# Pedagogy and the Geosciences

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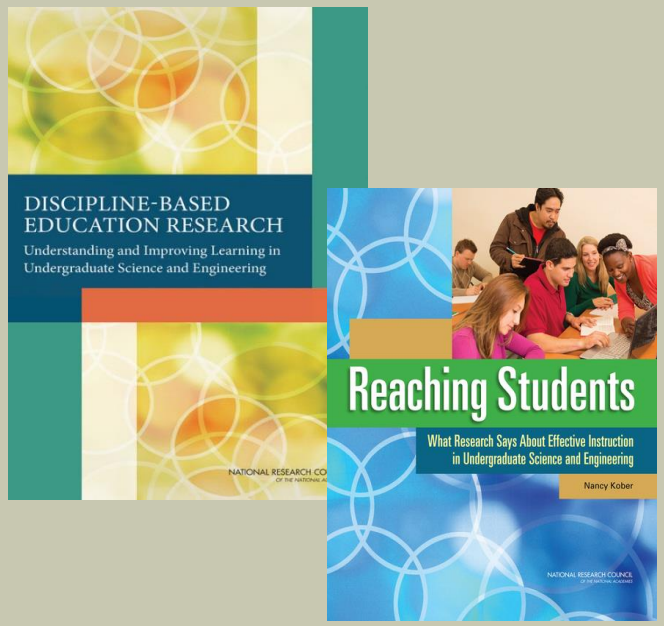
# DBER: Discipline-Based Education Research




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

**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.

Discipline-based education research, 2012, Singer, Nielsen, & Schweingruber, (Eds.) National Academies Press.
Reaching students, 2014, Kober, National Academies Press.

# WHAT DBER TELLS US ABOUT STUDENT LEARNING

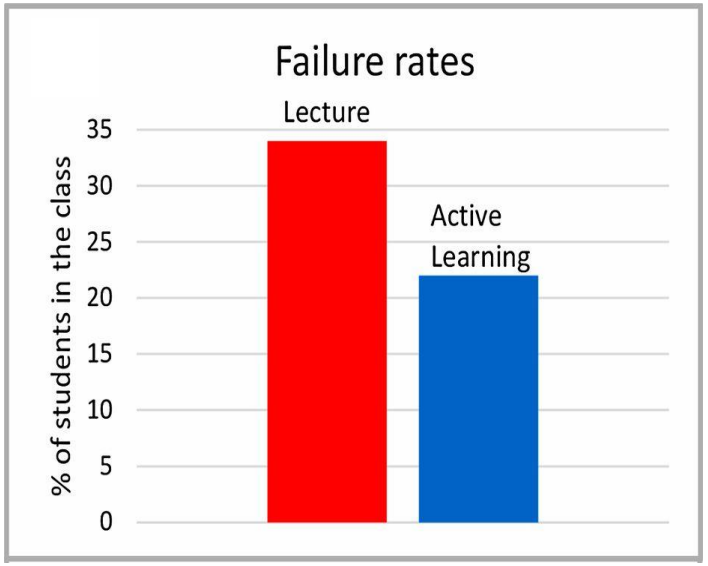
1. *Students learn key concepts better when they actively monitor their understanding in a variety of activities inside and outside of class (designed, structured activities).*
2. *Students become better learners when we challenge them to answer questions that require the use of higher order thinking 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 vs. Student Performance

