Conceptual Diagrams: Representing Ideas in Design

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Studies in cognition [1, 2] have investigated the role of external visual representations in different domains in supporting reasoning, problem solving, and communication. These studies often are confined to domains that pose relatively well-defined problems [3], such as geometry [4] and physics [2], with fewer studies in domains where the problems are ill-defined [3], such as meteorology [5] and architecture [6].

In many studies of well-defined problems, diagrammatic representations illustrate either causal or temporal relationships between parts of entities and phenomena that the diagram represents. In architecture, diagrams are used to represent causal relationships, such as with orientation diagrams, or temporal relationships, such as with circulation diagrams. There is, however, another kind of diagram that is used to represent the main idea or the core of a design. We call these diagrams *conceptual diagrams*. They differ, potentially, from other diagrammatic representations studied thus far in that they represent an abstract conceptualization of a potential problem solution.

Diagrams in other fields can be interpreted as conceptual diagrams as well, such as a diagram that shows the electron orbiting around a nucleus in atomic physics, or the supply-demand diagram in economics. In the domain of scientific discovery, Nersessian [7] has shown how the use of conceptual diagrams helped Maxwell to construct and communicate his representation of the electromagnetic field concept.

Conceptual diagrams are abstract representations that embed the core of a conceptualization of a problem solution. They are concise, yet powerful aids in problem solving in that they provide high-level commitments constraining solutions. In architecture, they embed the core of a design solution encapsulating its *generic* characteristics and constraints and conveying the form of possible *specific* solutions. That they are not detailed prevents early commitment to a specific design solution and, thus, they facilitate exploratory reasoning. At the same time they are not ambiguous in the way sketches are in that they fix meaning and define a set of related solutions.

This latter is important because design problems are ill-defined in that either the initial state, the goal state, or the operators--or all of them--require further specification. With ill-defined problems there exists a set of potential goal states instead of one goal state. One way that architects delimit the range of alternatives is by analogy. Conceptual diagrams function in a way similar to analogies in that they provide constraints that restrict the set of specified goal states.

We propose salient characteristics of conceptual diagrams that are significant for

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design cognition. First, as abstractions, conceptual diagrams provide idealizations that represent complex ideas in a simple and easily communicable and retainable form. Second, they can represent spatial, functional, or formal relationships. These two characteristics make them important in collaborative design problem solving and communication with the client. Third, they are easier to transform into final design solutions than conceptualizations represented verbally, in part, because conceptual diagrams are in the same representational mode as the end product of designers. We will now consider two examples illustrating the use of conceptual diagrams in design.

The first example is from an expert designer, Louis I. Kahn. Kahn formulated a design theory that held that a designer first finds a "conceptual idea" and then implement the idea in different schemes. The conceptual idea remains constant whereas the implementation changes. In one of his projects, the First Unitarian Church of Rochester, Kahn drew a conceptual diagram at his first meeting with the client (Figure 1).

This diagram conveys in generic form Kahn's conceptualization of the problem and of potential solutions. It consists of concentric circles that represent how different spatial components of the church building relate to each other. The main idea here is that all the components of the design are to be in a concentric relationship, i.e., they are defined in reference to the center that Kahn in another speech defined as the locus of contemplation. He described his concept as follows:

Fig. 1. Kahn's concept diagram

> A chapel, to me, is a space that one can be in, but must have excess of space around it, so that you don't have to go in. That means, it must have an ambulatory, so that you don't have to go into the chapel; and the ambulatory must have an arcade outside, so that you don't have to go into the ambulatory; and the object outside is a garden, so that you don't have to go into the arcade; and the garden has a wall, so that you can be outside of it or inside of it. [8, p. 86]

Kahn's conceptual diagram was crucial in communicating his main idea to the client. The client in turn used this concept to assess different schemes proposed by Kahn. It supported collaboration in that it assisted the client to see the problem and to contribute to the definition of the problem.

The second example is from a student's design project. The project asked students to integrate a leftover space on a university campus into its surrounding. The final presentation included a conceptual diagram and also two photographs that embed the conceptualization of possible design solutions (Figure 2).

Fig. 2. The diagram on the right represents the design concept.

The top photograph shows a group sitting around a circle, illustrating that the student views the problem as a problem of gathering of people around a common object. The bottom photograph shows an outdoor theater representing a precedent solution. His conceptual diagram is of a central circle and several tangent lines to the circle. The circle represents the central area of focus that gathers people around whereas the tangent lines represent the lines of flow that connect the area of focus to its immediate surroundings. The diagram helped the student to convey his main idea to the jury members and facilitated their comments and contributions to his design.

In conclusion, we have presented two examples of conceptual diagrams. In these examples the conceptual diagrams embed generic conceptualizations of solutions that constrain the possible allowable designs. Designers in both cases used the conceptual diagram to convey an idea, as well as employing it in their further problem solving. In Kahn's case, it ensured a commitment to the generic concentric composition, while allowing further explorations. In the second case, it enabled the student and the reviewers to form a shared understanding of the conceptualization behind the solution.

The study of conceptual diagrams has implications for understanding collaborative problem solving and for enhancing design education. In collaborative problem solving, conceptual diagrams make it easy to communicate and grasp the central ideas constraining the range of problem solutions under consideration. If used more extensively in architectural education, conceptual diagrams could serve to encourage students' self-reflections on high-level commitments in their design processes. Research into conceptual diagrams promises new insights about the role of diagrams in different contexts and, more generally, of external representations in cognition.

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