C. M. Herr, N. Gu, S. Roudavski, M. A. Schnabel, *Circuit Bending, Breaking and Mending: Proceedings of the 16th International Conference on Computer-Aided Architectural Design Research in Asia,* 569-578.

GAINS, LOSSES AND LIMITATIONS IN DESIGNING PARAMETRICALLY

A critical reflection of an architectural design studio in China

CHRISTIANE M. HERR[1]
National Cheng Kung University, Tainan, Taiwan,
cmherr@mail.ncku.edu.tw

Abstract. This paper argues that learning to design parametrically in the architectural studio entails gains but also losses, since the parametric design approach tends to and encourage certain patterns of thought while discouraging others. This investigation complements previous research focusing mostly on technological aspects. Based on observational data from a parametric design studio in China, this paper discusses how parametric designing can pose challenges to existing design values and approaches, specifically within a Chinese context. It further draws attention to the limitations of parametric designing, which in the observed cases required both students and teachers to break and extend parametric models besides and beyond parametric variation to make them work architecturally. This paper aims to inform educators employing parametric designing in their architectural design studios as well as researchers who examine such studios.

Keywords. Parametric design; studio; design culture; education.

1. Introduction

Parametric designing has become central to international architectural discourse, both in theory, practice and education, as demonstrated by the series of Smart Geometry conferences and workshops. Following the example of several leading design schools, such as the Architectural Association in London, many schools of architecture internationally are introducing, or have recently introduced, parametric design tools and related design approaches to their design studios. Parametric designing hinges mostly upon the use of

parametric software tools and promises architects "new degrees of freedom in aesthetics, processes and structural design" (Anders 2003). As Kolarevic (2003, p.27) suggests, the parametric approach to design "profoundly changes the entire nature and the established hierarchies of the building industry, as well as the role of the architect in the processes of building". In addition to its modelling capacities, the potentials offered by parametric designing when integrated with fabrication or BIM has been demonstrated by a range of papers previously presented at CAADRIA.

Beyond the scope of a set of software tools or modelling techniques, parametric designing has also come to be understood as a distinct architectural design approach. In his 'Parametricist Manifesto' Schumacher (2009) claims that parametric designing has inspired a new movement characterised by "radically new ambitions and values" (ibid., p.15). In a normative manifesto style, Schumacher (ibid.) advances several imperatives of parametric designing, centred around the articulation of programmatic, institutional and social complexity: According to Schumacher (ibid.), a designer with "parametricist sensibility" emphasises variety and continuous differentiation through establishing relational systems, and pursues elegance as ordered complexity. Rigid geometric primitives and the simple, unmodified repetition of elements as found especially in Modernist design, are to be avoided. Schumacher's propositions have been subject to considerable debate demonstrating how ideologically charged parametric designing may be.

Previous case studies in design-educational studio contexts have typically reported on the potentials and techniques of modelling form through topological models (see for example Schnabel 2006, Hewett and Burke 2010), and on ways of linking parametric designing to fabrication (see for example Bechthold 2007). But in addition to such gains and potentials, parametric designing must realistically also be assumed to imply limitations - as any other design approach pursued in exclusivity. Snooks (2011) for example argues that parametric tools may be useful in design development, but not necessarily useful in sketch design or early stages of a project. Iordanova (2007) and Iordanova et al (2009) are among only few studies examining parametric design in the architectural design studio discussing challenges in teaching this subject. Many open questions remain: What are these limitations and how do students and teachers deal with them? How can parametric designing be integrated with other design approaches in the design studio? How does the introduction of parametric designing and related design criteria relate to the contexts of different design cultures and values? This paper investigates qualitatively an architectural design studio project in which parametric designing was introduced to students to whom the approach was new. It reports and discusses

observations made over the course of the studio in terms of the gains, losses and limitations experienced by involved students and teachers.

2. Introducing parametric designing to an architectural studio in China

The studio presented in this paper was held at Shenzhen University in 2009/2010. It lasted for one semester and included the semester break, a total of 24 weeks. Twenty students from mixed undergraduate years (mostly third year students) were working in design teams of four. The studio was co-taught by two Western teachers (one of which being the author) in English language tutorials and critiques. Most participating students had not been taught by foreigners before, and had limited knowledge of CAAD. The design brief for the studio called for a mixed-use high-rise building to be designed within an urban village in Shenzhen, which required students to reconsider the typology of conventional high-rise buildings to accommodate the surrounding urban village context. As part of the studio, students were introduced to both Rhinoceros 3D and parametric modelling in Grasshopper, which students were required to try but not necessarily to rely on exclusively. Figure 1 illustrates examples of design works resulting from the studio. Outcomes of the studio were presented to and discussed with international guest critics in three design critiques and shown in a final exhibition.

