Researching Learning in the Geosciences

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

July 2009

Who are we teaching?

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%

b. 25/45%

c. 45/25%

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

Cross, P.K. and Steadman, M.H., 1996. Classroom Research: Implementing the Scholarship of Teaching. Jossey-Bass, San Francisco, p. 226.

Getting Started (con't)

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

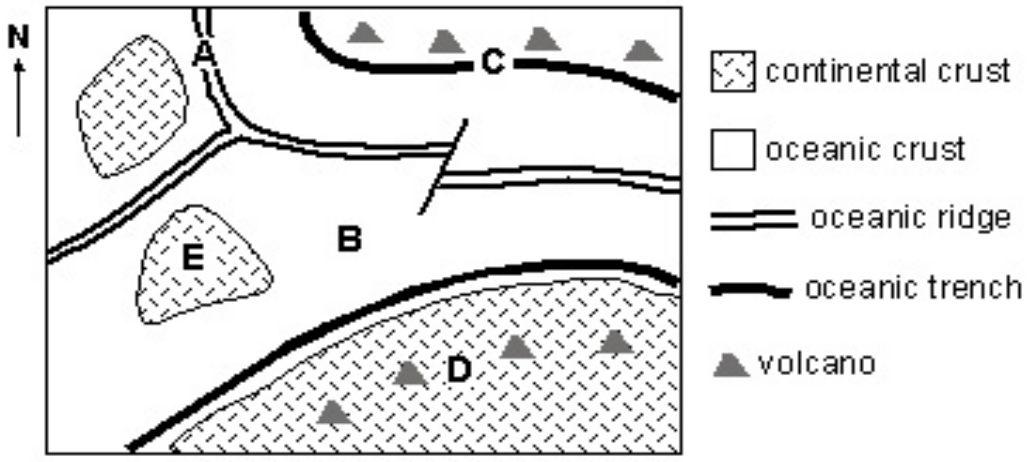
Cross, P.K. and Steadman, M.H., 1996. Classroom Research: Implementing the Scholarship of Teaching. Jossey-Bass, San Francisco, p. 226.

Example: Earth Science Conceptest

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

a. 3 (26%; 0%) **c.** 5 (44%; 75%)

b. 4 (19%; 18%) **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

McConnell, D.A., et al., 2006, Journal of Geoscience Education, v. 54, #1, p.61-68.

Geosciences Concept Inventory (GCI)

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

Libarkin, J.C., and Anderson, S.W., 2005. Assessment of Learning in Entry-Level Geoscience Courses: Results from the Geoscience Concept Inventory; Journal of Geoscience Education; v. 53. p. 394-401.

Libarkin, J.C., and Anderson, S.W., 2006, The Geoscience Concept Inventory: Application of Rasch Analysis to Concept Inventory Development in Higher Education: in Applications of Rasch Measurement in Science Education, ed. X. Liu and W. Boone: JAM Publishers, p. 45-73.

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

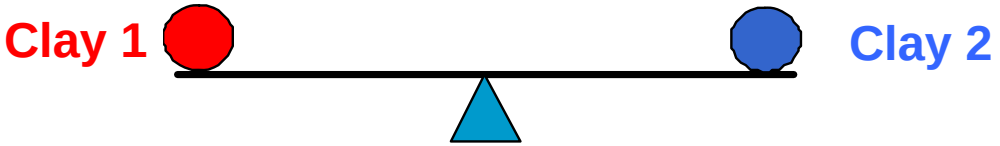
Combinatorial Reasoning

Correlation Reasoning

Roadrangka, V., Yeany, R.H. and Padilla, M.J., 1983. The construction and validation of the Group Assessment of Logical Thinking (GALT), Paper presented at the annual meeting of the National Assoc. for Res. In Sci. Teaching, Dallas, TX, April meeting.

