

## STAGE-BASED DESIGN BRIEFING BEYOND THE WATERFALL MODEL

*Tracing students' design processes in relation to prescribed design stages throughout an architectural design studio*

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**Abstract.** Based on visualisations of data obtained from field observations, this paper describes and discusses how a group of ten undergraduate students of architecture negotiated their ways through the tutorials of a design studio lasting 17 weeks. The main question guiding this empirical study is how the initially prescribed linear, stage-based framework of the design studio relates to design processes as experienced by participating students and as observed by myself as tutor and participant observer. Visualisations of tutorial observations show that instead of proceeding from one stage to the next sequentially, students tend to engage in continuous and parallel re-consideration of almost all aspects of their work. This results in a process that can be described as a cumulative and layered process, and illustrated as 'fan'-shaped diagrams. The role of the design stages initially scheduled in the detailed studio brief seems to be to gradually introduce students to increasingly advanced and challenging project scopes rather than to enforce sequential design steps.

**Keywords.** Design stages; design process; design education; data visualisation; tutorials.

### 1. Design process models

As recent research work in the field of design cognition takes a critical attitude towards previous stage-based models of the design process, design education finds itself in a dilemma: While experienced architectural practitioners

lean towards scepticism of stage-based models of the design process, those involved in structuring, coordinating and monitoring design processes – be it in design education or in design management – still tend to appreciate such frameworks. Stage-based, linear models of design processes enable teachers to prescribe, direct and control the flow of design processes and to provide guidance to inexperienced learners, and for these reasons often find their way into the design curriculum. Furthermore, increasing pressures on universities to adopt explicit and outcome-based accounts of teaching are likely to encourage prescriptive tendencies in brief writing as well as studio scheduling.

In observations of applied design processes, however, designers appear to follow such predefined linear processes only to a limited extent. Based on a detailed empirical study of applied design processes, Guindon (1990) suggests that prestructured top-down decomposition of design tasks is a problematic approach, and that experienced designers will typically embrace individual and opportunistic choice-making. Conklin and Weil (1990) illustrate this difference in line diagrams where a line plotted to illustrate designers' progress indicates sudden and unpredictable jumps between predefined design stages rather than an orderly and linear waterfall model. In a comprehensive review of previously proposed design process models, Gedenryd (1998) rejects the separation of design processes into stages entirely and argues that design processes may best be described as processes of interactive inquiry. During design processes, understanding of design challenges typically proceeds in parallel to, and in relation to, the development of design proposals. Maher et al. (1996) have described this pattern as co-evolution of problem and solution. This requires designers to maintain awareness of the possibility of reconsideration of many aspects of an ongoing project even when focusing on one particular aspect.

Guindon (1990), Conklin and Weil (1990) and Maher et al. (1996) all employ diagrammatic visualisations to illustrate and discuss the characteristics of design processes, which are difficult to describe in their entirety. Conklin and Weil (1990) present an abstracted and simplified explanatory model that illustrates the discrepancies between prescribed stage-based models of design processes and applied design processes in the context of design in practice. But does this discrepancy between prescribed design stages and applied design processes suggest inadequacy as Conklin and Weil suggest? Alternatives to stage-based models such as inquiry (Gedenryd, 1998) or evolution (Maher et al., 1996) do not seem to offer educators similarly practical frameworks in writing studio briefs. In this context, this paper examines how prescribed design stages and applied design processes are related within the educational setting of an architectural design studio. Can the discrepancy

between the need to prescribe on the part of the teachers and the need to divert from prescribed schedules on the part of the students even be understood as a productive context for design processes? To this end, this paper presents digital data visualisations of field observations as a way of reflecting on design studio experiences. The aim of this study is primarily to describe, analyse and make explicit the authors' observations to inform future design teaching and to explore alternatives in organising design studios.

## **2. Tracing prestructured design processes in tutorial conversations throughout an architectural design studio**

The architectural design studio discussed in this paper was a particularly well-planned second-year studio, set at a Chinese university in 2009. It was taught by 8 tutors, each supervising a group of 8-12 students, who worked individually. As is often the case for architectural design studios, the schedule and brief of this studio set out a linear sequence of several design stages, which students are required to follow in order to achieve good design outcomes. A detailed schedule handed out in the beginning of the semester (which I as a tutor followed but did not write) prescribed students' design activities for each of the twice-weekly tutorial meetings and lectures in the following stages: 1. site analysis, 2. concept development, 3. spatial design, 4. structural design, 5. elevation and façade design, 6. staircase design, 7. finalising and drafting. This overall plan was consistently enforced through the requirements that students had to comply with in seven interim presentations and submissions. During studio tutorials, however, students' design processes and progress seemed to differ not only from the initially given plan, but individual students also differed from each other.

