Supplementary material to “How Geoscientists Think and Learn”

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Citation:

Notes on Sources
The work of the Synthesis of Research on Thinking & Learning in the Geosciences Project has been carried out through an extensive literature review, a virtual Journal Club, a web-based system for sharing manuscript drafts and internal reviews, a week-long writing retreat at Black Rock Forest in Cornwall, NY, and one-to-one collaboration between two-person writing teams each comprising one geoscientist and one cognitive/social scientist. In this online supplement, we document the main human, print and web resources that provided direct input to the EOS article. The individuals cited below participated in structured discussions with the Synthesis group as either
members of the virtual Journal Club or as Discussants at the writing retreat. A far larger group of colleagues have informed our thinking through informal discussions.

One of the products of the Synthesis project is an online annotated database of print and on-line resources relevant to the Synthesis themes of geological time, spatial thinking, systems thinking and learning in the field. The database and other information about the project can be accessed at http://serc.carleton.edu/research_on_learning/synthesis/ (click “Browse Synthesis Resources.”) Papers cited below are sources for specific ideas or findings in the EOS article. However, our thinking was informed by the larger group of resources in the database, especially our prioritization of what insights to showcase in this overview article.

**Introduction**


**Thinking about Time**

Jeff Dodick, Stephanie Pfirman, Tim Shipley and Michael Tabor contributed to the Synthesis group discussions of geological time and temporal thinking.

- **Deep time is important for broader population**: Zen, E.-a., What is deep time and why should anyone care?, *Journal of Geoscience Education*, 49 (1), 5–9, 2001.
Patrick Louchouarn, Stephanie Pfirman, Michael Piburn and James Slotta contributed to the Synthesis group discussions of complex systems and systems thinking.

- **Water cycle for K-12:** [http://ga.water.usgs.gov/edu/watercycle.html](http://ga.water.usgs.gov/edu/watercycle.html)

**Field-based learning**

Eric Riggs, Tim Shipley and Michael Tabor contributed to the Synthesis group discussions of field-based learning.

- **Students’ inscriptions in field-based learning:** Roth, W.-M., Where is the context in contextual word problems?: Mathematical practices and products in Grade 8 students' answers to story problems, *Cognition & Instruction, 14*, 487–527, 1996.
Spatial Thinking
Ben Jee, Yael Kali, Michael Piburn, Stephen Reynolds, Tim Shipley, and Michael Tabor contributed to Synthesis group discussions of spatial thinking in Geosciences.


- **Phase diagrams for mineral composition**: good examples are at: [http://serc.carleton.edu/research_education/equilibria/ternary_diagrams.html](http://serc.carleton.edu/research_education/equilibria/ternary_diagrams.html)


- **Formal education lack of attention to spatial**: National Research Council 2006, *op. cit.*


Community of Practice
Richard Duschl provided insights on including mastery of scientists’ professional practices as an important learning goal for science education.


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Illustration by Linda Pistolesi, Lamont-Doherty Earth Observatory.


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(d) after Titus, S., and Horsman, E., in press, Characterizing and improving spatial visualization skills, Journal of Geoscience Education. Used with permission.

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