Sample GALT question

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

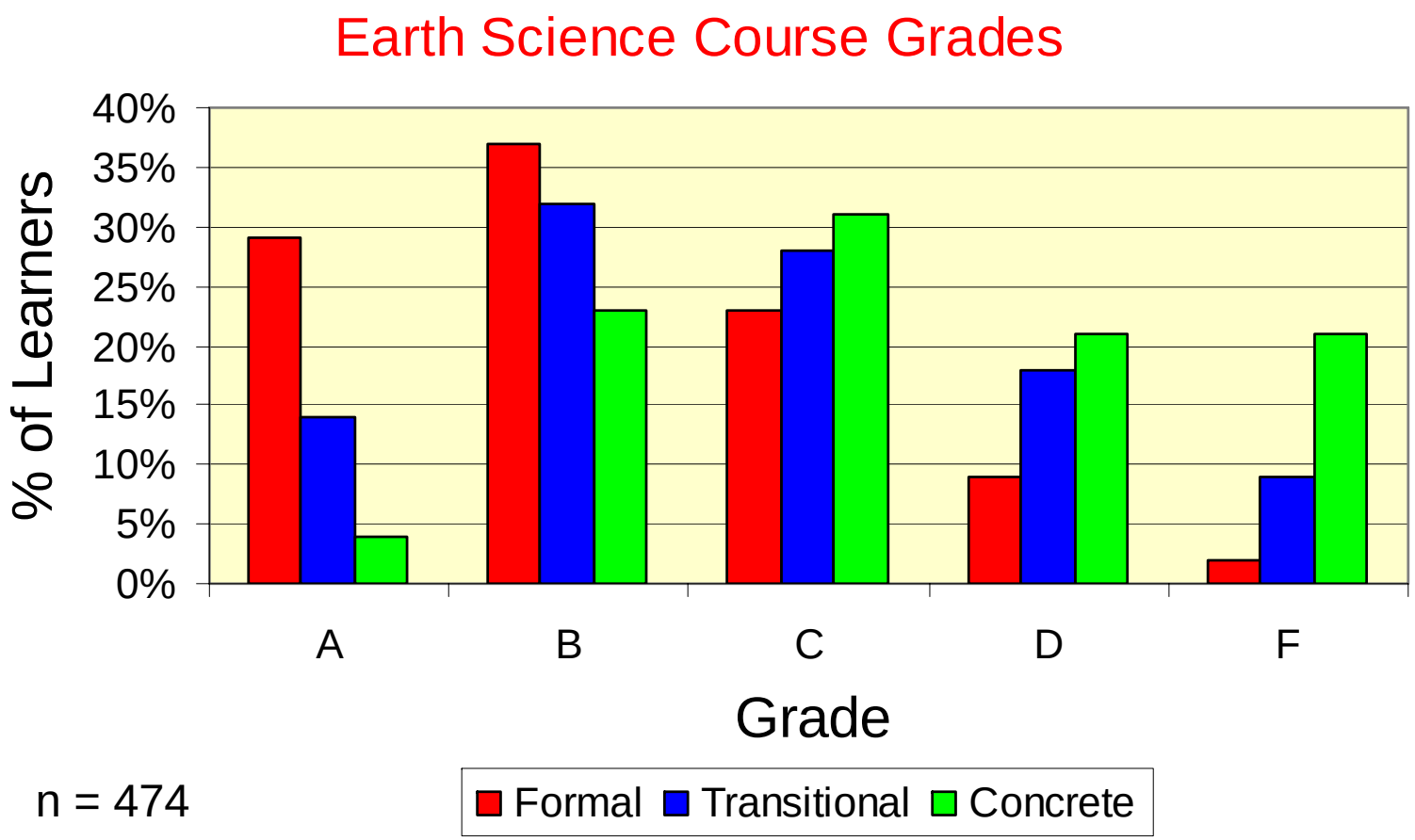
Active Learning, n=465

GALT score 0 - 4	GALT score 5 - 7	GALT score 8 - 12	Totals
2.1	1.2	0.2	18%, $p < 0.001$
1.2	0.6	-0.2	9%, $p < 0.001$