**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**.

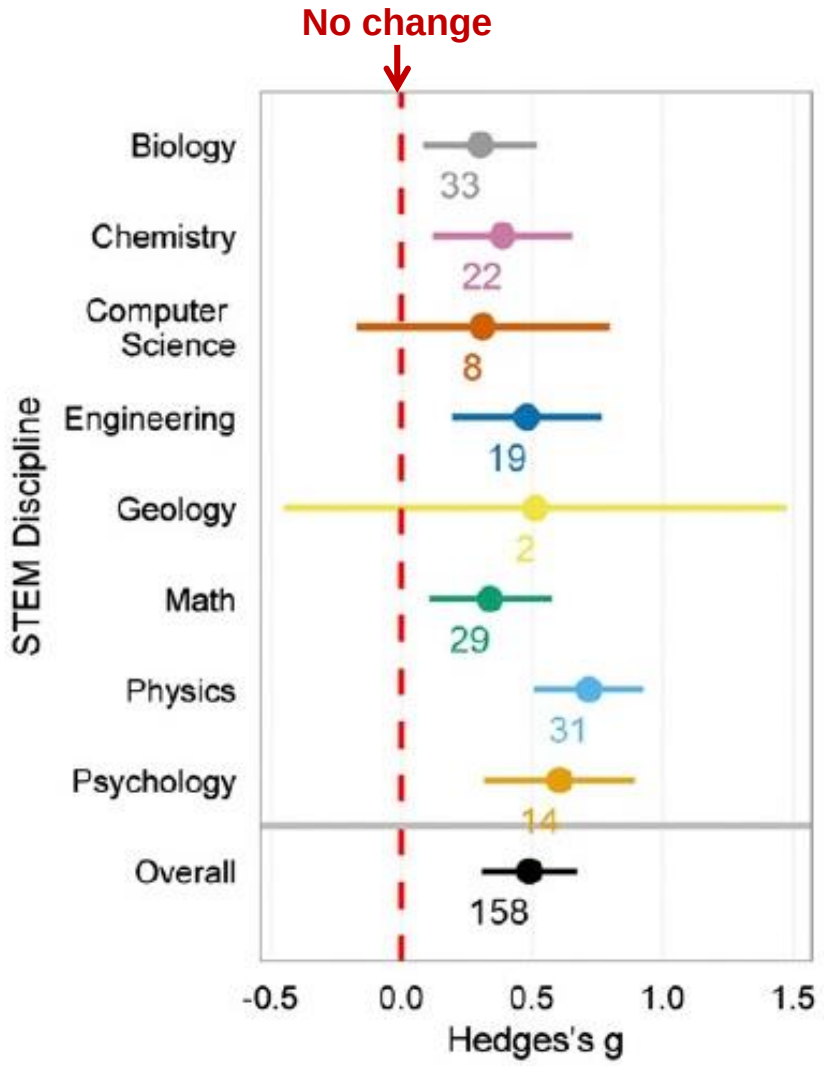
(Freeman et al, 2014)




1. Failure rates (DFW) in active learning classes less than in traditional format, 34% → 22%
   (n=67 studies; 29,300 students)

Freeman et al., 2014, Proceedings of the National Academy of Sciences v.111, #23 p. 8410-8415.
Wieman, 2014, Proceedings of the National Academy of Sciences v.111, #23 p. 8319-8320.

# Active Learning vs. Student Performance




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

Freeman et al., 2014, Proceedings of the National Academy of Sciences v.111, #23 p. 8410-8415.

# Active Learning vs. Student Performance

3. Helps all students, reduces performance gaps

The New York Times

EDITORIAL
Eastern Europe's Short Memory

EDITORIAL
How Segregation Destroys Black Wealth

DAVID BROOKS
The Biden Formation Story

JOE NOCERA
The Pyramid Scheme Problem

SundayReview

## Are College Lectures Unfair?

SEPT. 12, 2015

Gray Matter

By ANNIE MURPHY PAUL

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DOES the college lecture discriminate? Is it biased against undergraduates who are not white, male and affluent?

The notion may seem absurd on its face. The lecture is an old and well-established tradition in education. To most of us, it simply is the way college courses are taught. Even online courses are largely conventional lectures uploaded to the web.

Yet a growing body of evidence suggests that the lecture is not generic or neutral, but a specific cultural form that favors some people while discriminating against others, including women, minorities and low-income and first-generation college students. This is not a matter of instructor bias; it is the lecture format itself — when used on its own without other instructional supports — that offers unfair advantages to an already privileged population.

The partiality of the lecture format has been made visible by studies that compare it with a different style of instruction, called active learning. This approach provides increased structure, feedback and interaction, prompting students to become participants in constructing their own knowledge rather than passive recipients.

