Researching Learning in the Geosciences

David Steer
Department of Geology & Environmental Sciences
The University of Akron

July 2009
Hundreds of students in a non-major, general education Earth Science course at the University of Akron were given a logical thinking test to determine their stage of intellectual development. Based on test scores, students were characterized as concrete, formal, or transitional (30% were transitional).

Predict the approximate proportions of students who were concrete/formal thinkers.

a. 60/10%  c. 45/25%
b. 25/45%  d. 10/60%
Levels of Teaching Research

- Teaching scholarship
- Scholarly teaching
- Scholarship of Teaching and Learning

- Inquiry to student learning
- Advances the practice of teaching
- Publicly disseminated results/findings

http://www.issotl.org
Getting Started

- Start small
- Set limits
- Practice the technique in advance
- Make purpose and process clear to students
- Plan your data analysis in advance

Getting Started (con't)

- Be flexible
- Don’t ask for data you do not want or need
- Collaborate
- Give students feedback

Examine the map and answer the question that follows. How many plates are present?

- a. 3 (26%; 0%)
- b. 4 (19%; 18%)
- c. 5 (44%; 75%)
- d. 6 (11%; 7%)

Individual responses

Post-discussion responses

Results when using physical models:
(56%; 84%)

Geology conceptest database:
http://serc.carleton.edu/introgeo/interactive/conctest.html

Geosciences Concept Inventory (GCI)

- Valid and reliable geoscience assessment instrument
- 73 geoscience questions
- You design a 15 question subtests


Sample GCI question

Which technique for determining when the Earth first formed as a planet is most accurate?

(A) Comparison of fossils found in rocks
(B) Comparison of different layers of rock
(C) Analysis of uranium and lead in rock
(D) Analysis of carbon in rock
(E) Scientists cannot calculate the age of the Earth
Using the GCI

- Formative assessment
- Summative assessment
  - Cover the topic/not the questions
  - Plan when you administer
  - Expect little improvement
  - Bracket student performance levels

http://newton.bhsu.edu/eps/gci.html
Group Assessment of Logical Thinking (GALT)

- 12 question instrument that tests six logical operations (summative assessment)

  Conservation
  Controlling Variables
  Probabilistic Reasoning
  Proportional Reasoning
  Combinatorial Reasoning
  Correlation Reasoning

Tom has two balls of clay. They are the same size and shape. When he places them on the balance, they weigh the same.

The balls of clay are removed from the balance. Clay 2 is flattened like a pancake.

Which statement is true? REASON

a. The pancake-shaped clay weighs more
b. The two pieces weight the same
c. The ball weighs more
## Improvement in Thinking Skills

### Point gains in GALT score vs. Course Structure

<table>
<thead>
<tr>
<th>GALT score</th>
<th>Active Learning, n=465</th>
<th>Traditional Lecture, n=276</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>2.1</td>
<td>1.2</td>
<td>18%, p &lt; 0.001</td>
</tr>
<tr>
<td>5 - 7</td>
<td>1.2</td>
<td>0.6</td>
<td>9%,  p &lt; 0.001</td>
</tr>
<tr>
<td>8 - 12</td>
<td>0.2</td>
<td>-0.2</td>
<td></td>
</tr>
</tbody>
</table>

Earth Science Course Grades

- A: 25% Formal, 15% Transitional, 60% Concrete
- B: 40% Formal, 30% Transitional, 30% Concrete
- C: 30% Formal, 40% Transitional, 30% Concrete
- D: 20% Formal, 20% Transitional, 60% Concrete
- F: 10% Formal, 10% Transitional, 80% Concrete

n = 474

Impact of Groups vs. Grades

ES Course Grades (thru 3 exam periods)