Traditional Lecture, n=276

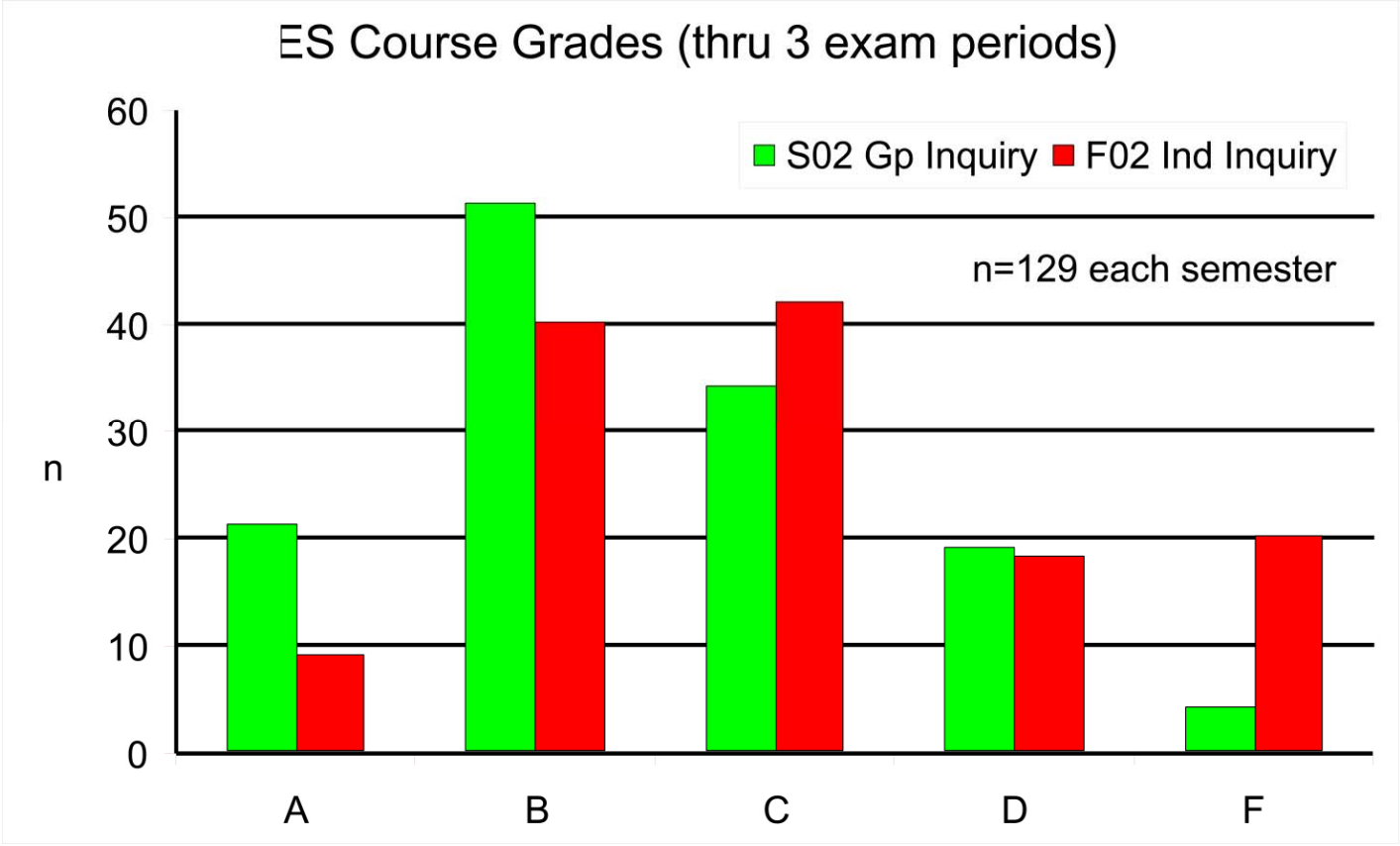
McConnell, D.A., Steer, D.N., Owens, K., & Knight, C., 2005, Journal of Geoscience Education, v. 53, #4, p. 462-470.

