Generic Abstraction in Design Creativity

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Abstract

This study examines the role of generic abstraction in architectural design, specifically how it facilitates design exploration through formulation of a family of design schemes. We maintain that exploration in design, as it is in scientific discovery, is not solely based on serendipity, as often claimed, but that designers often reason in ways that strategically structure their explorations. We single out three instances of structuring through 'generic abstraction' in the case study of Staatsgalerie by Stirling.

Keywords: abstraction; diagrammatic reasoning; design cognition.

Design cognition studies emphasize the facilitating role of sketches in the process of creative discovery (Goel, 1995; Goldschmidt, 1991; Schön, 1992). These views describe the discovery process almost exclusively either in terms of 'serendipity' (Suwa, Gero, & Purcell, 2000) or of piecemeal evolution of design ideas through localized changes (Maher & Tang, 2003). In the area of scientific discovery, however, research shows that creative outcomes are often the outcomes of processes of reasoning through extended structured explorations (see, e.g., Nersessian, 2008).[1] Nersessian (1999, 2008), for instance, has shown how a process of what she called reasoning via 'generic abstraction' was central to the scientific discoveries of both Maxwell and Faraday, and can be seen in the work of numerous other scientists. In this paper, we argue that generic abstraction, consisting of "selectively suppressing information instantiated in representation so as to make inferences that pertain only to the generic case" (Nersessian, 2008) could also be an exploration strategy to foster creativity in architectural design.

We highlight the salient features of generic abstraction in one particular case study: James Stirling's Staatsgalerie Museum extension project using cognitive-historical analysis of archival records (Nersessian, 1995). In this project, the abstraction processes were sustained through a collaborative effort within a distributed cognitive system (Hutchins, 1995) that consisted of one senior and two junior designers, and representations in the form of sketches and diagrams.

Study of the Design Process

The Staatsgalerie case study is based on an investigation of archival materials from the Stirling Collection at the Canadian Center for Architecture and correspondence with the two junior members of the design team. The archival materials, approximately 505 graphical materials such as sketches and different types of drawings, plus textual materials such as correspondence and minutes from meetings, include all the available documents from the design process.

The Staatsgalerie design process lasted for five months, with August 30, 1977 as the deadline for the submissions. The competition brief emphasized the urgency of restoring the spatial and historical continuity of the urban fabric by enhancing pedestrian movement. In response, the design team configured a scheme that would accommodate the public circulation through the building without disrupting the integrity and wholeness of the Museum, while allowing the public a close experience of the activities in the Museum.

Starting the project, Stirling asked Ulrich Schaad and Russell Bevington, his assistants, to start thinking about the design and he would join the process later. As a starting point, the assistants identified two precedents as sources of ideas: their previous museum competition project for Düsseldorf, the Kunstsammlung Nordrhein-Westfalen, and the historical Temple of Fortuna (Schaad)[2]. In both Kunstsammlung and Staatsgalerie projects, a pedestrian path and a circular courtyard are the two significant elements of the design. Inspired by the Temple of Fortuna, the architects for the Staatsgalerie layered the building on a series of terraces and used ramps to connect the different levels. The transferred elements from the two precedents, i.e., terraces, ramps, public path, and a central court, began as and remained significant design elements throughout the design process.

After these initial decisions, the design proceeded through two coordinated explorations. First, the junior designers produced a vast number of variations. Second, the senior designer, Stirling, took these variations and produced generic schemes with the idea of incorporating a public path

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[1] Of course, there are cases of serendipitous discovery in science as well, as, e.g., discussed by Thagard (2002)

[2] References to Schaad are personal communications (2002) unless otherwise noted.

going through the building with a central court, as drawn in the final competition submission (Figure 5.12).

The path, the first important theme of the design, was worked out in numerous sketches. There are no schemes without some sort of a path crossing the building. The shape and configuration of this path, though, changed throughout the exploration. The team considered two categories of variations of the idea of path: paths with no turns and paths with turns. The primary example of the first is the straight path scheme (22 instances). The example for the second is a zigzag path where the public circulation makes several turns through the building (14 instances). There are two further variations of each of these categories. The large curved path (3 instances) is a variation of the scheme with no turns, whereas the meandering path (13 instances) is a variation on the zigzag path scheme. The final category comprises hybrid schemes of straight paths and paths with turns (99 instances). An example of this category is a path that enters the site directly, makes half a circle around the sculpture courtyard, and then proceeds directly to the outside of the site. Generally, the team tried to achieve a scheme where the public would use the path as a shortcut and still enjoy the building as much as possible. In the hybrid schemes, the time spent is elongated and the general public is given a chance of a momentary pause to experience the sculpture court.