Based on the understanding of designing as a circular, conversational process, where new ideas arise from differences in understandings or viewpoints between those engaged in the conversation (Glanville, 1995), tutorials and the opportunities for exchange they provide can be seen as central to design development. While students can emulate such conversations by and with themselves (*ibid.*), tutorial conversations with tutors are essential sources of ideas as they are usually not entirely controlled by either student or tutor, and support both variety generation as well as variety reduction. In tutorial conversations, new ideas may thus hatch between the perceptions and intentions of tutors and students (Herr and Karakiewicz, 2008). In this primarily qualitative case study, tutorials are seen as pivot points of the design process, where students' thoughts and decisions are developed and made explicit. For this reason, observational data collected during these occasions is taken to be representative of students' current design stage. Tutorials during which stu-



For producing visualisations from the field observation data stored in the Excel spreadsheet, a combination of VBA scripting in Excel and three-dimensional modelling in Rhinoceros 3D presented a straightforward procedure. Rhinoceros 3D allows for the production of both line drawings as well as three-dimensional models and provides a wide range of import and export options for subsequent editing of graphics. While digitally aided presentation may seem merely a simple step in this project, it has afforded insights that may be difficult to gain, illustrate and show otherwise. The following questions underlie the data visualisations presented in the following sections: How can individual students' design processes be described in relation to the predefined framework of design stages? How do individual students differ from each other? How do answers to these questions relate to perceptions of the role of the design tutor? Furthermore, how could these answers inform the prestructuring of future design studios and how could design progress be managed more appropriately?

#### 4. From spirals to fans

The diagram format developed to express the field observation data in terms of the seven design stages prescribed in the studio schedule consists of concentric circles, each divided into seven segments corresponding to the seven prescribed design stages. The concentric circles indicate the progression in time from the centre of the diagram outwards, such that each ring describes one of an overall total of 30 tutorial meetings. Within each ring, any combination of seven stage segments is possible to indicate the design concerns observed during tutorials and coded to conform to the seven design stages outlined in section 3. In the following, this diagram format provides the basis for illustrating tutorial observations by the author. In figures 3, 5 and 6, the basic diagram format is changed slightly to allow for more emphasis and clarity or to facilitate quantitative comparison.

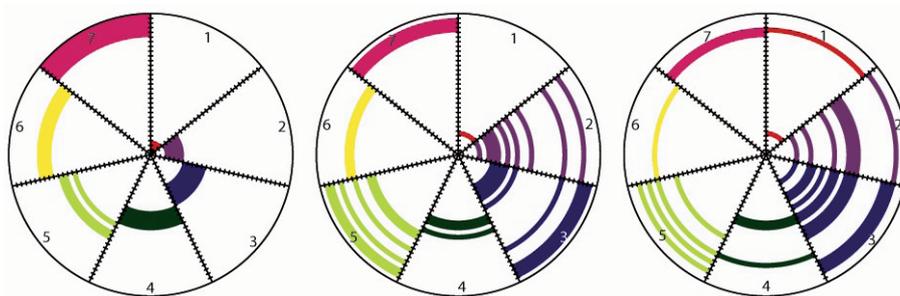


Figure 2. Design stages as prescribed in the studio brief (left) and as observed in the design processes of two students during design tutorials (middle and right).

Figure 2 illustrates the predetermined sequence of design stages as found in the studio brief (left-hand side) and the design processes of two students (middle and right-hand side) as observed during studio tutorials. When comparing visualisations of students' design processes to the prestructured sequence, students' design processes differ in two main aspects: the sequence of progressing through the predetermined design stages, and the amount of attention and overall time dedicated to each of these stages. Where the prescribed design stages are aligned neatly along a spiral, students' design processes are much more spread out, in particularly in the 'earlier' sections of the diagrams. None of the ten students followed the prescribed sequence of stages exactly as set out in the studio brief.

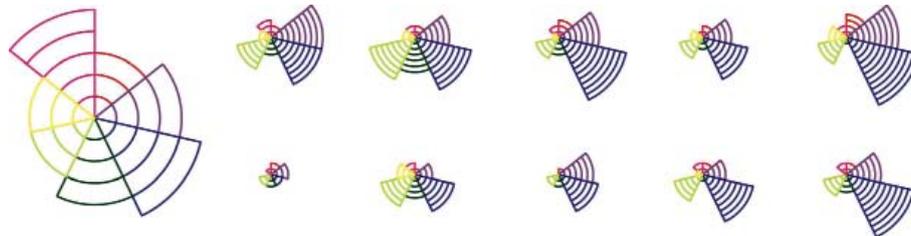


Figure 3. Quantification of attention paid to each design stage, as prescribed in the studio brief (large) and as observed from individual students during tutorials (small).