Same population characteristics both semesters
Same exercises, HWK and exams

More As and fewer Fs using team approach (green)!
# Some GALT results

<table>
<thead>
<tr>
<th>Item</th>
<th>Operation</th>
<th>AB Pre: AB Post</th>
<th>DF Pre: DF Post</th>
<th>AB Pre: DF Pre</th>
<th>AB Pre: DF Post</th>
<th>AB Post: DF Post</th>
<th>Difficulty Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 4</td>
<td><em>Conservation</em></td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>0.78, 0.46</td>
</tr>
<tr>
<td>8, 9</td>
<td><em>Proportional Reasoning</em></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>0.15, 0.26</td>
</tr>
<tr>
<td>11, 13</td>
<td><em>Controlling Variables</em></td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>0.27, 0.24</td>
</tr>
<tr>
<td>15, 16</td>
<td><em>Probabilistic Reasoning</em></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>0.19, 0.21</td>
</tr>
<tr>
<td>17, 18</td>
<td><em>Correlation Reasoning</em></td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>0.16, 0.05</td>
</tr>
<tr>
<td>19, 20</td>
<td><em>Combinatorial Reasoning</em></td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>0.65, 0.2</td>
</tr>
</tbody>
</table>

- N: No Correlation
- Y: Positive Correlation
- Red: Negative Correlation

<table>
<thead>
<tr>
<th>Operation</th>
<th>AB Pre: AB Post</th>
<th>DF Pre: DF Post</th>
<th>AB Pre: DF Pre</th>
<th>AB Pre: DF Post</th>
<th>AB Post: DF Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 4</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>8, 9</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>11, 13</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>15, 16</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>17, 18</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>19, 20</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>

n = 53  n = 56
Motivated Strategies for Learning Questionnaire (MSLQ)

- Assesses motivation and learning strategies
- Self reporting
- 81 items (modular)
- No right or wrong answers (Likert Scale)
- Widely used and tested

What grade do you believe you will earn in this Earth Science class?

- 95% of students believe they will earn an A or B grade
- Approximately a third will earn an A or B
- No one thinks they will earn D or F
Science Knowledge vs. Performance

Earth Science, Sp07

- Higher ACT Science scores → better class scores; smaller range
- Low scores often linked to low ACT scores
- Students with near average ACT scores perform at a range of levels
  - Why do some of these students excel while others do poorly?
Why did you learn a lot in class?

Consider a class that resulted in a lot of new learning, and one where you didn’t learn much at all. Why did you think you learned a lot in one class and relatively little in the other?
Earth Science, Sp07

• Student attendance measured by use of clickers

• Average attendance for students completing all four exams was 81%

• *Why do some of these students attend class consistently while others do not?*

\[ R^2 = 0.3838 \]
### Science Knowledge vs. Performance

<table>
<thead>
<tr>
<th>Cognitive Level</th>
<th>AB</th>
<th>C</th>
<th>DF</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>92%</td>
<td>88%</td>
<td>73%</td>
<td>83%</td>
</tr>
<tr>
<td>Transitional</td>
<td>91%</td>
<td>84%</td>
<td>67%</td>
<td>83%</td>
</tr>
<tr>
<td>Formal</td>
<td>90%</td>
<td>82%</td>
<td>66%</td>
<td>85%</td>
</tr>
<tr>
<td>Average</td>
<td>91%</td>
<td>85%</td>
<td>69%</td>
<td></td>
</tr>
</tbody>
</table>

Students in biology classes at U. of Minnesota improved scores by a letter grade as a result of instructor stressing attendance*  

*Moore, R., et. al., 2003, American Biology Teacher, v.65, #5, p. 325-329
Students are often unaware of alternative learning strategies and their relationship to performance.

**Rehearsal**
- Reading class notes and textbook chapters over (and over again); memorizing key words.

**Elaboration**
- Writing summaries of the main ideas from readings and class notes; linking information from different sources.

**Organization**
- Synthesizing readings and class notes; constructing charts, diagrams, outlines for key concepts.

What proportion of students use these strategies effectively?