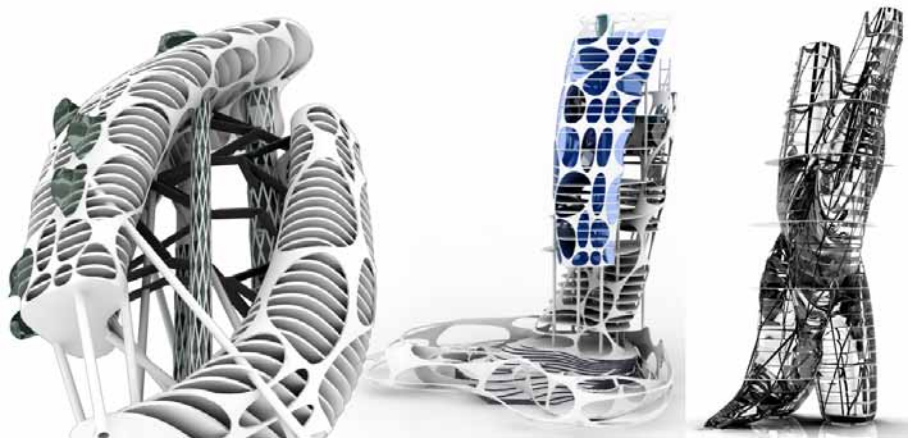

Figure 1. Parametric design proposals for a mixed-use highrise in Shenzhen,China.

Throughout the studio, observational data was collected in multiple formats for qualitative analysis, including student comments in open-ended questionnaires, transcripts from design critiques, field observation notes as well as photos, drawings, posters and presentation materials. The data analysis

process proceeded according to the grounded research methodology following Glaser (1998). A grounded research approach similar to Herr and Karakiewicz (2008) was chosen as it allows for the construction of explanatory models from progressive coding of various kinds of qualitative observational data with minimal influence of existing models. Collected data was examined with special focus on aspects of creativity, significant personal experiences and values as expressed in the comments of involved students, critics and teachers. I argue that this aspect has so far been under-represented in mainly quantitatively and technologically focused previous work and may be of value to educators involved in digital design research and teaching, in particular those teaching in Asian, and especially Chinese, contexts. The analysis process of observational data resulted in a descriptive framework of students' learning processes in relation to teachers' and critics' requirements in this particular studio. The analysis further suggests new questions that may inform similar educational research in the future. In the following sections, observations are summarized under four main guiding questions which structured and guided data analysis.

3. Were parametric models used for generating ideas early on?

Parametric modelling requires designers to develop geometry in terms of hierarchical and logical relationships of "parametric schemata" (Woodbury 2010). As Iordanova (2007) notes, learning to design parametrically from scratch is difficult and can be aided by providing a library of case studies or "referents" to aid students in quickly building up own parametric models by adapting and integrating existing parametric models. In the design studio discussed in this paper, students initially worked from (non-parametric) diagrams that connected site analyses to design proposals. These diagrams were developed in ongoing processes, in parallel to and supporting the development of design ideas. As students' conceptual idea diagrams kept changing, often dramatically, questions regarding building form were not decided upon in the first half of the design studio. Only when diagrams were reasonably consolidated, commitments to topological forms were agreed upon within the design teams, which could then be modelled parametrically. Parametric variation of form thus happened only in the last phase of the design process. Students described their use of parametric designing as helping to "realise" their ideas, not as supporting idea development. This matches with Snooks' characterization of parametric design tools as primarily useful in "design development" yet not in "conceptual development". One student group commented in an interim design critique: "We have an image in our mind. It has its logic mostly about the space. But it is different from Grasshopper logic, which is more

about data. When we translate it into Grasshopper, generally we cannot get a satisfying result." In analogy to Iordanova's (2007) use of referents, students of this studio tended to make use of referents, too – although these were not parametric models but diagram formats. Figure 2 illustrates similar diagram formats used by different groups, adapted from the analytical visualisation of functions as for example used by OMA in the design of the Seattle public library. In both cases shown in Figure 2, the diagrams served idea development purposes but did not determine the final building forms.

