Chapter Z

One Step Forward and Three Back: A Study of the Patterns of Interdisciplinary Conceptual Design

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Z.1 Introduction

Design activity, particularly at the early stages of a project, is recognised as being dynamic, highly iterative and non-linear. However, under the rigours and pressures of the contemporary project environment, designers are being urged to undertake early design activity in a far more programmable, and thus manageable, fashion. Within this environment iterative, or cyclic, design progression is often criticised, with the concept of 'going round in circles' being one that is generally discouraged (Hickling 1982). However, design is a learning activity and, owing to the complexity of contemporary building projects, it is often only by moving ahead to improve knowledge of the problem, before taking a step back to re-address a problem with improved understanding, that the design process can progress (Lawson 1980). This is possibly the most commonly recognised type of iterative design progression among design researchers and practitioners. However, there are many other types of iterative design progression that are common to early stage design activity. For the last two years the MDP (Mapping the Design Process during the conceptual phase of building projects) research project has endeavoured to improve understanding of conceptual design activity. It as been undertaken at the Department of Architecture, University of Cambridge, in close collaboration with Loughborough University and a number of construction industry firms. The research team has gathered empirical evidence which suggests that, although every design project is unique, there are commonalties within the iterative structure of periods of design progression across projects. This paper describes briefly the genesis of a framework for conceptual design before describing the results from two of the seven design teams studied to track design progression. The maps of design activity are then discussed and analysed to unravel and reveal the iterative trends within conceptual design progression.

A literature survey, encompassing upward of 200 texts starting with the early design methods literature that lead to the formation of the Design Research Society in the mid-1960s, provided a wide and far-reaching outline of the pre-existing knowledge of design. This, along with reviews of process models both within and beyond construction (Macmillan *et al.*, 1999a), interviews with designers about case histories, and observations of workshops where interdisciplinary teams of designers were observed during the concept phase of a design project, enabled a preliminary framework for concept design to be devised (Macmillan *et al.*, 2000). This comprised: i) a standard framework describing five design phases that are generic from one project to the next; and ii) at the lowest level, a structured set of 12 generic design activities in which project specific tasks, knowledge, and data could be stored. The framework was developed to be flexible and adaptable, to accommodate different types of project, client, and design environment, while still offering a structure to which project specific sub-models can be connected.

This framework was utilised subsequently as a means of tracking the conceptual design progression of seven individual interdisciplinary teams. Six of the teams were monitored over the course of two 'Designing together' workshops (Austin *et al.*, 1999 and 2000; Steele *et al.*, 1999). The first involved designers from a single multi-disciplinary organisation collaborating in the research; the second involved designers from each of the MDP project's industrial collaborators.

