Bringing Research on Learning to the Earth Sciences:

A NSF and Johnson Foundation Workshop Report

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Why is it Important?

Advances in the science of learning have reached the stage where application to educational practice can have a major impact on student learning (How People Learn, NRC, 2000; Knowing What Students Know, NRC, 2001). To apply these results in the geosciences we need a geoscience learning community that can adapt general research results to the specifics of geoscience education and address the research problems specific to the geosciences.

What are the Issues?

Six central issues were identified as of high importance to geoscience education.

1. What are the goals or desired learning outcomes of instruction in the geosciences?
2. What methods are effective in helping students understand time and spatial scales?
3. What strategies will help undergraduates become comfortable with the complex representations common in the geosciences?
4. How do scientists learn about and understand complex systems? How can this expertise be developed in students?
5. How do geoscientists combine knowledge from observations, experiments, and theory to create knowledge? How can this expertise be developed in students?
6. What types of instruction and learning environments work well for the geosciences?

A New Research Agenda

Research is needed in three broad areas:

1. What characterizes expert cognition in the geosciences?
2. How do we facilitate learning that leads to this expertise?
3. How do we effectively design learning environments to support geoscience learning?

Topics that are ripe for study include

- **Visualization**: how do people look at, interpret and describe geoscience images
- **Representation:** how do we understand and represent things abstract, unseen, and beyond everyday human experience
- **Space:** how do we effectively teach the spatial reasoning skills fundamental to studying the Earth (e.g. distance, shape)
- **Learning in the field**: how do people observe, interpret, and draw conclusions from natural systems
- **Deep time**: how do we effectively teach about deep time, rates, and the importance of history in the evolution of the earth
- **Expert-novice relationships**: what characterizes geoscience expertise; how do geoscientists learn things and draw conclusions
- **Complex systems**: How do we teach and learn about complex systems
- **Models**: How do we teach about models and use them to learn about the Earth (creation, use, analysis)
- **Evaluation** of learning, methods, teaching environment

What needs to be done?

Dissemination: Currently, geoscientists are not fully aware of the advances in learning science that are relevant to their teaching. Materials need to be created and disseminated that present these results in a context that is accessible to geoscience faculty and makes a compelling case for adoption.

Professional development: Capacity needs to be developed for research on learning in the geosciences. Professional development opportunities that bring together geoscientists, educators and learning scientists are a fundamental aspect of this capacity building, as are opportunities for faculty to to develop their capacity to observe student learning, design and evaluate their teaching practices.

Research: New research that addresses areas of high interest to both geoscientists and learning scientists will have major benefits in both fields improving the ability of geoscientists to both pursue their own research and to instruct their students while providing new avenues to address important issues in understanding human cognition and learning.

A workshop report: A geoscience learning science community will require contributions from geoscientists, geoscience educators, learning scientists and those working to apply learning science to other disciplines. This summer a workshop at the Wingspread Conference Center funded by the National Science Foundation and Johnson Foundation brought together 24 leaders from these groups to initiate the development of a community engaged in applying learning science to the geosciences. For further information on the conference visit the website:

serc.carleton.edu/research_on_learning/workshop02/