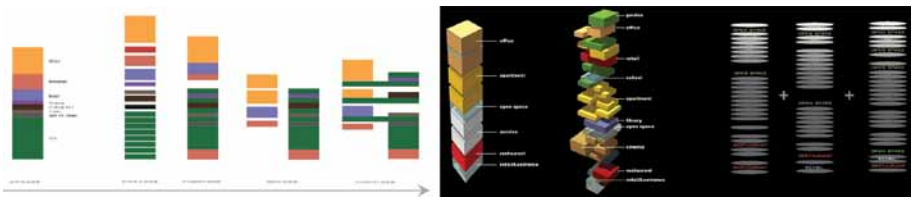

Figure 2. Diagrams for idea development in two different groups based on OMA's Seattle Public Library design, preceding the parametric design process.

Based on these observations, the variety and differentiation enabled by parametric modelling, as emphasised by Schumacher (2009), seems to affect only a limited part of the architectural model: it allows variations of parametrically defined shapes but the topological structure of the model remains largely unaltered. This may explain the observation that students preferred to work with diagrams while they were still reconsidering the topology of their architectural proposals, and only committed to parametric models (and variation of geometric form facilitated thereby) once a topology was agreed upon.

4. When was parametric designing used, and when were parametrically designed results fundamentally revised or abandoned?

Student questionnaire feedback as well as field observations indicate that students integrated parametric designing into a wide variety of design approaches. Among the approaches deployed were sketches, physical models, digital parametric and conventional models in various digital modelling tools, diagrams as well as visual programming in Grasshopper. Iordanova (2007, p. 688) acknowledges that architecture may be too complex a subject to expect any model to take into account many of its aspects – in this way models may become either simplistic or too deterministic, which prevents design exploration. Hewett and Burke (2010, p. 146) argue that instead of homogeneous parametric models, projects of significant architectural complexity require multiple and loosely connected ecologies of parametric systems to be relevant in terms of design

control and in terms of relationships to larger social, environmental and political contexts. Students' comments throughout the studio discussed in this paper echoed these viewpoints. One student team commented that "the translation between human thought and computer language is not very direct and requires a lot of effort". Students in all teams found some aspects of their designs easier to approach parametrically than others: When faced with this decision, they simply used the approach they thought was best suited to the task, which led to a unique and pragmatic combination of methods and viewpoints in each design team. Parametric designing was used in particular for façade patterns and automated function layouts within large volumes of space. In some cases, parametric models were apparently established too early, and the parametric logic became too limiting for the architectural design required. In several intermediate design critiques, students were asked by teachers and critics to "break" overly consistent parametric models in which generated variety was seen as arbitrary or meaningless. Figure 3 (left) illustrates an example in which a constraining parametric model needed to be "broken", adapted, modified and integrated with other design approaches to achieve the architectural ideas aimed for as illustrated by students' sketches (Figure 3, right). Departing from the constraints of the parametric model in these cases allowed for an architecturally more appropriate understanding of variety.

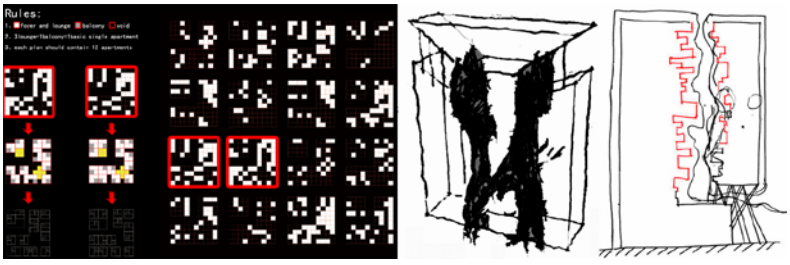

Figure 3. Overly constraining parametric model (left) compared to students' sketches (right).

Since these comments came from critics who have long-term practice in parametric modelling, this observation may call for a more differentiated understanding of parametric generation of variety in the architectural design studio. Where in previous educational studies, the teaching of parametric modelling and programming were typically the primary aims, the studio discussed here focused on architectural design. Parametric tools and design approaches were offered and taught but not required exclusively. This gave students the flexibility and opportunity to openly reflect and comment on the challenges of achieving the desired architectural quality by exclusively using parametric modelling. Critical feedback was encouraged and did not reflect badly on students' grades. Educational approaches in teaching parametric designing as

part of architectural design studios may require more research and discussion regarding how parametric designing can be integrated with other ways of working and thinking.