The second important theme in the design was the idea of a centrally located sculpture court that would unify the fragmented components. The court emerged early in the design process, most likely in reference to the Düsseldorf competition entry. There were only 13 schemes without a court as opposed to 228 schemes with a court among all the sketches investigated in detail. Once it emerged, the idea was studied in several variations, which can be grouped in six headings according to shape: triangle (2), rectangle (11), square (13), ellipse (6), circle (195), and semi-circle (1).

The team considered numerous schemes. Neither the path nor the court, however, was studied independently. The trajectory of the path determined the shape of the court and the shape of the court determined the configuration of the path. In terms of the configuration of the path and court, there are five categories, with their respective numbers of occurrence: Path without a court (19), Path without connection to court (17), Path tangent to the court (10), Path intersecting the court (24), Path around the court (95).

In those schemes without a court, the path dissects the building into disconnected fragments. In the schemes with a court, the court is a central focal element. Where the court is disconnected or tangent to the path, the building remains somewhat fragmented. When the path enters the courtyard diagonally, it is either the path or the court which is dissected and their continuities disrupted.

Finally, in schemes where the path wraps around the court, there is a compromise. Neither the path nor the court is fragmented. The path retains its integrity while providing enough exposure to the museum. When the section sketches and the axonometric drawings are studied, we see two sub-

categories of this variation, of which one is the final scheme. In the first sub-category the path wraps around the courtyard yet it stays at a higher level, i.e., the path never reaches down to the courtyard floor (Figure 1). In the final scheme, the path proceeds downward to the floor of the court along the curvilinear wall of the courtyard (Figure 2). It is this scheme the team entered into the design competition. In its new configuration, the court became a place of pause for pedestrians, including non-museum goes living in the neighborhood. This suggests a shift in the conception of the court from being solely a central place for the building to becoming a center of focus for both museum visitors as well as the residents of the neighborhood using the path.
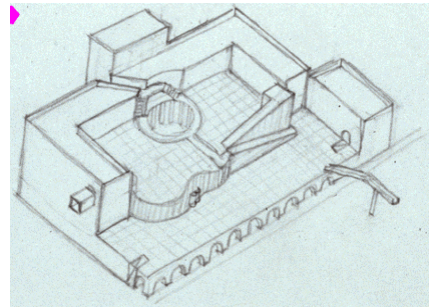

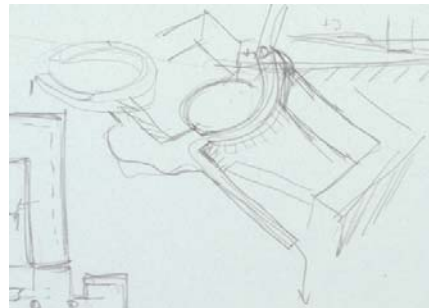Figure 1: A variation where path circles around the court. [3]

Figure 2: A variation where path circles downwards.

All the important shifts during the design process, including the emergence of the idea of court, appear to have occurred through processes of abstraction. In these abstractions, Stirling first conceived the path and court in terms of their basics, then established a meaningful connection between them, and finally, modified their meaning to achieve a new satisfying scheme. In the remainder of this paper we are going to illustrate three such instances of generic abstraction.

