Spatial Thinking

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Spatial thinking is not unitary but rather a complex of skills that not only can be cultivated but must be. Spatial thinking is key not only to professional life but also to everyday life, to understanding and using the multitude of maps, graphs, sketches, diagrams, and spatial descriptions, concrete and abstract, needed to carry on the business of life. Despite difficulties that children and adults have in aspects of spatial thinking, it is rarely taught.

Spatial thinking in various instantiations has occupied my research for years: objects, bodies, the space around the body, the space of navigation, the spaces people create to augment their own cognition and well-being. Putting ideas on paper, in sand, on stone, are ancient means for remembering, conveying, and manipulating ideas, concrete, like maps, and abstract, like mandalas and diagrams. We have studied the natural mappings people construct using place in space, horizontal, central, vertical, and simple marks in space, like dots, lines, arrows, blobs and configurations of them to represent structures, such as maps, buildings, and networks, as well as processes, such as explanations of how to do something or how something works. We have also studied how people interpret and understand visual expressions of thought and related diagram production and use to spatial abilities. Those high in mental rotation, for example, not only produced better diagrams for explaining processes but also more effective language for explaining processes (e.g., Daniel and Tversky, 2012). By contrast, those adept at finding embedded figures were better at finding new interpretations in ambiguous sketches, a component of creative thinking (e.g., Tversky and Suwa, 2009).

What if there is no paper? People draw in the air, that is, gesture. Like diagrams, gestures spatialize both concrete and abstract structures and processes using virtual marks in a created space. In two sets of studies, students, alone in a room, read descriptions of spatial problems and attempt to solve them (Kessell and Tversky, 2006; Jamalian, Giardino, and Tversky, 2012). Many of the students gesture while reading the problems and their gestures structure the spatial situation described. Those who gesture are more successful at solving the problems. Gestures can be incorporated into computer modules for teaching. Children’s performance in mathematics was enhanced when the gesture actions were congruent with the thought actions (Segal, Tversky, and Black, submitted). In particular, addition was better with discrete gestures and number line estimation was better with continuous gestures.

Viewed gestures can also facilitate student learning if the gestures correspond to thought. Kang, Tversky, and Black (2012) used the same diagram and verbal script to teach the workings of an engine. Half the students saw gestures showing structure, half saw gestures showing action. Structure is usually easier to grasp than action, and both groups did well. The group who had
viewed action gestures performed better on action questions and conveyed more action information in their subsequent visual and verbal explanations, inventing their own gestures to do so. Jamalian and Tversky (2012) found that viewed gestures changed the ways people thought about time, specifically, understanding cyclicity, simultaneity, and temporal perspective.

Encouraging spatial thinking is easy to adopt in classrooms and has immediate benefits on student learning. Bobek and I (in preparation) taught junior high students lessons in chemical bonding and mechanical thinking. They were first tested, and then asked to construct either a visual or a verbal explanation of the processes, followed by a second test. All students improved on the second test without intervening teaching. Those who constructed visual explanations improved far more. In our view, the visual explanations were superior because they can map the processes to space. Diagrams provide a check for completeness, a check for coherence, and a platform for making inferences from structure to process. They also provide useful feedback for teachers.

Children (and adults) need to learn structure and process in many domains, STEM, history, literature, and more. Spatializing thought through diagram and gesture can be easily incorporated into the classroom, with clear benefits.