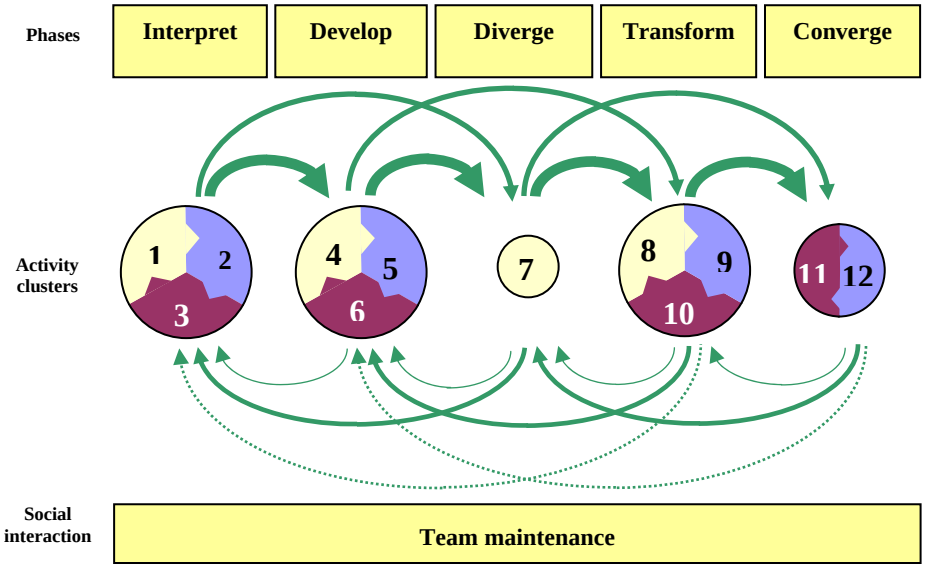

Figure Z.1 Reinterpreted conceptual design framework model

The design exercise within the two-day workshop involved the design of a window façade system for the re-cladding of 1960's office buildings.

Upon analysing the patterns of design progression of the workshop teams it became apparent that iterations across the activities and phases of the design processes that were recorded during the workshops fitted within a higher level of iteration representing the entire conceptual design phase. In light of this finding the preliminary design framework model was developed into a more realistic representation of the conceptual design phase (figure Z.1).

The seventh and final team was tracked over the course of a conceptual design workshop on a live project in industry. This workshop, which aimed at developing a concept proposal for an airport terminal, also allowed a preliminary web-based design support system to be trialled; details of this component of the research are provided elsewhere (Steele *et al.*, 2000). Two of the seven patterns of design progression that were produced are illustrated and discussed in the remainder of this paper.

Z.2 Patterns of Design Progression

Traditionally, models of the design process comprise sets of stages, phases or activities that are followed linearly during design activity; an example of which is the RIBA Plan of Work for Design Team Operation (1969), which, although developed some 30 years ago, remains the most widely referenced model of building design. Typically, this type of model appears to imply that the components of design are of broadly equal duration and importance.

However, when the conceptual design framework is used to track the design progression of interdisciplinary teams in practice, a more complex set of relationships between activities emerges. The two maps of design progression, which are discussed in the following section, provide insights into the nature of interdisciplinary conceptual design activity. Additionally, a number of trends have become apparent which suggest that, although the patterns of design progression are unique to particular teams within particular working environments, elements of design activity, and the reasoning behind them, are ubiquitous.

Z.2.1 Experimental workshop team

Although a linear sequence of phases was pre-defined by this experimental workshop team it became apparent that the design actually progressed linearly but in a number of iterative bursts. Two iterations were performed to establish requirements while developing a design strategy, after which a period of concept generation and transformation took place. Two further iterations were undertaken to arrive at the final proposal - one to generate and choose the primary concept and another, to conceive and crystallise sub-elements of the proposal. The team members collaborated successfully throughout the exercise with little, if any, confrontation between members.