Motivated Strategies for Learning Questionnaire, Pintrich and others, 1991
### Student Learning Strategies: Rehearsal

<table>
<thead>
<tr>
<th>Rehearsal Strategies</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>When I studied, I practiced saying the material to myself over and over.</td>
<td>3.9</td>
<td>9.8</td>
<td>19.6</td>
<td>21.6</td>
<td>25.5</td>
<td>9.8</td>
<td>9.8</td>
</tr>
<tr>
<td>When studying for the course, I read my notes and the course readings over and over again.</td>
<td>1.9</td>
<td>7.5</td>
<td>9.4</td>
<td>17.0</td>
<td>22.6</td>
<td>20.8</td>
<td>20.8</td>
</tr>
<tr>
<td>I memorized key words to remind me of important concepts.</td>
<td>0.0</td>
<td>1.9</td>
<td>9.6</td>
<td>15.4</td>
<td>23.1</td>
<td>25.0</td>
<td>25.0</td>
</tr>
<tr>
<td>I made lists of important items for the course and memorized the lists.</td>
<td>7.8</td>
<td>11.8</td>
<td>17.6</td>
<td>31.4</td>
<td>23.5</td>
<td>3.9</td>
<td>3.9</td>
</tr>
</tbody>
</table>

n = 48-53

Motivated Strategies for Learning Questionnaire, Pintrich and others, 1991
### Elaboration Strategies

<table>
<thead>
<tr>
<th>Elaboration Strategies</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>When I study, I pull together information from lectures, readings, and discussions.</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>14</td>
<td>16</td>
<td>38</td>
<td>18</td>
</tr>
<tr>
<td>When reading, I try to relate the material to what I already know.</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>16</td>
<td>24</td>
<td>38</td>
<td>20</td>
</tr>
<tr>
<td>When I study, I write brief summaries of the main ideas from readings and notes.</td>
<td>17.6</td>
<td>17.6</td>
<td>21.6</td>
<td>17.6</td>
<td>13.7</td>
<td>5.9</td>
<td>5.9</td>
</tr>
<tr>
<td>I try to understand the material by making connections between the readings and the lectures.</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>16</td>
<td>26</td>
<td>28</td>
<td>28</td>
</tr>
</tbody>
</table>

n = 48-53

Motivated Strategies for Learning Questionnaire, Pintrich and others, 1991
## Student Learning Strategies: Organization

<table>
<thead>
<tr>
<th>Organization Strategies</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>When I study the readings, I outline the material to help organize my thoughts.</td>
<td>16.3</td>
<td>12.2</td>
<td><strong>18.4</strong></td>
<td><strong>18.4</strong></td>
<td>12.2</td>
<td>12.2</td>
<td>10.2</td>
</tr>
<tr>
<td>When I study, I go through the readings and my notes and to find the most important ideas.</td>
<td>0</td>
<td>0</td>
<td><strong>4.17</strong></td>
<td><strong>8.33</strong></td>
<td><strong>29.2</strong></td>
<td><strong>16.7</strong></td>
<td><strong>41.7</strong></td>
</tr>
<tr>
<td>I make simple charts, diagrams, or tables to help organize course material.</td>
<td><strong>29.2</strong></td>
<td><strong>27.1</strong></td>
<td><strong>18.8</strong></td>
<td><strong>10.4</strong></td>
<td><strong>4.17</strong></td>
<td><strong>6.25</strong></td>
<td><strong>4.17</strong></td>
</tr>
<tr>
<td>When I study, I go over my notes and make an outline of important concepts.</td>
<td><strong>10.2</strong></td>
<td><strong>12.2</strong></td>
<td><strong>16.3</strong></td>
<td><strong>28.6</strong></td>
<td><strong>12.2</strong></td>
<td><strong>10.2</strong></td>
<td><strong>10.2</strong></td>
</tr>
</tbody>
</table>

n = 48-53

Motivated Strategies for Learning Questionnaire, Pintrich and others, 1991
Other things to think about

- Focus on your interests
- Keep it simple
- Review literature in advance
- Write a research question
- Discuss with other faculty
- Focus on the student
- Try a pilot
- Publish results
- Select a research process (don’t reinvent)

Timely Research Topics

- Quantifying characteristics and needs of your students
- Impact of placing students in appropriate learning environments
- Developing conditions for intellectual growth
- Monitoring of student learning
- Developing methods for improving teaching and learning
Some questions to consider …

• Does it count toward tenure?
• How will my Department view this research?
• Are there College of Education collaborators?
• Are there institutional resources?
• Can I team with outside collaborators?
References