Thinking Skills vs. Grades



McConnell, D.A., Steer, D.N., Owens, K., & Knight, C., 2005, Journal of Geoscience Education, v. 53, #4, p. 462-470.

Impact of Groups vs. Grades



Same population characteristics both semesters
Same exercises, HWK and exams

More As and fewer Fs using team approach (green)!

Some GALT results

Item	Operation	AB Pre: AB Post	DF Pre: DF Post	AB Pre: DF Pre	AB Pre: DF Post	AB Post: DF Post	Difficulty Factor
1, 4	•Conservation	N	Y	Y	N	N	0.78, 0.46
8, 9	• Proportional Reasoning	Y	Y	N	N	N	0.15, 0.26
11, 13	• Controlling Variables	Y	N	N	N	N	0.27, 0.24
15, 16	• Probabilistic Reasoning	Y	Y	Y	N	Y	0.19, 0.21
17, 18	• Correlation Reasoning	Y	N	N	Y	N	0.16, 0.05
19, 20	•Combinatorial Reasoning	Y	N	N	Y	N	0.65, 0.2
		n = 53	n = 56				

Positive Correlation No Correlation Negative Correlation

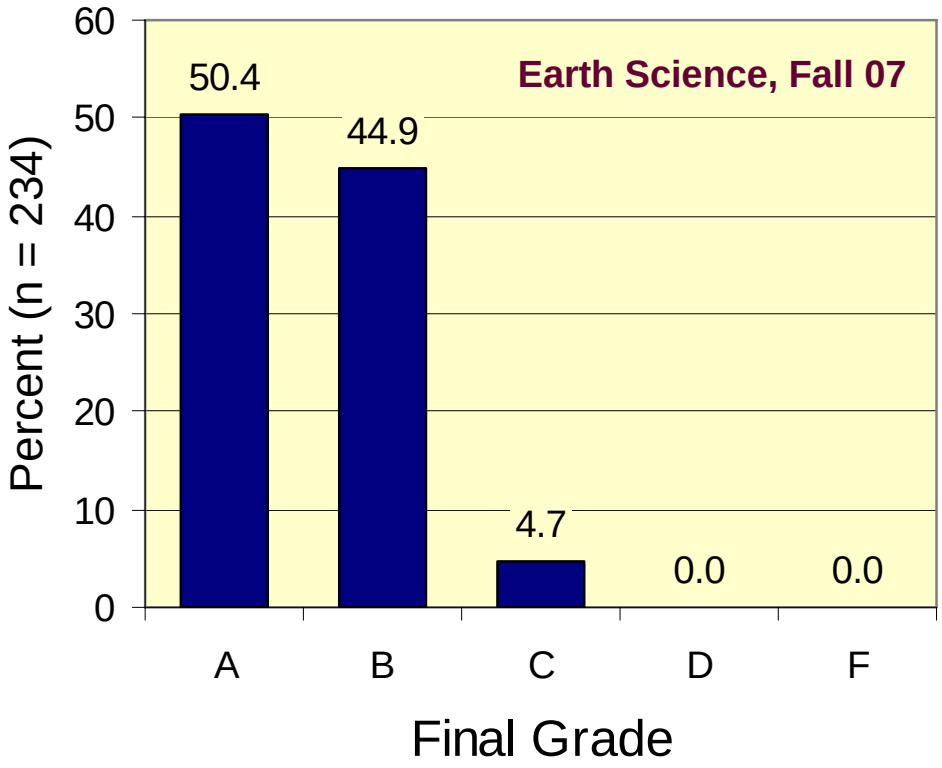
Motivated Strategies for Learning Questionnaire (MSLQ)

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

Pintrich, P.R., Smith, D.A.F., Garcia, T. and McKeachie, W.J., 1991. *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*, Ann Arbor: Univ. MI., National Center for Research to Improve Postsecondary Teaching and Learning, 87 pp.

