How Does Spatial Thinking Contribute to the NRC Framework for K-12 Science Education?

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How does the recent National Research Council (NRC) Framework for K-12 Science Education, Practices, Crosscutting Concepts and Core Ideas (2012) reflect the value of spatial thinking? Any NRC report on science education tends to be a barometer of how education experts in scientific disciplines in academia would like to see future pedagogy. Moreover, this national Framework, the first since 1995, serves as a basis for a future set of science standards in preparation by the National Science Teachers Association. Therefore it is important to consider how consistent it is with the goal of promoting spatial thinking in the undergraduate curriculum.

Advocates for the importance of spatial thinking across the undergraduate curriculum must promote the case that spatial awareness enables students to analyse and represent their understanding across domains. For example, The National Research Council (NRC) report on Learning to Think Spatially (2006) presented compelling examples of the significance of spatial thinking in discovery and understanding in the science disciplines, building the case those students in K-12 schools can improve their achievement in science by demonstrating spatial literacy. Has that argument been convincing for the panel members of this new report?

The NRC Framework structure
The Framework, as the title implies, includes three main sections. Listed below are the main topics in the first section of the report. Both Practices and Crosscutting Concepts are presented before the third section on Core Ideas, countering the traditional focus on disciplinary knowledge as the key component of science curriculum. However, the report defines the word practice as a combination of skills and knowledge, thus reintroducing the importance of factual information.

Scientific and Engineering Practices
1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
Clearly the focus on models (#2) assumes the ability to employ spatial thinking, especially as it includes 3D modeling. The report claims that students will learn how to ‘construct drawings or diagrams that represent processes or models’. However that statement is made without any explicit reference to the contribution of spatial thinking. Nor do any of the titles in this list address the role of spatial analysis in scientific and engineering practices.

**Crosscutting Concepts**

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change

The list of Crosscutting Concepts includes several topics fundamental to the “Concepts of Space, Tools of Representation and Processes of Reasoning” that were outlined in the 2006 report and the fact that Patterns is the first on the list clearly seems to raise the profile of spatial thinking. Closer examination of this section raises questions about that link:

*Patterns: Observed patterns of forms and events guide organization and classification and they prompt questions about relationships and the factors that influence them.* (p.84)

Compare this brief outline with the analysis of the components of pattern observation listed in the NRC report on spatial thinking (Hochberg, 1978).

- Distinguishing figures from ground
- Recognizing patterns, both outline shapes and internal configuration
- Evaluating size
- Discerning texture
- Recognizing color
- Determining other attributes

This contrast may be explained by the fact that authors of this Framework do not focus on how K-12 students will learn the highlighted practices and crosscutting concepts, leaving that task to the group of practitioners who are charged with developing the new standards for science teaching.

However, the Framework does specify that students will be able to represent and explain scientific phenomena with multiple types of models and with accurate scale, proportion and quantity, assuming implicitly that somehow students will learn how to demonstrate those skills. This example illustrates how little of the specific focus of *Learning to Think Spatially* has made its way into this new document and presents a challenge to those who want to promote the value of explicit instruction on spatial thinking.