Figure 3 presents a visual comparison of the overall attention students paid to each of the design stages, as expressed in the overall number of tutorial meetings during which topics pertaining to each design stage were discussed. The comparison of field observation data shows that students tend to distribute their energy unevenly and not necessarily according to the prescribed design schedule. Students instead seem to emphasise individually chosen aspects of their design processes while trying to simultaneously comply with the prescribed design stages in order to fulfil basic requirements. These individually determined foci can further be described as 'clusters' along the timeline (figure 2). The design process visualised in the middle diagram of figure 2, for example, indicates the students' preoccupation with plan development and refinement (stage3) in two distinct bouts early and late in the design process.

With students' design processes diverging not just from each other, but often also from the prescribed studio schedule, studio tutors experience discussions across a broad range of topics during each tutorial. Figure 4 illustrates how each tutorial meeting (consisting of individual discussions with all ten students) covered a much broader range of design stages than the prescribed stages for that meeting (as suggested by the spiral-shaped visualisation in figure 2, left).

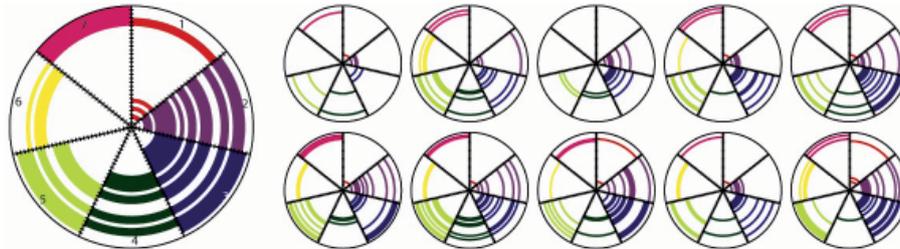


Figure 4. Design tutor's covering of design 'stages' in discussions with students throughout the design studio (left) and individual design processes of all observed students (right).

As illustrated in figure 2, students' design processes seem to negotiate and compromise between adhering to prescribed design stages roughly while still maintaining individual ways of working and thinking. To emphasise individual ways of addressing the initially prescribed design stages, the previously introduced diagrams are rendered three-dimensionally, with the circular segments indicating tutorial meetings placed with increasing distance along the z axis according to the studio timeline. Figure 5 compares three-dimensional visualisations of two students' design processes (left-hand side and middle) with the initially prescribed 'spiral' of progressing through design stages (right-hand side). In the diagrammatic visualisations presented in this paper, all students' design processes present as cumulative, fan-like shapes. In many instances, new design stages introduced or suggested by the studio schedule do not only incite students to consider new aspects of their developing design proposals, but also seem to trigger the re-thinking of previously addressed aspects, adding new layers to a cumulative process of thinking, which produces the 'fans'. The role of prescribed design stages in the observed design processes seems to be to 'unfold' these fans.

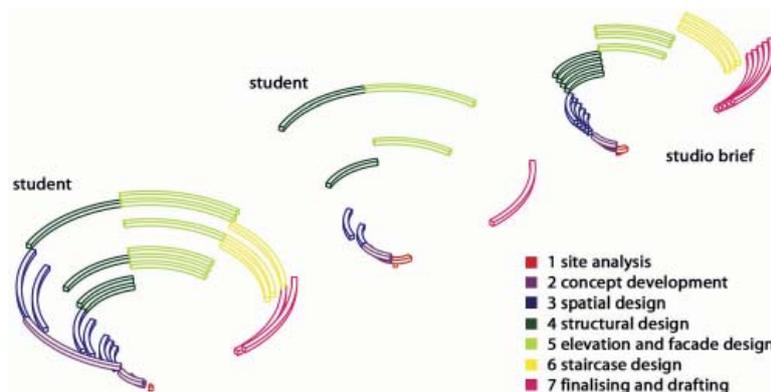


Figure 5. Three-dimensional visualization further emphasises the differences between prescribed design stages and observations of students' design processes.

### 5. Relating process visualisations, studio performance and final grades

Students' final grades were determined at the end of the studio based on a weighted calculation of previous submissions and reviews of drawings and models handed in at the end of each design stage. When comparing visualisations of students' design processes to their grades, it seems that those students who engaged more actively in rethinking and refining their projects beyond the currently prescribed design stage received good grades (average and above). None of the ten observed students followed the schedule literally in terms of exclusive sequential design stages. Figure 6 shows the design processes of a student performing very well in terms of final grades (left-hand side), an average student (middle) and a student performing not very well in terms of final grades (right-hand side). When comparing the process visualisations, it may be concluded that willingness to reconsider and revise previous decisions is a designer's strength rather than a weakness. Based on my observations during tutorial meetings, the best-performing students characteristically developed very intense engagements with their design projects, often reconsidering many previous thoughts in the light of new ideas to 'get it right'.