Dynamics of generic abstraction

During the design process, communication among the team members evolved mainly through sketches and diagrams (Schaad). Wilford, Stirling's office partner, describes this

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[3] All the drawings are from © James Stirling/Michael Wilford Archive, Centre Canadien d'Architecture/Canadian Centre for Architecture, Montréal unless otherwise specified. Reprinted with permission.

collaboration in terms of successive stages. First, the brief or the program document was placed on the desk of everyone involved in the design. From then on, Wilford reports "a wide ranging diagrammatic exercise [was] carried out to establish all possible ways of configuring the building" (Wilford, 1996, p. 14). The members of the team would create photocopies of their sketches and Stirling would take these as the basis of his own sketches. Stirling would work on these alternative sketches to "select, edit, alter, add" (ibid.). He would do this by "taking the A4 photocopied clip and putting an A4 tracing paper on top and doodling" (ibid.). Wilford characterizes Stirling's manipulation of others' sketches as a process of *simplification* of the complexity of the design situation. The drawings are reduced to their basics and essentials, which Wilford describes as "stripping away extraneous information… by overlaying tracing paper on an under drawing and redrawing it, often many times, until the scope and detail are paired down as required" (Wilford, 1994, p. 5). According to Schaad, through this processes Stirling gained mastery which allowed him "to pick on ideas (drawn) and mould them into the whole once a basic scheme had been determined."

The strategy of simplifying the exploration by way of reducing the set of available design solutions was a conscious effort on the part of the designers. Wilford states that "the office was a searching factory; it was not a pick-and-choose operation but an elaboration of an agreed-upon set of ideas, a sequence of sketches rather than 25 alternatives" (Wilford, 1993).

The sketches are small, simple, and drawn on standard, small size sketching papers. Their simplified form makes them easier to study, to inspect, and to grasp the essentials. Furthermore, there are usually a set of sketches on a page making simultaneous comparisons more efficient.

First generic abstraction: In the first instance of generic abstraction, Stirling used abstraction to transfer architectural components from the Düsseldorf competition project (Figure 3a) to the Staatsgalerie project. In this early schematic plan drawing (Figure 3b), which belongs to a set of drawing schemes without a court, there is a generic scheme drawn in red pen.
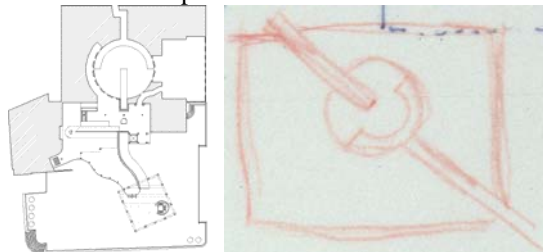

Figure 3 (a) Kunstsammlung; (b) First generic abstraction.

We know that the convention of the office was for only Stirling to use a red pen to edit and comment on the drawings of the other designers (Wilford, 1994). In Figure 3b, Stirling abstracted the Düsseldorf scheme to its bare bones as a square and a path with a court, which made it easier for him to transfer only these generic elements and their relationship to the Staatsgalerie competition project.

Second generic abstraction: Among the early sketches of Staatsgalerie, there are several indicative of how the schemes are compared through re-sketching by superimposing papers or by tracing over the sketches. With one such drawing (Figure 4), the team configured a generic scheme regarding the nature of the path and the court.
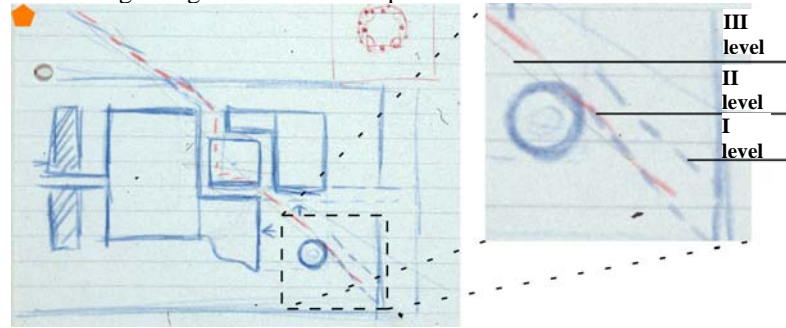

Figure 4: The second generic abstraction with the three levels of abstraction.

In this drawing, the superimposed lines show three phases of abstraction on the idea of path: blue dashed lines, a red dashed line, and a gray diagonal line. Here, two parallel dashed blue lines at the entrance of the site and at the exit of the site literally correspond to a path with a specific width. The red dashed line superimposed on the blue line, however, is more abstract and represents the movement and not a particular path. This line abstracts the path to a circulation line, representing the trajectory of the movement and the turns along this trajectory. The third superimposed line, i.e., barely visible gray line crossing the circle, advances abstraction one step further. Here the indication is not of width or trajectory, but rather it denotes the architectural notion of an abstract circulation axis passing through the building.

