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DIAGRAMS AS PARAMETRIC SYSTEMS IN URBAN DESIGN

Parametric systems applied to conceptual design

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Abstract. The paper describes how parametric systems have been used to help students bridge from conceptual design to descriptive results. Specifically, it describes projects set in two cities, Hong Kong and Melbourne, to address substantive urban design issues and illustrate that the approach is not scale or culturally bounded. The project undertaken in Hong Kong establishes interdependency models for dense urban structure and examined urban systems that contribute positively to their contextual setting. Parametric models were used to develop diagrams of site potential through models of air movement, light and sun exposure, in particular addressing air quality in one of the most polluted places in Hong Kong. The Melbourne case studies examine urban systems as self-organising systems. In these, the case studies identify parameters that determine two patterns: material pattern of the city and cognitive pattern of the city. The paper illustrates the use of a parametric system as a diagramming tool to explore urban propositions from an urban system.

Keywords. Urbanism; systems thinking; parametric; diagrams.

1. Setting up the objectives

This paper presents two studio experiences in which digital systems were employed to explore the development of design ideas from conceptual to descriptive stages using parametric systems. The particular context was that of urban design; this was selected as the scale of the problems is enormously rich in opportunity yet prevents the designer (or student) from focusing on description or form alone as the outcome. Instead, urban design offers the

opportunity to approach design description as a framework from which form is established, reflecting the principles of parametric description.

The two studios described here both address an urban transportation problem, a railway station, and both use the same software strategy but are set in different cultural and physical contexts and are carried out by students from different institutions. The first was conducted in The University of Hong Kong in 2005, the second in The University of Melbourne in 2009. The authors ran the first design studio to explore new morphologies of Hong Kong as an element in a larger research project on urban design during which it became evident that students were finding it difficult to bridge their computer skills, learned in elective courses, to conceptual design thinking at a large scale. The studio approach here allowed us to explore the bridge from conceptual to descriptive design and, in this context, we identified a potential for parametric design processes beyond their popular form making or BIM applications.

The work described here therefore addresses three questions. Firstly, to what extent can parametric systems be applied to conceptual design processes as diagrams? Secondly, is the earlier experience of introducing students to digital systems continued or do parametric systems demand different approaches? Thirdly, can these systems be used in culturally neutral manner?

1.1. THE URBAN DESIGN CONTEXT

The use of digital systems needs to be grounded in broader theories of their application. This paper starts, therefore, with a description of the urban theories and then describes the design intents and outcomes of each studio before reflecting on the use of the digital systems.

In urban design contexts, Modernism has been promoting separation and segregations and this in turn has led to remoteness and loneliness of many cities inhabitants. Cities have been analysed by breaking them down to identify underlying structures as discrete parts from which they are composed and then analysing these parts in as much detail as possible. In this manner, the separate sub-elements are individually understood and separately optimised. For example, traffic engineers optimise the roads, developers optimised the financial return and politicians optimise their ability to win next election. This phenomenon follows on the principles of reductionism and it is clear that reductionism can constrain a system's emergent properties. Experience suggests that optimising road configuration, transport interchanges or other individual urban infrastructure results in underperforming urban areas. We can observe that our newer urban areas underperform when compared to more complex and socially more engaging places. As a result we have created too many places which alienate us rather than invite us to participate. The process

of spatial segregation, the formation of barriers and the reduction in free movement due to a predilection for prioritising car oriented developments have incrementally reduced opportunities for such rich engagement with place.

With this background, we established goals for our projects that the idea of architecture as an object should be rejected and replaced with the idea of architecture as elements in larger complex adaptive urban systems. These were defined as systems that have ability to learn or systems that have property of emergence, in other words, the ability to result in more rewarding opportunities than available in the elements from which it is assembled (Wootton, 2004). By contrast to engineered or biological systems where goals are relatively low, cities as complex adaptive system have high aspirations. We therefore proposed that the result of urban design is a system with underspecified goals that constantly evolves and is never complete (Sorkin, 1996); this approach is not dissimilar to the approach used in 1960s for the design of *Fun Palace* with Cedric Price (Pask, 1962).