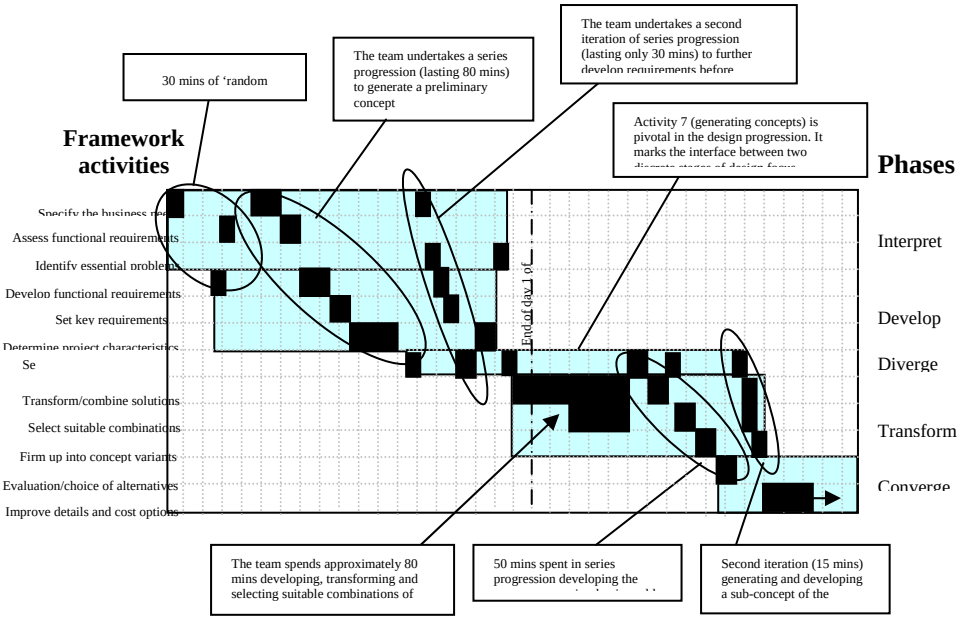

Figure Z.2 Pattern of progression of Experimental-workshop team.

Z.2.2 Live-workshop team

Initially the team addressed a number of activities in parallel, that focused on achieving the phase objective of interpreting the client's need. This was followed by a brief exploratory step to generate concepts before stepping back to resume a fairly linear progression. The pattern of progression portrays an iterative spike mid way through the design activity. This was a needless iteration that occurred as a result of an oversight on the part of an individual. Thus, the design time spent performing this iteration could well have been avoided. The design team comprised individuals that had worked together previously on projects of this type for the same client. Consequently, there was a good team dynamic from the outset and no real confrontation between members.

Z.3 Trends within the patterns of progression

The two patterns of design progression that have been described and illustrated are, like the other maps produced, unique in that the same holistic pattern is never repeated. However, in analysing sections of design progression it is apparent that there are certain generic sub-patterns of design activity.

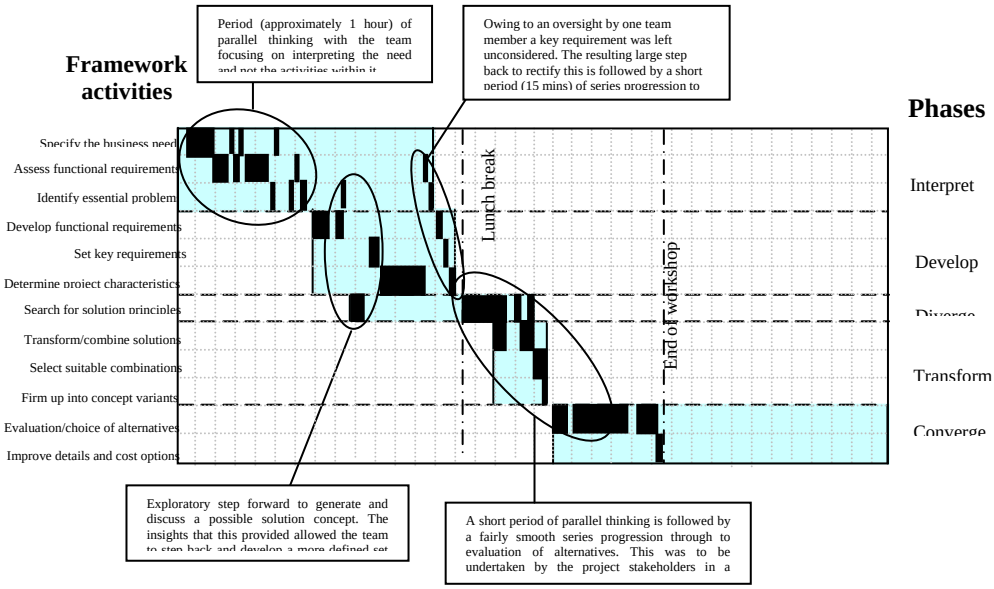

Figure Z.3 Pattern of progression of live-workshop team

Z.3.1 Series and Parallel Progression

In analysing figures Z.2 and Z.3 it appears as if steps between activities mean exactly that - that each of the activities are considered in isolation of the others for that period of design time. It may be more beneficial for the design team to think of activities as objectives that it must strive to reach (ways of thinking to reach an objective), rather than as steps that can be made in sequence if certain tasks are performed at each step. Of course, if this idea is applied, exactly what each member cogitates becomes irrelevant as long as the focus of their individual thinking aims at achieving the activity objective – their thought processes will be very different but their objective in thinking is synchronised. Thus, depending on the manner in which the steps were taken (two types are identified in figure Z.4) it is suggested that the team are focusing on a different level of objective, i.e. they are working toward the phase, rather than the activity, objective – in effect, different periods of design time are spent focusing on different levels of the framework.

