Pedagogy and the Geosciences

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DBER: Discipline-Based Education Research

DBER goals:

• Understand how people learn concepts, practices, and ways of thinking of science and engineering;
• Understand the nature and development of expertise in a discipline;
• Identify and measure appropriate learning objectives and instructional approaches that advance student learning;
• Contribute to the knowledge base to help guide DBER findings to classroom practice;
• Identify approaches to make science and engineering education broad and inclusive.

DBER Research Programs at US Institutions (n=178)
Physics = 89
Chemistry = 35
Biology = 40
Geoscience = 14

Reaching students, 2014, Kober, National Academies Press.
**WHAT DBER TELLS US ABOUT STUDENT LEARNING**

1. *Students learn key concepts better when they actively monitor their understanding in a variety of activities inside and outside of class (designed, structured activities).*

2. *Students become better learners when we challenge them to answer questions that require the use of higher order thinking skills.*

3. *Knowledge is socially constructed and people learn best in supportive social settings (e.g., in small collaborative groups).*

4. *Most students rely on ineffective learning strategies (e.g., rereading) and are unaware of more effective techniques (e.g., retrieval practice)*

   Classes that support research-validated teaching strategies may be described as reformed or student-centered or active learning environments.
Active learning engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work.

(Freeman et al, 2014)

1. Failure rates (DFW) in active learning classes less than in traditional format, 34% → 22%

(n=67 studies; 29,300 students)

2. Students in active learning classes do better (~6%) on exams (n=158 studies)
Active Learning vs. Student Performance

3. Helps all students, reduces performance gaps

Murphey Paul, 2015, New York Times, September 13, p. SR12,
Review material and practice retrieval by writing down as much information as possible (or answering questions).

Do it the first time during or within a few hours of original lesson

Repeat retrieval process at regular intervals prior to exam

The more time that passes before attempting retrieval, the more we forget

Roediger & Karpicke, 2006
Which of the following study strategies do students apply most frequently?

1. **Self-explanation** - explaining part(s) of your learning process, thus merging new information with prior knowledge

2. **Summarization** - writing a summary of material from class or readings

3. **Practice testing** - practice activity completed outside of class, can involve practice problems or even simple flashcards

4. **Highlighting, underlining** what you determine to be the important parts of the text as you read

5. **Rereading** - reading material that you have already read at least once before

6. **Retrieval practice** - reviewing material, practicing recall and retrieval of material by writing down as much information as possible

7. **Distributed practice** - distributing learning over time, typically days apart

8. **Keyword mnemonic** - associating an image that has some easily recognizable relation to the word that you are trying to remember

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2, 4, 5, 8 → little evidence of consistent learning

1 → moderate evidence of learning

3, 6, 7 → considerable evidence of effective learning

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Dunlosky et al., 2013, Psychological Science in the Public Interest, v.14, #1, p.4-58.
Active learning becoming more common in geoscience classrooms
Reformed classrooms featuring more active learning practices have higher RTOP scores.

Classroom Observation Project
205 instructors/classes
Average RTOP score = 39.7

1Sawada et al., 2002; MacIsaac and Falconer, 2002
# Observed Teaching Practices

<table>
<thead>
<tr>
<th></th>
<th>Most Traditional Lecture n=10</th>
<th>Mean Traditional Lecture n=10</th>
<th>Mean Transitional Lecture n=22</th>
<th>Mean Active Learning n=12</th>
<th>Most Active Learning n=11</th>
</tr>
</thead>
<tbody>
<tr>
<td>No/few questions asked by instructor</td>
<td>50%</td>
<td>27%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>No/few questions from students</td>
<td>60%</td>
<td>36%</td>
<td>9%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Students are passive/not asked to do anything</td>
<td>70%</td>
<td>36%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>No student-student interaction/ conversation</td>
<td>70%</td>
<td>80%</td>
<td>32%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Student-student interactions or group work</td>
<td>0%</td>
<td>9%</td>
<td>59%</td>
<td>100%</td>
<td>91%</td>
</tr>
<tr>
<td>Students read graphs, maps, use data</td>
<td>20%</td>
<td>27%</td>
<td>27%</td>
<td>67%</td>
<td>45%</td>
</tr>
<tr>
<td>Students answer open-ended questions</td>
<td>0%</td>
<td>0%</td>
<td>4%</td>
<td>17%</td>
<td>45%</td>
</tr>
<tr>
<td>Instructor assesses students (new or prior) knowledge</td>
<td>10%</td>
<td>18%</td>
<td>18%</td>
<td>33%</td>
<td>45%</td>
</tr>
<tr>
<td>Lesson adjustments based on student work or prior knowledge</td>
<td>0%</td>
<td>0%</td>
<td>9%</td>
<td>33%</td>
<td>54%</td>
</tr>
</tbody>
</table>

Data courtesy of Rachel Teasdale
Factors that influence learning

- Personal Characteristics of Student
  (age, gender, academic rank, experience)

- Course Context
  (tasks, grading policy, pedagogy, instructional resources)

- Student motivations
  (things that drive learning, e.g., task value, self-efficacy)

- Student self-regulation of learning
  (studying and/or learning behaviors, e.g., planning, monitoring, reflection)

- Course Outcomes
  (effort, interest, performance)

- Instructional Design
- Learning Process
- Mastery

adapted from Pintrich, P. R., & Zusho, A. (2007). Student Motivation and Self-Regulated Learning in the College Classroom. In R. P. Perry & J. C. Smart (Eds.), The Scholarship of Teaching and Learning in Higher Education: An Evidence-Based Perspective (pp. 731-810). Dordrecht: Springer.
**Self-Regulated Learning Cycle**

**Planning**
Students determine what they need to learn, establish goals, and decide how they will study (choosing strategies and tactics).

**Action**
Students apply specific strategies and tactics to learn material.

**Reflection**
Students think about what they did and determine why they did or did not meet their goals.

**Regulation**
Students continue with strategies and tactics they decided worked and change those that didn’t.

Lukes, 2014
Importance of Student Reflection

Students completed a task (e.g., logical reasoning test) and estimated how their score would compare with other students.

Low scoring students
- overestimated their own skill level
- failed to recognize skill in others
- failed to recognize the degree of their insufficient knowledge
- recognized their lack of skill, only if they were trained to improve

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Workshops, panel discussions, presentations on topics such as:
• Introducing active learning strategies to large intro courses
• Teaching geo-competencies
• Incorporating thinking about the Earth into other disciplines
• Ways to change your teaching to help diverse students to thrive
• Spatial reasoning in the geosciences
• Teaching sustainability and the environment within and across disciplines
• How to incorporate service learning in your course and curriculum
• Principles of lesson design
• What are the core competencies and skills for earth science students?
• Fostering student interest and motivation in the classroom
• Using databases in your classroom
• Making undergraduate research a key part of your curriculum