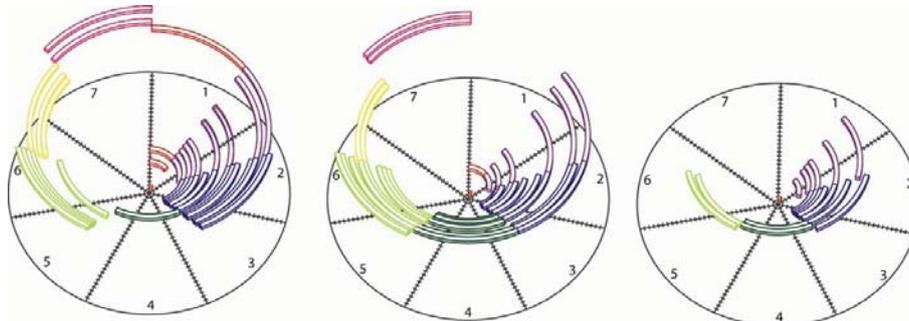


Figure 6. Design processes of students performing very well (left), average (middle) and not very well (right) in terms of final grades.

Students were assessed independently of whether they followed the prescribed design stages during each meeting, which suggests that adherence to the linear stage model was not necessarily expected by studio tutors. There seems to be an implicit understanding that prescribed design stages coordinate the design process and assure completeness of student work but that they are not meant to be taken literally nor actually followed. Rather than prescribing sequential stages, they seem to introduce new layers to a cumulative and holistic thinking process. To experienced architects, this may be a self-evident statement – to others, including students learning to master architectural design processes, this understanding may not be as obvious.

## **6. Navigating design processes**

This study is limited to the detailed examination of one particular design studio and the design processes of ten students as I observed them as their tutor throughout the design tutorials of one semester. While the scope of this case study is limited, it has provided a basis for developing an understanding of the design studio process and its underlying expectations as well as visual material to share this understanding. The process of coding and visualising field observation also required choosing a particular viewpoint. This is expressed in the formats of the diagrams presented in the previous sections, where emphasis is placed on the description of students' design processes in terms of design stages, their expression as visual patterns, their quantification and their unfolding in time.

Assuming design processes as cyclical in nature, how can the linearly structured studio accommodate cyclical re-entry? The 'fan' shapes expressed in particular in figures 2, 3 and 5 may provide one possible answer. Design processes are described as cyclical as they are experienced as generating new ideas in a process of recurring playing with, re-considering and modifying of previous ideas. The fan-shapes in the visualizations suggest recurrent and parallel consideration of individually chosen foci, where new ideas trigger the rethinking of previously made decisions. The fan shapes can thus be read as design cycles that increasingly widen their scope with the introduction of every new design stage, which leads to interconnections, increasing coherence and stability amongst all elements of the projects. If the prescribed design stages were to be followed exactly and exclusively, students would have to set all other considerations aside to focus on only one aspect of their projects at a time. Most students observed in this study instead seemed to maintain a holistic view of their design projects by remaining open to discard previous and partial solutions in favour of more fitting or more consistent ideas. While working on particular tasks, students seemed to keep previous decisions in mind for possible changes, thus consistently keeping options for improvement open.

## **7. Inquiry between cycles and stages**

Based on the outcomes of this study, I understand the relationship of prescribed design stages and applied design processes in the architectural design studio both as a dynamic and interdependent relationship. This may be described in analogy to the relationship between design tutors and students: Studio tutors usually have empathy with their students and will attempt to 'steer' them into a direction deemed desirable, but will also take into account their individual

or collective tendencies in design processes, possibly even over-compensating for such tendencies. Students' design processes will neither follow teachers' advice literally nor may this be intended by the tutors. Tutor advice can inspire and initiate new aspects and layers of thought, which lead students to develop their own responses (that may be quite different from the ideas of the tutors). While students' design processes may be unpredictable and highly individual, design studios need to be planned and structured to fit into allocated times and budgets similar to design processes in practice. The traditional studio structure which emphasises intense individual tutorial conversations between tutors and students once or twice per week already provides a middle ground between rigid overall frameworks and the opportunistic and unpredictable design processes experienced by individual students. Based on the outcomes of this study, it seems that the studio structure provided support to unfolding accumulative processes rather than determining a linear roadmap. In future design studio instances, I am thus interested in exploring this understanding further, such as by suggesting a layered structure that acknowledges explicitly the need to simultaneously (re-)consider any aspect of the design project that may be necessary. Another possibility may be to avoid a literal prescription of design stages and taking into greater account the dynamic navigation process characteristic of designing which Gedenryd (1998) has characterized as "interactive inquiry".

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