1.2. THE PARAMETRIC CONTEXT

In the past five years we have been using digital systems to explore parametric urbanism from the premise that cities are open, complex, self organising systems, unpredictable and uncontrollable and inherently unplannable (Castells, 1996). From this basis we have sought to establish interdependency models that guide, not determine, the growth of the urban systems. In this investigation we have directed students to ask the question: what strategy creates better answers – dependence on planned system changes or anticipating new properties and behaviour which can emerge from unpredicted interactions within the system and with external environments? These studios have engaged the possibilities of parametric design in a fundamentally different manner that the normal manner of using such a digital capacity. Parametric design has been defined as: “An experimental design in which the amount of the independent variable is systematically varied across several levels” (Rotheroe, 2002). Parametric design has been taken up also by urban designers who can now manipulate road widths with building heights, setbacks etc (Sharpe, 2008). In these studios, we have extended parametric applications into urban diagrams. The work has been carried out using a number of digital platforms including Digital Project and Rhino, demonstrating that the approach is not platform specific.

Diagrams, including data and symbolic representation, are an important mode of exploration and representation in design, allowing the designer to move beyond preconception and, by working in an abstracted manner, explore

the potential in the opportunity rather than solving the problem. In other literature, this is “problem framing” rather than “problem solving” (Schon, 1984).

2. The Hong Kong project

These urban design principles were adopted in redeveloping Mong Kok station as part of the Linear City Research Project. Here, we decided that we will not be just looking and designing the station as an object but trying to develop an interdependency model for the station as a part of bigger system which could be parametrically controlled.

The Mong Kok KCRC Station is one of the busiest stations on the major rail connection through the city but is separated from the neighbourhood’s primary commercial and living area by a large but relatively slender strip (500m × 60–80m) of land occupied mostly by schools and government buildings. This block offers limited access to the public and is consequently a barrier between the station and neighbourhood, crossed at only one point by a route that is neither easily read nor particularly pleasant to use. The area is extremely popular for its entertainment, shopping and food, well connected to a variety of transportation system and, as a consequence, heavily congested and with poor air quality. The community potential for this railways station site is not achieved so improving this and the air quality were primary goals of the proposed changes.

2.1. THE APPROACH

Analysis of the community identified that it is greatly under-provisioned with recreational space (19 ha less than needed) and facilities that enhance quality of life. There is a well established need to provide a healthy environment for children to study, exercise, socialise, and play; for elderly to participate in society; for residents and workers to enjoy the environment. The dynamic nature of the neighbourhood is better supported by an environment for changes, not carefully designed spaces where prescribed activities take place. What was needed was a framework for the community to claim as its own. Within this framework we were able to address the issues of quality of life and density of habitation.

Further analysis suggested that the reason behind poor air quality in the area was due to the barrier created by the station and government buildings around the station which prevented the prevailing wind from penetrating the urban structure of Mong Kok. Better conditions can be achieved by simply providing a more porous structure. The smaller urban grain at the street level needed to be maintained yet a larger structure accommodates recreational

facilities more readily. With appropriate attention, the design of the KCRC station together with surrounding buildings can contribute to increasing air movement in the area to the west and therefore substantially improve the air quality in the area as would use of plants to moderate the environment.

Our research documented that Hong Kong cannot be analysed with common vocabulary of urban discourse (Karakiewicz, 2005). For much of its urban history, Hong Kong has engaged in layering, superimposition, co-existence of unlike parts, and collage of unexpected, all long-standing features of Hong Kong's urban structure. The implication of systems thinking philosophy for the assignment was clear: our objective was to propose a strategic approach to urban and station design that aimed to facilitate emergence of that interpretation of a redeveloped Mong Kok station that would satisfy the agreed and reasonable functional objectives of all legitimate stakeholders. This required that no one particular aspect of the redeveloped station was optimised at the expense of achieving a facility that was more than the sum of its parts. In this context, we note that parametric software enables us to develop a bottom up approach by which we specify the interactions and relationship between parts of the city. Using components and data, we were able to engage with parametric design methods to explore conceptualisation of these relationships through unpredictable outcomes through progressive parametric abstractions as diagrams.

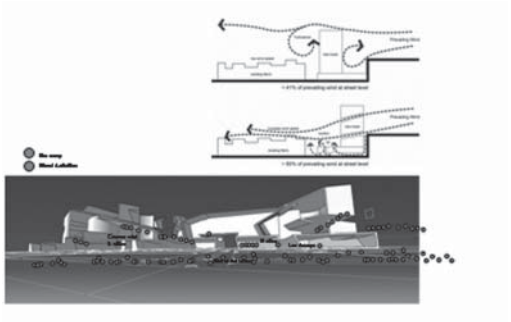

Figure 1. Airflow analysis and possible form (Angus Ngai).