Figure Z.4 illustrates two very different types of iteration. Instead of regarding all steps between activities in the same manner it may be valuable to differentiate between these periods in terms of parallel thinking (1) and series thinking (2) periods. Assuming this is the case then figure Z.4(a) could be better represented as figure Z.4(b). The patterns of design progression can be misinterpreted if it is assumed that taking a step forward automatically means that the last activity has been completed and is no longer being considered. Although this does occur during series progression it is not always the case. However, it is important to recognise that the dominant form of design progression was observed to be steps forward

sequentially (series progression), followed by a leap back over several activities before entering series progression again.

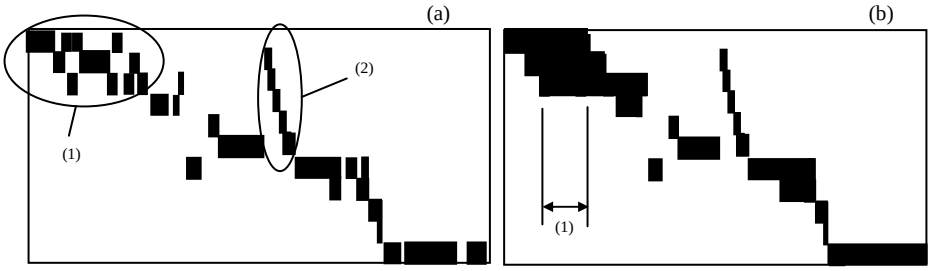

Figure Z.4 Differentiating between parallel and series focus

Z.3.2 Speculative Progression: Stumbling Vs Exploration

Typically, if there is a large jump forward over a number of activities (e.g. 2 – 7) it is followed by a similarly large step back (7 – 2, 7 – 3). This type of sporadic leaping can been described as speculative progression and is driven by speculative thinking (figure Z.5). This type of progression, which is common in the patterns of design progression, suggests that either: i) the team members have progressed hastily and, upon realising that they did not do enough background investigation to achieve the objective, are forced to step back to the original activity; or ii) the step was taken, for example, to attempt a solution to improve problem definition before stepping back to address the earlier activity with improved knowledge.

If the latter is the case, then it is assumed that the problem must be ill-defined and as a result, there is some underlying rationale behind the sporadic stepping between activities. If the former is the case the latter will occur, to some extent, by default. However, this represents a stumbling progression in design terms and it could be described as neither effective nor efficient design behaviour – it is purely a symptom of having designers who do not understand fully the high level design phases and activities.

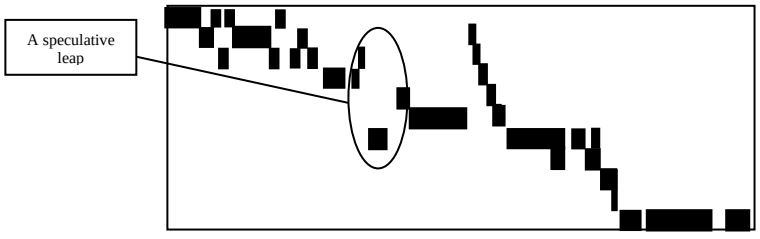

Figure Z.5 Speculative design progression

Z.3.3 Iterative Steps

When progression has been made either using series or parallel thinking, a large backward step over a number of activities is typically followed by some further series or parallel thinking/progression. It was common to see this pattern of iteration repeat until an appropriate design was generated (see figure Z.2).

