

## Visualizations, Maps, and Symbolic Development

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I am a developmental psychologist by training, and for most of my career I have focused on the development of children's understanding of symbols. I am interested both in how children come to understand symbols and in the cognitive consequences of symbol use. I have found that studying children's developing understanding of maps provides a window onto both issues. In addition, maps are perhaps the historically earliest and most frequently used form of visualization. Therefore, research on map use may be directly relevant to understanding how students' comprehension of visualizations. For these reasons, much of my experimental work has been on the development of children's understanding and use of maps.

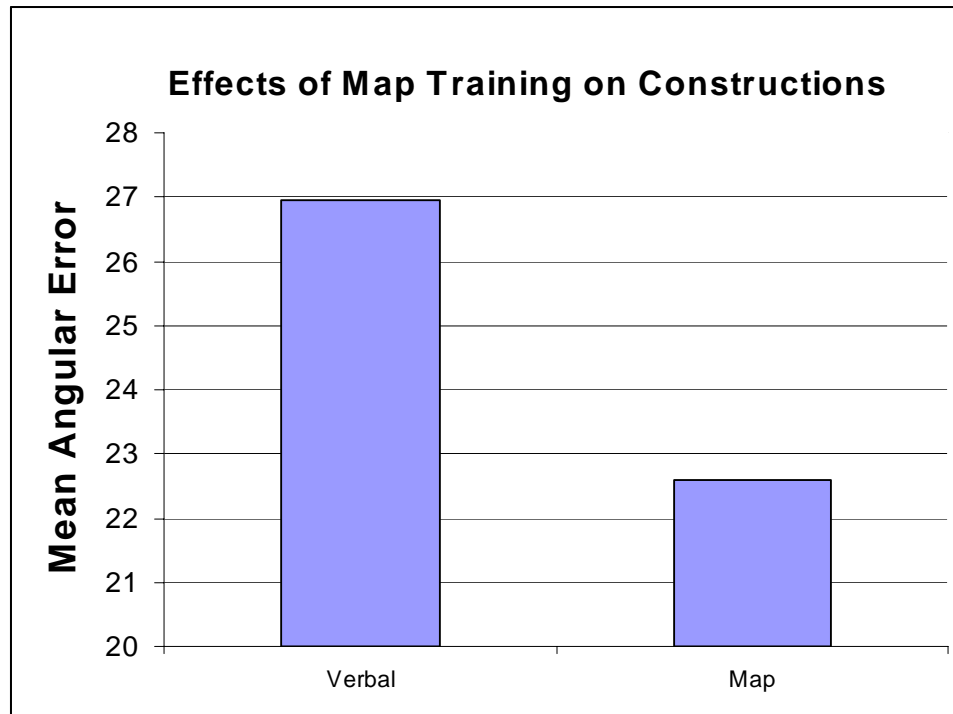
In this essay, I first report on a study that I am currently conducting that illustrates the kind of research that I do. I then discuss the relevance of my research to work on understanding of visualizations. I end with a call for research on students understanding of visualizations, arguing that there is an important opportunity for synergistic collaborations

*Sample Research...* With the help of Clare Davies (Davies & Uttal, 2003), I have studied how using a maps can affect children's developing conceptions of a familiar space, their neighborhood. Our specific focus is on whether studying a map helps children to think about spatial information in a manner that transcends how the information has been experienced. Put simply, does looking at a map help children to acquire survey-like knowledge of their neighborhoods? We studied children's knowledge of their neighborhoods because this provides a strong test of the idea that maps can influence children's thinking. We expected that children (ages 7 to 10) would already be familiar with their neighborhood. The question of interest was whether studying the maps could change *how* the children thought about and mentally represented the spatial relations among familiar landmarks.

We began in pilot testing by assessing children's familiarity with a set of potential landmarks. Our goal was to winnow a list of approximately 40 landmarks to a much smaller set of approximately 18 landmarks. We chose those landmarks that most children were familiar with as those that would appear in the main study.

We began the main study with a baseline of assessment of children's familiarity with the landmarks and of their knowledge of the relations among them. For example, we took children on a walk of the neighborhood and asked them to point to out-of-sight landmarks. After the baseline assessments, the children were assigned to either the *map* or *verbal* group. The map group studied maps of the neighborhood at the next two sessions. The verbal group provided a control for the effects of learning from the map. These children received extensive training about the locations, but they did not study a map. For example, we described the landmarks in detail, showed pictures, and asked the children about routes they might take between the landmarks.

The results show a substantial effect of exposure to the map on children's cognition of the large-scale neighborhood. As shown in the figure below, the children who saw the map were better able, for example, to construct map like representations, even for landmarks that were not included on the maps.



In other situations, however, the results interacted with the sex of the subjects. For example, for tasks that involving pointing to unseen locations differed substantially by sex. While boys benefited substantially from the map view, girls on the other hand actually benefited more from the verbal instructions.

*Application to Visualization Research.* My interest in natural science visualizations grew out of a conference on spatial thinking in chemistry that I attended a few years back.. I was struck by similarities in how novice chemistry students understand complex images and children's understanding of simpler visualizations, such as scale model or maps. In both cases, people must learn to view information in a new way. The assumption often has been that visualizations work by providing direct access to key spatial information that may be unobservable otherwise. But my work in symbolic and spatial development led to a different perspective, which is that even seemingly simple visualizations are symbolic representations, and neither students nor young children can be expected to “see through” the visualizations to the underlying concepts. I am interested in how students construct an understanding of what the visualization may represent.

Rather than viewing visualizations as an educational panacea, I see them as a powerful

tool that must be carefully matched to the user's level of understanding. Research on the development of symbolic understanding may be highly relevant to this endeavor. The results of several studies (e.g., DeLoache, Kohlstad, & Anderson, 1991) suggest that physical similarity is particularly important in early understanding of symbolic relations. If a map or model does not look much like the space that it represents, then children may have great trouble using it as a spatial representation. But at the same time, similarity may be something of a cognitive “trap”. Children often assume that the map or model *must* look like the object it represents, even when the correspondences are arbitrary and symbolic. This finding may have direct implications for understanding students' confusion in comprehending colors in using new visualizations in chemistry, the geosciences, or other natural sciences. If students continue to believe that the color of a symbolic representation must match its intended referent, then they may have difficulty understanding the abstract, symbolic correspondences that are entailed in using visualizations. Highly attractive and visual compelling images may actually be a dual-edged sword; vivid images may lead students to believe in correspondences that do not exist.

In attending this conference, I hope to move forward with establishing collaborations for research on the process of understanding scientific visualizations from the standpoint of symbolic development. I am interested in collaborating with researchers and educators in the geosciences and chemistry to establish a research program on the development of students' understanding of visualizations. I think such a program of research would be beneficial from an educational perspective, and it would also provide a forum for testing theoretical ideas in developmental and cognitive psychology.

#### References.

Davies, C., & Uttal, D. H. Influences on Children's Large-Scale Spatial Cognitive Strategies: How Using Spatial Symbols Affects Children's Knowledge of their Neighborhoods. Paper presented at the meetings of the Cognitive Development Society, Park City, Utah. October, 2003.

DeLoache, Judy S; Kolstad, Valerie; Anderson, Kathy N. Physical similarity and young children's understanding of scale models. *Child Development*. Vol 62(1) Feb 1991, 111-126. Blackwell Publishers, US