The difference in the colors supports the claim that the abstraction evolved in three phases from path to movement to axis. Again, what is significant is the process of abstraction which enabled Stirling to think in terms of the generic issues concerning the path and its relation to the court rather than the physical properties of the design. Abstraction helped Stirling in thinking of the path in terms of a linear movement and of the court in terms of a central space located along the linear movement.

Third generic abstraction: A set of drawings by Stirling (Figure 5), illustrates the processes of abstraction through which Stirling conceived of an integrated generic scheme. The set starts with a plan drawing showing the configuration of the lecture hall, temporary exhibition space, and the court (Figure 5.1). They are all lined up on a linear axis. In two partial plan drawings, Stirling studied first the alignment of the court in relation to the museum block. The court is moved up and down within a vertical band (Figure 5.2, Figure 5.3).

In the second complete plan drawing (Figure 5.4), Stirling introduced an abstract diagonal axial line representative of the public path going through the center of the sculpture court. This shows an effort to integrate the path and the court. In two small sections, Stirling sketched how the integration would work between the different levels of the upper terrace, the courtyard floor, and the lower terrace (Figure 5.5, Figure 5.6).

In the third complete plan drawing (Figure 5.7), the diagonal axial line becomes a dashed line, which intersects with a vertical axial line. Here, the path and the court are defined according to an integrated set of axial lines. The vertical axial lines determine the positioning of the court while the horizontal band indicates the horizontal positioning of the court. Another important feature of this drawing is the differentiation of line thickness for different areas of the building complex. The interior contour lines of the building are thickened as opposed to the outer contour lines. This marks an emphasis on the in-between space defined by the building blocks.

In the following three partial plan drawings, Stirling studied this in-between space (Figure 5.8, Figure 5.9, through Figure 5.10). In the third drawing of this series (Figure 5.10), Stirling studied only the upper terrace floor of the scheme. Here, the void, composed of terraces and the courtyard, becomes both a constitutive element of the scheme and also the core of the composition. This indicates how the central court became a focal area in the overall scheme when compared to the first plan drawing of this set in which the court is only one of the three equal spatial components of the scheme. Until now, each drawing furthers the abstraction process. In the last drawing, Stirling made a final complete drawing that is a re-configured arrangement of the interior spaces (Figure 5.12). Over the course of creating the drawings in the set, Stirling proceeded from a relatively detailed drawing to more and more abstract drawings and finally to a re-configured detailed scheme. The abstractive processes enabled Stirling to distill the detailed scheme to its basics, which in turn led to his reconfiguration of the overall composition of the path, the sculpture court, and the major spatial components.

Generic abstractions were produced by using conventional abstract diagrammatic features, such as axial lines, hatched vertical or horizontal zones, and differentiation of line thicknesses. All the other drawings in the entire collection of the archive, with the exception of the diagram from the second instance of abstraction, lack such abstract diagrammatic features.

In the first instance of abstraction, Stirling introduced the notion of a central court in relation to a path. In the second, he studied how the path and the court could relate to each other. In the third, he qualified this relation by devising a path that would accommodate both those who are passing through the building and those who would like to pause.