When this iterative design progression occurred it was apparent that, in all cases, the gradients of the iteration were different to the gradients of the first occurrence of design activity. Although it might be expected that the iteration would always be steeper than the first occurrence of design progression (as some learning should have occurred) this was not the case. Generally, when a team progressed rapidly through a series of activities, any iteration tended to take longer to perform than the first occurrence i.e. a reduced gradient was apparent. This type of progression, be it series or parallel activity focused, tended to lead to a lack of certainty in proposals and increased the possibility of oversights. Conversely, when a team progressed slowly through a number of activities, any iteration through those activities tended to be undertaken more quickly, i.e. an increased gradient was apparent. In outlining the differences between the types of iteration it must be noted that no data has been gathered to suggest that one is more beneficial then the other. Furthermore, excluding the case of parallel lines, it is impossible for the gradients to be anything but flatter or steeper than the first progression. However, this latter type of iteration could be deemed more beneficial for team members as it provides short periods of reflection on design activity thus improving their understanding of solution and problem as they progress (see Schon (1983) for details of this concept of ‘reflection-in-action’).

Z.4 Effects of problem definition on patterns of design progression

Problems can be categorised in terms of their level of definition or degree of complexity. Rittel and Webber (1973) have described this as the ‘wickedness’ of the problem. Ill-defined, or wicked, problems require, typically, exploratory (speculative) design progression and large amounts of iteration in order to be solved. Conversely, well-defined problems, typically, require far less iteration (although it is still a very necessary component of the design activity) and speculation in order for a suitable proposal to be developed. The difference between the types of iteration that are performed to solve these types of problem rests in the size of the ‘leaps’ between activities. The previous section has identified differing types of design progression that characterise periods of conceptual design activity. At times, step progression from one activity to the next does not necessarily mean that the team will stop performing the latter activity, it may mean the team merely bring another activity into consideration in parallel with any number of the prior activities.

Z.4.1 Iteration Bandwidth

If the activities being performed in parallel over a period of time are recognised as such (figure Z.4) a band can be drawn across the conceptual design phase which describes the activities that are under consideration over any given period of time. This is described as the 'iteration bandwidth'.

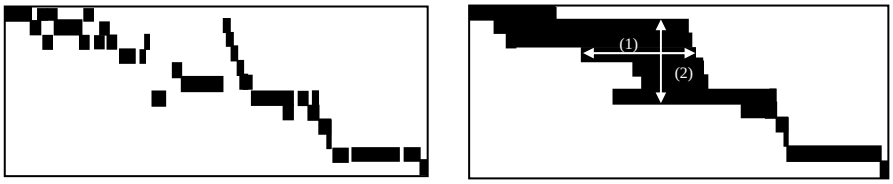

Figure Z.6 The concept of the evolving bandwidth – based on the design activity of the live workshop team

Depending on the manner in which a team progresses and, more importantly, iterates the width of this band may not remain constant but instead narrow and widen as the design activity progresses. If the analogy of a concertina is used, expanding and contracting over a period of time, it may be simpler to envisage the evolving band enveloping more or fewer activities as the team progresses. If this is related to the previous discussions on reasons for iteration it is apparent that the narrower the bandwidth becomes the fewer the number of activities that are enveloped, and thus addressed or considered, in parallel (vertical (1) dimension in figure Z.6) over a given period of time. Additionally, the horizontal dimension (2) at any point on the pattern of progression relates to the period of time over which a single activity or phase is considered (sporadically of constantly).

