Intentions in and relations among design drawings

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Designers use drawings to explore alternatives and to test ideas. We report here on two studies on design and drawing. The first study of design drawing symbols aims to determine whether and to what extent it is possible to infer, interpret, or even guess what a designer was thinking about by looking at the drawings she has made. In the second study we examined a collection of drawings for the design of a house to investigate the systems of design transformations. Drawings are characterized by drawing style, projection type, and key elements. We analyzed the relationships among the drawings and developed a notation system for documenting these relationships.

Keywords: drawing(s), architectural design, case study/studies, design activity, design research

We wish to understand the roles that diagrams and sketches play in designing, with the goal of building computational environments that better support designing than those in current use. By diagram we mean a drawing that uses geometric elements to abstractly represent natural and artificial phenomena such as sound and light; building components such as walls and windows; and human behavior such as sight and circulation, as well as territorial boundaries of spaces. In contrast, a sketch is mainly about spatial arrangements of physical elements. Despite these general differences, we do not draw clear-cut distinctions between diagrams and sketches, as a particular drawing may combine the two representations. We describe here two distinct studies of architectural design

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practice that we have performed in order to understand these roles. The first study analyzes the graphic symbols architects draw as they engage with different concerns in a design problem. The second study examines the types of graphic representation made by an architect in the conceptual exploration of a design, and illustrates a scheme we developed for coding relationships among the sketches and diagrams made in the course of this exploration.

Studies of diagrammatic reasoning and design drawings have become of increasing interest to cognitive scientists, artificial intelligence workers, and researchers in design studies. Researchers in these fields have argued that drawing is important to design as an external representation that helps in solving problems and generating ideas. The roles that researchers ascribe to diagrams and drawing in design include:

- generating concepts;
- externalizing and visualizing problems;
- organizing cognitive activity;
- facilitating problem solving and creative effort;
- facilitating perception and translation of ideas;
- representing real world artifacts that can be manipulated and reasoned with;
- revising and refining ideas.

Studies of thinking with diagrams often take one of two stances. The first is that diagrams are external evidence of an internal thinking process and serve as valuable clues to reveal its functioning. The second stance is that diagrams and diagram-making are an inherent part of the thinking process, thus a 'medium of thought'. Researchers also differ on whether design drawing is essentially a symbolic process—each drawing mark corresponds to design elements or concepts—or if non-symbolic modes of thinking come into play.

Larkin and Simon argue that a diagram is a representation created to externalize and visualize problems[1], and that certain observations about a problem are more easily available in a diagram. Chandrasekaran, Narayanan, and Iwasaki[2] note an emerging consensus that diagrams function as an aid in organizing cognitive activity. Blackwell's 'Diagrams about thoughts about thoughts about diagrams'[3] reviews work in experimental psychology (e.g., [4–6]) that understands a diagram as a notation that provides information and clues about intention in a visual form. Fish, in 'How sketches work' argues that sketches are representations of 'visual thought' that help facilitate perception and translation of ideas[7].

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2 **Candrasekaran, N, Narayanan, H and Iwasaki, Y** 'Reasoning with diagrammatic representations' *AI Magazine* Vol 14 No 2 (1993) pp 49–56

3 **Blackwell, A F** 'Diagrams about thoughts about thoughts about diagrams', in **M Anderson** (ed.) *Reasoning with diagrammatic representations II: AAAI 1997 Fall Symposium*, AAAI Press, Menlo Park, CA (1997) pp 77–84

4 **Goodman, N** *Languages of Art: An Approach to a Theory of Symbols*, Oxford University Press, London (1969)

5 **Bertin, J** *Graphics and Graphic Information Processing*, Walter de Gruyter, Berlin (1981)

6 **Ittelson, W H** 'Visual perception of markings' *Psychonomic Bulletin and Review* Vol 3 (1996) pp 171–187

7 **Fish, J C** *How Sketches Work—A Cognitive Theory for Improved System Design* (PhD dissertation), Loughborough University of Technology (1996)