5. How was students' work evaluated by teachers and critics?

The analysis of detailed transcripts of design critiques demonstrated that teachers and critics evaluated students' work and progress in two broad categories: the mastery and application of parametric tools on the one hand, and the quality of architectural design proposals on the other hand. In design critiques, critics and teachers consistently commented on either one or the other of these aspects when giving students feedback. When questioning students about their parametric models, teachers and critics typically expected students to provide rational explanations and appreciated ways of reasoning that described the purposeful use of parametric model construction. When commenting on architectural qualities however, critics and teachers tended to employ and expect a more qualitative or emotional language describing spaces and social context. Based on these observations, it seems that in the case of this studio, parametrically designed proposals were *explained* through reference to parametric models and their rationale. Parametrically designed proposals were however *judged* based on more broad architectural qualities, which did not necessarily take into account parametric models or rational reasoning. Once parametric designing is employed in an architectural design studio, the main criterion for evaluating student work is not whether students successfully learned techniques, as it may be the case in technical courses, but the overall quality of the design proposals (Iordanova 2007, p. 689). The analysis of successive design critique transcripts in the case of the studio discussed here indicates that students gradually learned to report a "parametric narrative" to satisfy teachers' and critics' expectations, while pursuing architectural aims through design approaches that often modified and abandoned exclusively parametric modelling. Student groups who initially commented critically on their experiences with parametric modelling later reported 'success stories' in final questionnaires, which may be due to the perceived pressure to present successful parametric design accounts. One aspect of parametric designing thus seems to be the development of parametric narratives to fit criteria and values to associated with parametric design proposals, as emphasized by Schumacher's 'Parametricist Manifesto'.

6. How did the parametric design approach work for Chinese students?

While any attempt at characterizing or explaining the values of any design

tradition explicitly is bound to be overly generalized and inadequate, I still would like to address this aspect since it has not been discussed within the field of CAAD research and education previously. The relevance of this aspect may elude readers raised and educated within the Western tradition: Cultural values tend to be invisible to those who share them and tend to become obvious mainly when they are challenged for some reason. The Chinese cultural context can be described as a "high context" culture according to Hall's (1976) framework, where much that is made explicit in Western cultures tends to remain implicit in communication. This aspect has been discussed in fields as diverse as management and web design, but has not yet drawn attention in digital design research. In the context of digitally supported designing, the parametric approach can be seen as a challenge to Chinese traditional design education, where evaluation of architectural work often depends on implicit emotional or pragmatic appreciation of the proposed form, in which evaluation criteria are rarely made explicit.

Kolarevic (2003, p. 27) states that with parametric designing, "architects are designing not the specific shape of the building but a set of principles encoded as a sequence of parametric equations by which specific instances of the design can be generated and varied in time as needed". This characterization shows the important role of explicit logic and rational reasoning in parametric designing. Many students commented on this aspect: "Western thinking seems more logical and more direct while Eastern design thinking seems more emotional and more indirect. Different ways of thinking may yield different results.", "This way of working seems more technical and can help us achieve several aspects of work beyond our previous scope", "When designing based on the parametric design approach, we had to find a way to make our idea explicit in an abstract architectural language. It's kind of bitter sweet". Deprived of a sensual or immediately form-based approach to architectural designing, many students initially struggled to see designing in terms of numbers and parameters. Students also commented that they disliked "making everything technical", and that they found it difficult to think of design in terms of "control".

With the introduction of parametric designing, students' and critics' attention seemed to shift towards issues of rationally describing sculptural form and away from the human-centred consideration of spatial experiences. Students were proud of the kind of shapes they could generate through parametric models, and the moments of surprise when seeing the outcomes generated through parametric variations: "We initially created a logic of related parameters according to our design ideas and aims, and implemented this logic in a Grasshopper parametric model. Parametric variations mostly concerned the

geometric operations of revolving, twisting, connecting and separating", "We found parametric software useful to form a great variety of beautiful shapes which we think cannot be done by conventional tools alone". The requirement to make design decisions explicit was experienced by students in various ways. Some students commented that their way of thinking was widened by the experience. Students appreciated most the experience of working parametrically in design teams, since making design ideas explicit in terms of relationships of parameters and numbers helped the groups to negotiate shared understandings.

7. Conclusions

This study presents the outcomes of a qualitative analysis of a single case study project in which the process of introducing parametric designing to students new to the subject was examined in an architectural studio setting. Results of the grounded analysis of field observations as summarized in the following are offered as points of departure for both educators as well as researchers employing or examining parametric designing as part of the design studio, in particular in Chinese or Asian contexts.