Student Perceptions of Performance

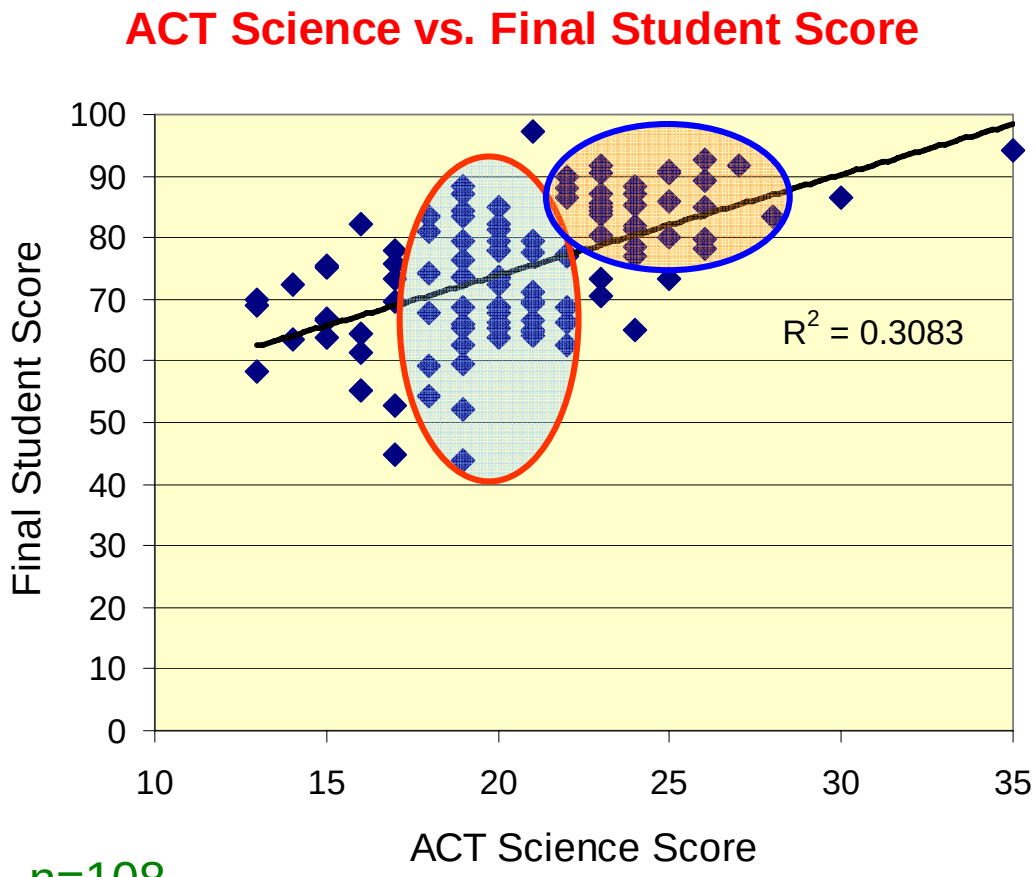
Student Grade Predictions



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

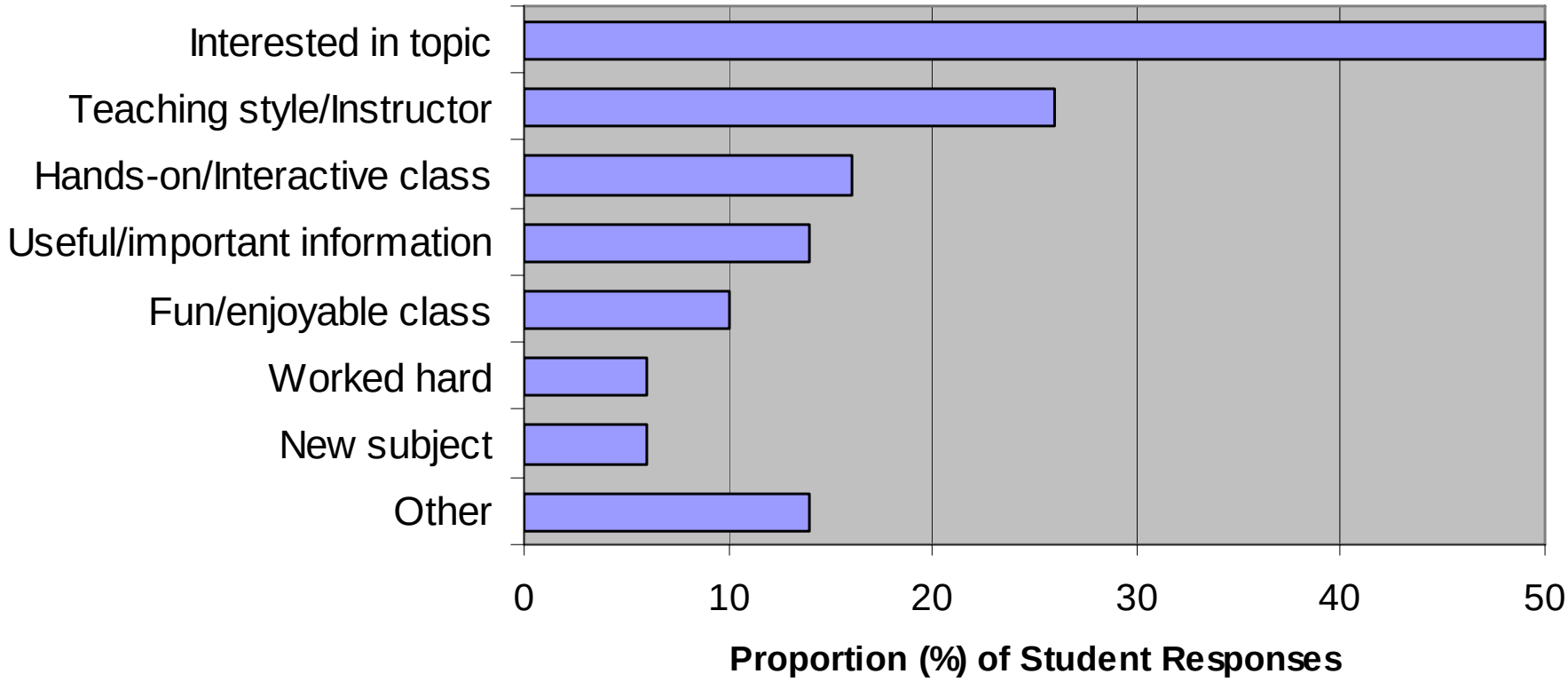


n=108

Earth Science, Sp07

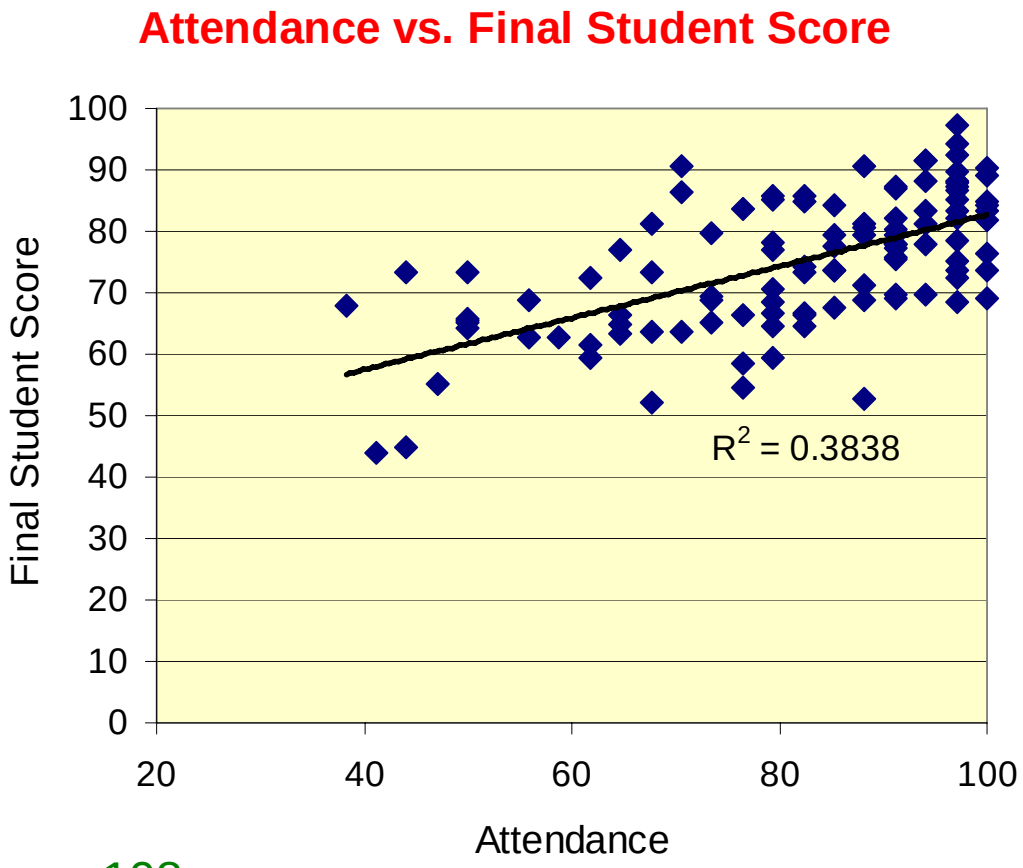
- Higher ACT Science scores → better class scores; smaller range
- Low scores often linked to low ACT scores
- Students with near average ACT scores perform at a range of levels
- *Why do some of these students excel while others do poorly?*

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?**

Science Knowledge vs. Performance



n=108

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?*

Science Knowledge vs. Performance

Attendance: Active Learning Class (n=465)

Cognitive Level	AB	C	DF	Average
Concrete	92%	88%	73%	83%
Transitional	91%	84%	67%	83%
Formal	90%	82%	66%	85%