Discussion

Stirling's design team made use of generic abstraction

deliberately in their exploration. The designers devised procedures that would facilitate the abstraction process. The sketches were small so that they could easily be "inspected by the eye." They were on standard, semi-transparent sketch paper, to facilitate comparison through superimposition. Different types of lines in the renderings had specific meanings within the group, making communication efficient and the drawings less ambiguous. The basic line types consisted of dashed lines indicating circulation; continuous lines indicating spatial boundaries; axial lines, for spatial configuration;
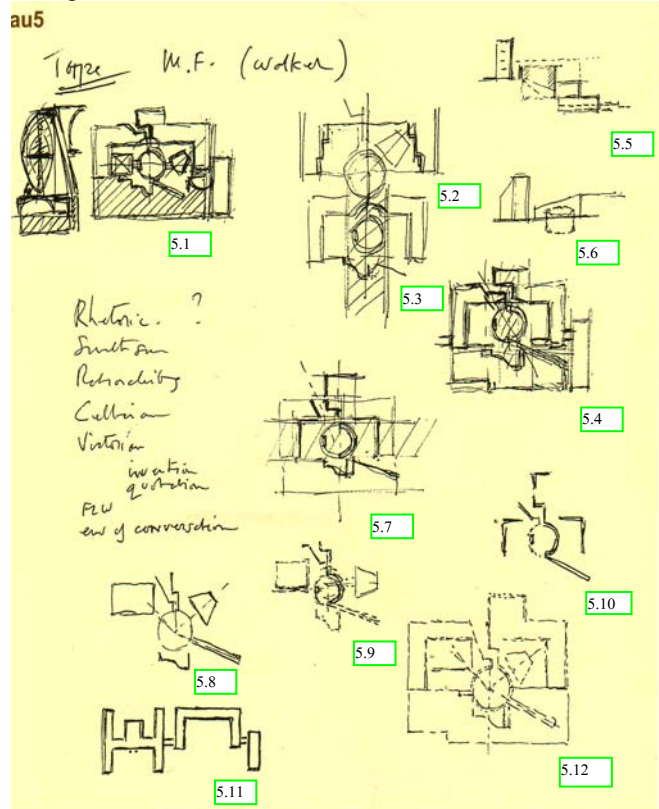

Figure 5: Progressive abstraction in Stirling's diagrams.
Published in A+U (1989).

and thicker lines for emphasizing spaces. The office also limited the color range in their drawings. Black ink was assigned to all designers, except the senior designer, who used red ink, especially when trying to reduce sketches to their "barebones". All of the above indicate a deliberate effort to facilitate abstraction and exploration in a collaborative design process.

The notion of a cognitive system is helpful for capturing the structured collaboration during the Staatsgalerie project (Hutchins 1995). The design progressed in a distributed fashion, involving the generation, manipulation, and propagation of representational states across media. Within the cognitive system junior and senior designers, as well as representations in the form of sketches and diagrams, performed distinct functions. The senior designer was in charge of leading the team by providing direction and integrating the various ideas of junior designers. The syntax

and semantics of representations were relatively unambiguous to the members of the design team (cf. Goel, 1995). Axial lines, hatching, and dashed lines designated specific abstractions. When these were in red they specified a clear direction for the design exploration by the senior designer.

On the one hand, the Staatsgalerie case study aligns with accounts of design cognition that also emphasize the centrality of sketches as the primary architectural representations in the process of discovery (Goel, 1995; Goldschmidt, 1991; Schön, 1992). On the other hand, it provides an alternative to views that single out the serendipity of discovery processes in design and the role of sketches at the expense of ignoring the more structured processes of discovery that are also evident in design. Researchers in design studies emphasize the view that designers often stumble upon new things while manipulating sketches, and benefit from them opportunistically (Cross, 2001; Cross & Cross, 1995). This no doubt happens with both expert and novice designers, however this fosters a view of designers as frantically doodling in hopes of suddenly discovering satisfying schemes. Our analysis highlights a process in which discoveries do not stem from reinterpretations of already existing visual marks in an unexpected manner (Suwa et al., 2000) but stem from deliberate efforts to attain insight by means of abstraction via drawing new generic diagrams representing a class of design schemes.

The Staatsgalerie design team explored a vast number of variations in the initial phases of design while they remained committed to a family of design schemes, yet this was neither an exhaustive search nor a linear search. It did not need to be exhaustive because the variations generated by the junior designers were occasionally summarized into generic schemes by Stirling, and they generated further, related variations.

The exploration was not linear because the team considered several variations more or less at the same time, which facilitated comparisons of different schemes. Some sets of sketches for the Staatsgalerie project, for instance, show a vast number of variations studied together. Others, which show a detailed rendering of one variation, have smaller sketches accompanying them, suggesting that the designers were considering related variations simultaneously and sometimes going back to a previous variation. In other sketches, drawings and layers are superimposed again suggesting an iterative rather than linear exploration. The designers considered several different schemes, compared them to each other, and sometimes jumped back and forth between schemes.

