

Constructive Perception: An Expertise to Use Diagrams for Dynamic Interactivity

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Diagrams Provide Dynamic Interactivity

By diagrams, we mean diagrammatic representations people use externally to their mind. They include pictures, sketches, charts, graphs and scribbles on napkins. Past literature (e.g. Anderson, Meyer and Olivier Eds, 2002) indicated that diagrams play facilitatory roles in inference and problem-solving; they reduce working memory load, serve as retrieval cues to evoke relevant information that might not otherwise be retrieved, promote inference by enabling perceptual judgements, and/or provide visuo-spatial cues for proper understanding of the structure of a problem. To serve these functions, the interpretation of the diagram needs to be static; it must stay the same in order not to introduce error in the operations performed from the diagram.

However, what diagrams could provide is not limited to such static interactivity. Rather, people using diagrams are encouraged to interpret them dynamically; the same appearance of parts of a diagram, especially when the diagram is vague and ambiguous, could evoke different interpretations at different times, dependent on what other elements surround the parts in focus at the moment or what the person has been thinking of. The situated cognition view (e.g. Clancey, 1997) corroborates this phenomenon. Dynamic interactivity of this sort afforded by diagrams is beneficial because it often enables dynamic construction of new thoughts on the fly in a situated manner.

A typical situation is design. Designers draw freehand sketches, often vague and ambiguous ones, and thereby see new features and relations among elements that they have drawn, ones not intended in the original sketch (Schon, 1983). These unintended discoveries promote the dynamic construction of new ideas and refine current ones. In recent years, we have explored ways that designers use sketches to dynamically construct design thoughts. Using the technique of protocol analysis, we examined the cognitive processes of experienced designers as they design through sketching. These protocols showed that the discovery of unintended perceptual features in sketches becomes a significant impetus for the generation of new ideas. Moreover, the generation of new ideas, in turn, was likely to become an impetus for further discovery of unintended perceptual features, so that each component process drives the other (Suwa, Gero and Purcell, 2000).

Constructive Perception to Benefit from Dynamic Interactivity

Dynamic interactivity, however, is by no means automatic when a diagram is available. To make it happen in using

diagrams requires some cognitive skill, i.e. what we call constructive perception. By constructive perception, we mean self-awareness of the ways that perception underlies interpretations of diagrams. The self-awareness allows searching for other ways to perceive, enabling reorganization of the diagram to promote novel interpretations. We have found that this skill is useful in two different domains (Suwa, Tversky, Gero and Purcell, 2001). One is the design domain. During a conceptual design process, an experienced architect was likely to make unintended discoveries when he reorganized perception using this skill voluntarily. The other is in the task of multiple interpretations of ambiguous drawings. Novices instructed about this skill generated more interpretations from a single ambiguous drawing, and exhibited slower rate of decline of generation of interpretations over time, than those not instructed. Moreover, we have found that experienced designers are superior to laypeople in this skill (Suwa and Tversky, 2001). These findings raise two issues, one cognitive and the other didactic. What constitutes the expertise of constructive perception? How can people be trained to use it? Research on these will promote successful use of diagrams in people's intellectual activities, e.g. in learning environments.

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