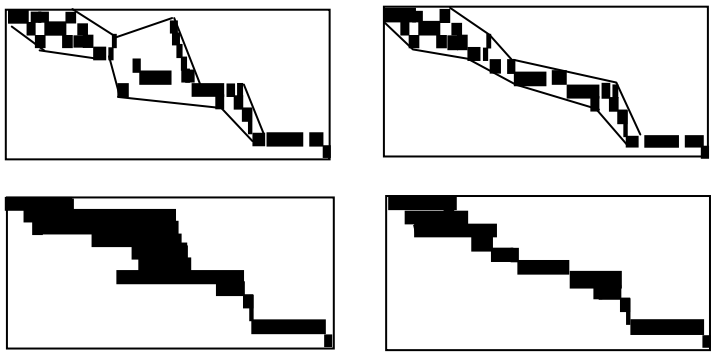

Figure Z.7 A reducing bandwidth (notional) resulting from improving understanding of the problem type – moving towards being well defined.

Given a working environment where a team has worked together previously on a similar project, and will do so again, it is fair to assume that knowledge of the problem will evolve, thus reducing its complexity. The members of the live-design team verified this notion during a post-design discussion by stating that; “This is an airport and we are all airport people and we kinda know where we are going…this is why the map [pattern of progression] is so smooth”. Thus, it is not unreasonable to suggest that teams that have worked together previously on a certain type of project for a certain type of client, could fine-tune their design progression around characteristic iterations. This, in theory, could allow the bandwidth to be tightened over the course of a number of projects (figure Z.7), thus removing any wasteful iteration from future design activity.

Z.4.2 Applying the Iteration Bandwidth Concept in Design Management

Our study to date has focused on the observation of design teams and the description of their processes. However, it may be possible to apply the findings more prescriptively to help designers become more reflective on their design progression and, potentially, to work more effectively. It is to be expected that teams addressing ill-defined problems would need to progress far more speculatively with large amounts of iteration (wide horizontal bandwidth dimension), addressing large numbers of activities in parallel (wide vertical bandwidth dimension), while those addressing fairly well-defined problems would expect to exhibit a narrower vertical bandwidth dimension, though not necessarily a narrower horizontal dimension. It may be possible to look at a design team, their experience on a particular project type, in a particular working environment and set expected (characteristic) iteration bandwidth dimensions. If a design manager were to monitor the design team based on the characteristic iteration bandwidth it would be possible to identify when the team step outside of it. Reasoning for the uncharacteristic step could be sought and then fed forward into the next project process of that type.

This concept is based around attempts to manage conceptual design by encouraging iteration within prescribed boundaries based on descriptions of previous design activity. In effect, bandwidth could be a mechanism that allows the iterative loops to be revised and reviewed over a number of projects, with the loops designating the appropriate expected bandwidth based around the model of conceptual design (shown previously in figure Z.1).

Z.5 Concluding remarks

The Mapping the Design Process project has provided an opportunity to monitor the design activities followed by interdisciplinary teams of designers during the concept phase of building projects. We have devised a simple graphical means of

recording and displaying the pattern of progression through the activities that the teams followed. We have also used this to study and analyse these patterns in terms of the gradients and bandwidths of iterative working.

It seems highly appropriate that graphical methods are being used to study design, since design is often a visually-based process. And indeed, the designers who have participated in the project do seem interested in these patterns, which they can readily assimilate. These ideas about iteration, bandwidth and gradient might be passed back to designers to encourage them to reflect on their own processes, and help design teams manage their own teamwork processes more effectively.

The notions of phases and activities of conceptual design have been embodied in a prototype web-based interactive system that can be run over the internet. This was tested in workshop seven. This support tool for conceptual design focuses on the gates between the various activities, and provides a database for recording design decisions taken during each of the phases. It also contains Team Thinking Tools, should designers need help to broaden the solution space by generating more concepts, set priorities, or choose between competing alternatives. Its development and testing has been reported elsewhere (Steele et al, 2000) and one of the industrial collaborators is proposing to develop it further as part of their in-house management of design.

Finally, only seven design teams have been monitored and, in every case, in workshops. Six teams were working on artificially defined problems in a training workshop. In the seventh case, the team worked on a live project, but again during a short workshop. We believe that the patterns we have identified are of considerable interest, but we have insufficient data to draw robust and generally applicable conclusions.

Z.6 Acknowledgements

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