An interdisciplinary approach to building students' spatial thinking skills from high school through college

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There is a large gap between the ability of experts and students in grasping spatial concepts and representations. Engineering and the geosciences require the highest expertise in spatial thinking, and weak spatial skills are a significant barrier to success for many students [1]. Spatial skills are also highly malleable [2]; therefore, a current challenge is to identify how to promote students' spatial thinking.

Interdisciplinary research on how students think about spatially-demanding problems in the geosciences has identified several major barriers for students and interventions to help scaffold learning at a variety of levels from high school through upper level undergraduate majors. The Geoscience Education Transdisciplinary Spatial Learning Network (GET-Spatial; http://serc.carleton.edu/getspatial/) is an NSF-funded collaboration between geoscientists, cognitive psychologists, and education researchers. Our goal is to help students overcome initial hurdles in reasoning about spatial problems in an effort to diversify the geoscience workforce.

Examples of spatial problems in the fields of geochemistry include scaling, both in size and time; penetrative thinking to make inferences about internal structures from surface properties; and graph-reading, especially ternary diagrams. Understanding scales outside of direct human experience, both very large (e.g. cosmochemistry, deep time) and very small (e.g. mineralogy, nanoparticles) can be acutely difficult for students. However, interventions have successfully resulted in improvements to scale estimations and improve exam performance [3].

We will discuss best practices for developing effective interdisciplinary teams, and how to overcome challenges of working across disciplines and across grade levels. We will provide examples of spatial interventions in scaling and penetrative thinking.

[1] Hegarty *et al.* (2010) *in* Spatial Cognition VII **6222**, 85-94. [2] Uttal *et al.* (2012) *Psychology of Learning and Motivation* **57**, 147-181. [3] Resnick *et al.* (2016) *Educational Psychology Review*, 1-15.