Average	91%	85%	69%	

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

Student Learning Strategies

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

Not true for me ⟶ **Very true for me**

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

n = 48-53

Motivated Strategies for Learning Questionnaire, Pintrich and others, 1991

Student Learning Strategies: Elaboration

Not true for me ⟶ **Very true for me**

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

n = 48-53

Motivated Strategies for Learning Questionnaire, Pintrich and others, 1991

Student Learning Strategies: Organization

Not true for me ⟶ **Very true for me**

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

n = 48-53

Motivated Strategies for Learning Questionnaire, Pintrich and others, 1991

Other things to think about

Focus on your interests

Review literature in advance

Discuss with other faculty

Try a pilot

Select a research process (don't reinvent)

Keep it simple

Write a research question

Focus on the student

Publish results

Cross, P.K. and Steadman, M.H., 1996. Classroom Research: Implementing the Scholarship of Teaching. Jossey-Bass, San Francisco, p. 226.

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

- Bransford, J. D., Brown, A. L., & Cocking, R. R. (eds.) (2000). How people learn: Brain, mind, experience, and school. Washington, DC: National Academy Press.(http://www.nap.edu/html/howpeople1)
- Angelo, T.A. and Cross, P.K., 1993. Classroom assessment techniques: A handbook for college teachers, 2nd ed., Jossey-Bass, San Francisco, 448 pp.
- Cross, P.K. and Steadman, M.H., 1996. Classroom Research: Implementing the Scholarship of Teaching. Jossey-Bass, San Francisco, 264 pp.