laypersons engaging in actual urban design processes must be a next step, rather than a final step.

CONCLUSION

As a foundation for our work with parametric urban design lies the hypothesis that a parametric approach to collaborative urban design holds great promise with respect to rendering the design process more effective and more informative. The parameterization of design principles may overcome many of the problems of closed design systems and facilitate participation. By way of parametric design tools, the stakeholder participation can be conducted with more detail and in less time consuming ways.

This study, however, is part of an ongoing research. Our broader research agenda contains the development of an effective digital platform for collaborative urban environments based on design parameters. Such a platform has complex properties and such a study needs much work and work time. The workshop shows the potentials of the software and how much work that can be generated within limited time.

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