Our case study illustrates a series of shifts in design conception that occurred through progressive abstractions that would be difficult to account for as serendipitous discoveries. Although we cannot detail more cases here, from our investigations this is not an atypical instance of discovery in design (Dogan & Nersessian, 2005).

Studies of scientific discovery, too, have shown the importance of generic abstraction as a means of structured exploration leading to creative outcomes. Nersessian (1999, 2008) proposes that generic abstraction facilitates building mental models that embody commonalities across seemingly dissimilar domains in scientific reasoning such that inferences derived from the specific models used in an exploration can be understood as applying to members of classes of phenomena (Nersessian, 2008). As Nersessian notes, taking an example from Bishop Berkeley, one cannot imagine a triangle-in-general, but only a specific instance. However, in making inferences about triangles in general, we are able to suppress the specific lengths of the sides and degrees of the angles of the specific instance. Similarly, in design it is possible to infer or derive multiple variations from a specific representation of a generic abstraction that has wider applicability.

Further, research in other areas of cognitive science lends support to our argument. Gattis and Holyoak's research on graphs (1996), e.g., provides one explanation for why abstraction could be important. They compared the effectiveness of graphs that have a higher pictorial correspondence with what is represented to graphs that preserve the correspondence at a more abstract level. Their results suggest that abstract representations of conceptually important features have significant advantages for making inferences. In Stirling's second case of abstraction (Figure 4), for instance, the progression from a relatively more realistic representation of the path to a more abstract representation of the idea of movement indicates an effort to emphasize the conceptually important features and align the attention of the design team on these.

An additional reason for the gradual abstraction of design schemes might relate to the ease of manipulation of the perceptual features of diagrams when they are simplified. In the Staatsgalerie, once design ideas were abstracted and associated with perceptual features of diagrams, manipulation of their perceptual features could facilitate manipulating features of a corresponding mental model, enabling the designers to simulate potential pathways. Through step-by-step abstraction Stirling could be interpreted as not only reducing the details of the drawings but also simulating a series of complex connected spaces. This point is clearer in diagrams from third case of abstraction. In this series Stirling abstracted elements of the design one at a time, as if he were simulating each element of the scheme at each stage of abstraction. Such piecemeal abstraction is similar to the notion of piecemeal animation of diagrams of complex mechanical systems, in which only parts of the system are animated at any given time (Hegarty, 1995). Narayanan (1995) and Qin and Simon (1995) also suggested that piecemeal manipulation of diagrams facilitate making inferences from complex mental models.

Finally, Greeno (1989) offers direction for developing a theoretical basis for understanding how manipulating diagrams can serve to facilitate transformations of mental models. He introduces a view of semantics in which

structured systems of symbolic notations are mapped to structured systems of objects and events, and he suggested that inferences are possible through manipulation of either system. On his account, mental models are structured systems of symbolic notations and correspond to structured systems of objects and events in the form of physical models. Any transformation in the physical model, therefore, can create a corresponding transformation in the mental model. The third abstraction in the Stirling case provides evidence that through manipulating the physical features of the diagram Stirling altered his corresponding conceptualalization. Reasoning via generic abstraction enabled the designer to think of the central court both as a focal and stopping point along a trajectory of movement.

Conclusion

The design of the Staatsgalerie was a coordinated effort among a team of designers. Ideas were exchanged through simplifying and abstracting representations through re-sketching. These processes enabled the design team members to identify the salient features of their schemes and formulate them in generic diagrammatic representations. Generic abstraction by means of diagrams facilitated aligning and propagating design commitments in the distributed collaboration.

The case illustrates a design process which evolved not through serendipitous discoveries in sketches but through generic abstractions and variations derived from these abstractions. We identified three such instances of generic abstraction in the case study: the first when the designer transferred the main generic components of an earlier project, the second and third when the senior designer abstracted the main design issues from variations produced by the junior designers. The generic design abstractions defined a family of design schemes which helped the designers remain committed to a set of designs. The variations considered could in turn be compared to each other for final decision making. Finally, the generic abstractions in the form of diagrams potentially helped the designers to mentally simulate different spatial components, especially the trajectories of possible movements through the physical space, which lead to the generation of a novel design conceptualization. The findings and conclusions from this study, however, needs to be further investigated in other case studies and more controlled studies to see the extent to which generic abstractions are used by designers.

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