2.2 THE PROPOSAL

The current model for station development encourages the station to take the form of an object and container. The container solution is an example of the Modernist's reductionist slogan form follows function. It is a singular solution that solves one problem while often creating others. Is there an alternative to the current KCRC railway/property development model? Narrowly interpreted, this represents a mechanism to finance railway development. Broadly interpreted, the question raises the possibility of changing the relationship of

a station to the city and hence the role of rail transport as a primary mode of transportation. To achieve this, however, we clearly need to move away from a prescriptive approach of legislating permitted solutions and move toward an underspecified goals oriented approach. In our research we found out that all the problem listed by us at the beginning (pollution, overcrowding, accessibility, lack of recreational space, facilities for the elderly and the community) are all interrelated and could be solved better if treated together than separately one by one.

Figure 2. Green wall (Justyna Karakiewicz).

We proposed a "green wall" as a three-dimensional air filter in which sport activities can take place, with transpiration from the plants in the wall and channelled airflow inducing breezes and lower temperatures in the surrounding area. Thus, the proposal not only contributed to improved air quality entering the urban structure, but also managed to provide much needed recreational space. A station should not be conceived as a container, but rather as a heart of the district that allows other parts of the city to grow. And even if the station as an object is design parametrically, it is still an object without any or very little possibility to influence wider area. In order to work as a heart of the district the station cannot be just simply a transit location, a point for processing people through and away from the station as soon as possible. The station as a heart of the district must be conceived as a destination in itself, the point for community interaction.

3. The Melbourne experience

In 2009 we decided to deal with the similar problem in a different location. The station has been proposed by government as part of new 17 km. Metro tunnel to link the growing western suburbs to the city and providing increase in capacity of the railway network. At the edge of the CBD, the station is

intended to link three separate communities: the university, adjacent hospitals, residential and commercial precincts. Focusing most narrowly on station functions, the opportunities for breaking barriers have been ignored.

Although our conceptual framework remains the same, however the site could not be more different than one in Hong Kong. In Hong Kong we were dealing with extreme densities at many levels: extreme plot ratio, extreme pedestrian densities, extreme residential density, and extreme vehicle densities at the road level. In Melbourne it is the other extreme; residential, pedestrian, and built form densities in Melbourne are extremely low. Introduction of some extra densities to the site in form of residential, commercial or even recreational facilities maybe useful, but how do we make sure that intensification will be beneficial to the area and not only to running of the train station?

Higher densities and compact developments can promote casual, unstructured interactions, but in the same time they can also create barriers and exclude possibility of interactions with outside. Hillier (1989) believes that spatial organisation plays very important role on the way people move through the space and interact with each other. Spatial form can either promote or discourage interactions so how do we create a form that can promote interaction, dismantle the barriers and create an urban system which can learn?

3.1. THE APPROACH

Our studio was divided into three parts: precedent study of Melbourne railway stations; site analysis from systems thinking point of view; designing and testing the system. The first step was to analyse four precedents within the Metro area. All four stations are very different and operate in different ways although their location is always at the edge of the city grid and therefore one could assume that their performance will be much the same. Students were asked to look at the stations through systems thinking and define the following: the system itself, its boundaries, the main elements of the system, and the rules which determine system survival. This exercise led to findings that some of the station operates very much as closed systems, having very little impact on the surrounding areas and closure of the station may cause some inconvenience but the larger area around the station will not be affected.

Complex adaptive systems exist by absorbing energy from outside environment through the system boundary. This energy is used to maintain the system. The system also needs to get rid of energy that is no longer desired or have negative effect on sustainability of the system. Therefore the boundaries of the system need to be flexible and porous enough that this process needs to be maintained. This process will hopefully will allow the system to adapt to changes and therefore allow it to learn. Students had to define environment

and parts of the system which will have most impact to maintain system life by interacting with bigger system.

3.2. THE PROPOSALS

One student decided early on to increase the catchment area to redefine the boundary of the system (figure 3). A quick exercise of the catchment area within a 5 minute walk illustrated that the catchment area diminishes from 502,654m^2 to 177,205m^2. Further analysis showed that existing land uses around the station determine a predominantly health precinct employees (over 15,000) and the sizeable student population (approximately 35,000). This population is split geographically by a major road and the largest catchment population will also be absent for during non-teaching periods (up to 5 months of the year). The proposed catchment area also includes predominantly day-time activities suggesting that the potential catchment population will not support the operation of train services into the evening. Some parametric testing led students to believe that proposed location for the new station may not be the best for its successful operation.