In students' design processes, parametric models were developed and used only after a phase of idea development through diagrams, which allowed for easy transformation topological aspects. These diagrams were often based on existing diagram formats and fulfilled a similar role to the parametric model referents employed by Iordanova (2007). Parametrically generated variety seems to affect models mainly in terms of shape but does not allow much deviation from predefined topologies. Breaking or abandoning overly rigid topologies of parametric models and integrating these with other modelling approaches seems necessary to pursue design aims which further supports observations reported by Hewett and Burke (2010).

In intermittent and final design critiques, students' work and progress was evaluated in two broad categories: the mastery and application of parametric tools on the one hand, and the quality of architectural design proposals on the other hand. While parametric modelling provides a context of justification and explanation, critics tended to evaluate parametric design proposals in terms of architectural quality, which resulted in two distinct categories of criteria. With teachers and critics expecting parametric design explanations, but evaluating based on more conventional architectural design criteria, parametric designing tends to become a framework of values and a narrative that glosses over students' need to manually revise and modify parametric models to achieve the desired architectural aims.

In this studio, set in a Chinese cultural context and design tradition, working

with explicit design rationales and reasoning as required by parametric designing has presented a challenge: Parametric designing in this studio encouraged sculptural form variation but tended to discourage thinking in terms of spatial qualities. Participating students felt that parametric design proposals could achieve form variation but felt limited in their ability to express their architectural ideas. Students however commented positively on the usefulness of parametric designing in teamwork, where making ideas explicit helped to negotiate and communicate about design proposals in groups.

Acknowledgements

I would like to thank all students, colleagues and friends at Shenzhen University for their generous support and help in this project, in particular Prof. Rao Xiaojun, Prof. Gong Weimin and Prof. Wang Haofeng. Many thanks also to our guest critics, in particular Martin Riese, Uli Blum, Prof. Ning Gu and Prof. Thomas Fischer. I would especially like to thank Prof. Marc Schnabel for making working and teaching together a very enjoyable affair.

References

Anders, P.: 2003, Four Degrees of Freedom, *Connecting >> Crossroads of Digital Discourse,Proceedings of the 2003 Annual Conference of the Association for Computer Aided Design In Architecture*, Indianapolis (Indiana) 24-27 October 2003, 17.

Bechthold, M.: 2007, Teaching Technology: CAD/CAM, Parametric Design and Interactivity, *Predicting the Future, 25th eCAADe Conference Proceedings*, Frankfurt am Main (Germany) 26-29 September 2007, 767-775.

Glaser, B.G.: 1998, *Doing Grounded Theory*, Sociology Press, Mill Valley, CA.

Hall, E. T. (1976): *Beyond Culture*, Doubleday, New York.

Herr, C. M. and Karakiewicz, J.: 2008, Towards an understanding of design tutoring: A grounded study of presentation materials used in tutorial conversations, *CAADRIA 2008, Proceedings of the 13th International Conference on Computer Aided Architectural Design Research in Asia*, Chiang Mai (Thailand) 9-12 April 2008, 321-327.

Hewett, B. and Williams, A.: 2010, Open tower: developing design research practice, *Proceedings of the 15th International Conference on Computer Aided Architectural Design Research in Asia*, Hong Kong 7-10 April 2010, 137-146.

Iordanova, I.: 2007, Teaching Digital Design Exploration: Form Follows, *International Journal of Architectural Computing*, **5**(4), 685-702.

Iordanova, I.; Tidafi, T.; Guité, M.; De Paoli, G. and Lachapelle, J.: 2009, Parametric methods of exploration and creativity during architectural design: A Case study in the design studio, in T. Tidafi and T. Dorta (eds.) *Joining Languages, Cultures and Visions: CAADFutures 2009*, PUM, 2009, 423-439.

Kolarevic, B.: 2003, *Architecture in the digital age: design and manufacturing*, Washington, DC: Taylor & Francis, 2005.

Schnabel, M. A.: 2006, Architectural Parametric Designing, *Communicating Space(s): Proceedings of eCAADe 2006*, Volos (Greece) 6-9 September 2006, pp. 216-221.

Schumacher, P.: 2009, Parametricism - A New Global Style for Architecture and Urban Design, *Architectural Design - Digital Cities*, **79**(4), 14-23.

Woodburry, R.: 2010, *Elements of Parametric Design*, Routledge, London.

"Interview with Roland Snooks on Algorithmic Design": 2011. Available from: Suckerpunch Daily <http://www.suckerpunchdaily.com/2010/04/25/interview-with-roland-snooks/> (accessed 20 February 2011).