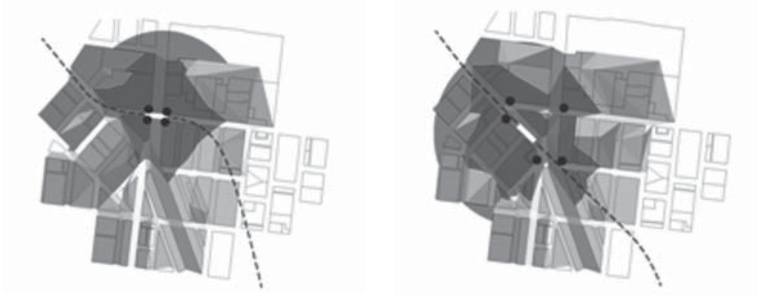

Figure 3. Station catchment analysis (Leanne Hadyl).

Second project (figure 4) applied Digital Project and Vonoroi diagrams for neighbourhood analysis and then design and a third (fig 5) identified that location of the tunnel and station platforms 50 m below the street level opens up opportunities for intensification not only above the ground but also below the ground level. The proposal used swarm analysis to define the location and role of the attractors. The system responded to the changes not only associated with immediate site but also with most of the stations and their surroundings in bigger part of the city.

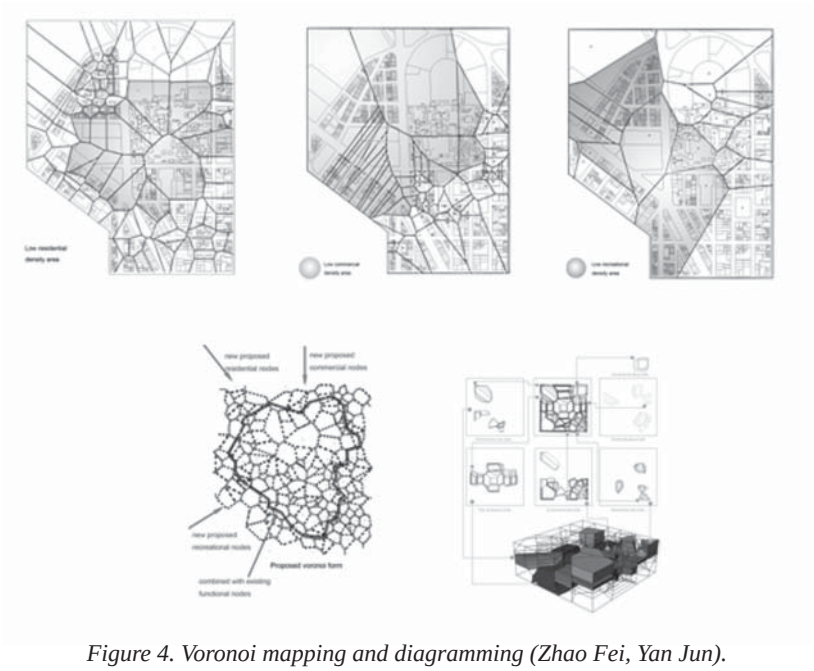

Figure 4. Voronoi mapping and diagramming (Zhao Fei, Yan Jun).

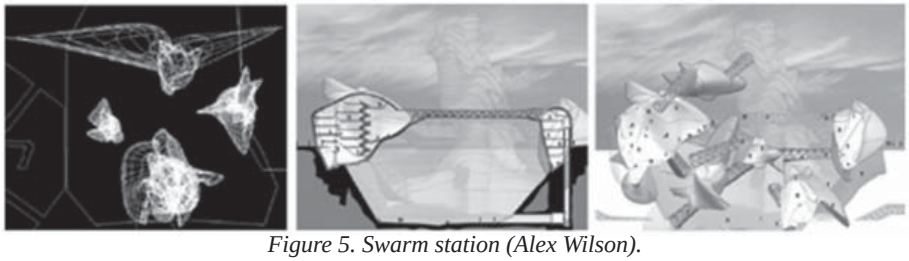

Figure 5. Swarm station (Alex Wilson).

4. Discussion

Students demonstrated a capacity for abstraction and diagramming techniques using these tools (Portugali and Hanken, 1992), not only form making. We found that one of the biggest problems was students' understanding of parametric implications and defining relationships that could guide their design beyond a literal mapping, in other words seeing beyond what they have been taught in their digital media classes. Hong Kong experience showed us that driving skill acquisition through design purpose was effective. It allows students to test what they learn in digital media class through their design. Therefore the knowledge that they gained is reinforced through experience. Also the possibility to test design ideas through pushing conceptual underpinning of computational ability can go much further. The parametric systems brought

out the diagrammatic nature of data and students acquired capacity to sketch through data and parametric relationships. The approach worked in very different contexts of density, culture and institution. Most importantly, students learned that parametric systems can be applied to diagramming, not only form making or BIM modeling.

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