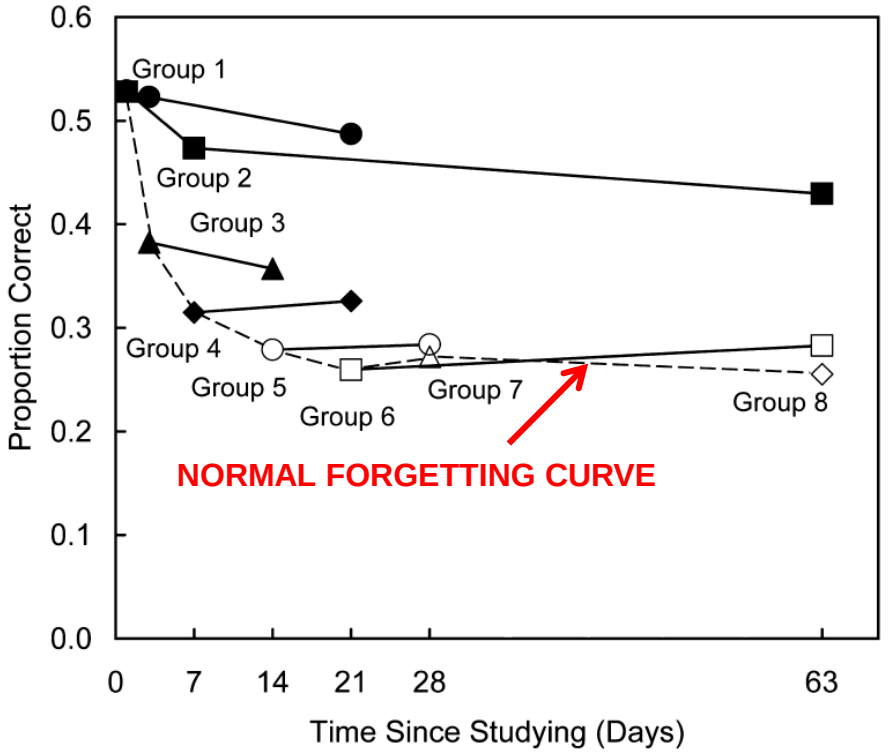
Gérard DuBois

Power Your Business

Murphey Paul, 2015, New York Times, September 13, p. SR12,

# Why this works: Retrieval Practice (Testing Effect)

- 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

2, 4, 5, 8 → little evidence of consistent learning
1 → moderate evidence of learning
3, 6, 7 → considerable evidence of effective learning

Dunlosky et al., 2013, Psychological Science in the Public Interest, v.14, #1, p.4-58.

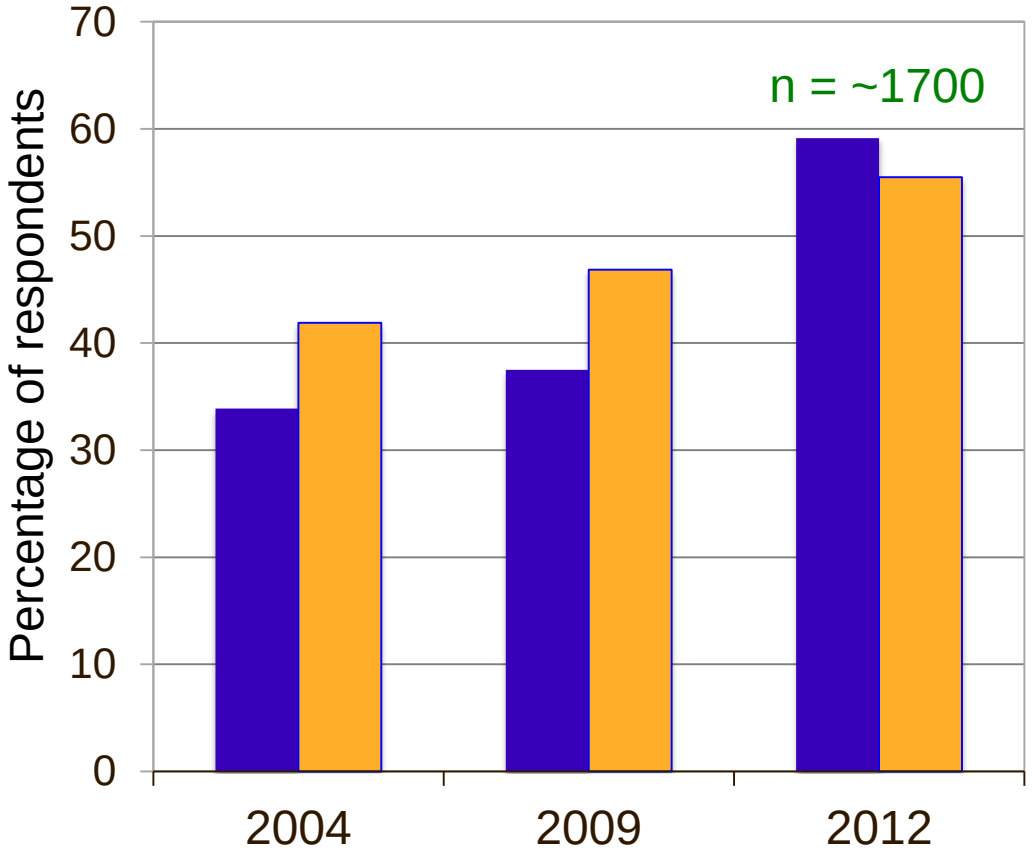
On the Cutting Edge

*Professional Development for Geoscience Faculty 2012-13*

# ON THE CUTTING EDGE

## GEOSCIENCE FACULTY SURVEY

- Active learning becoming more common in geoscience classrooms

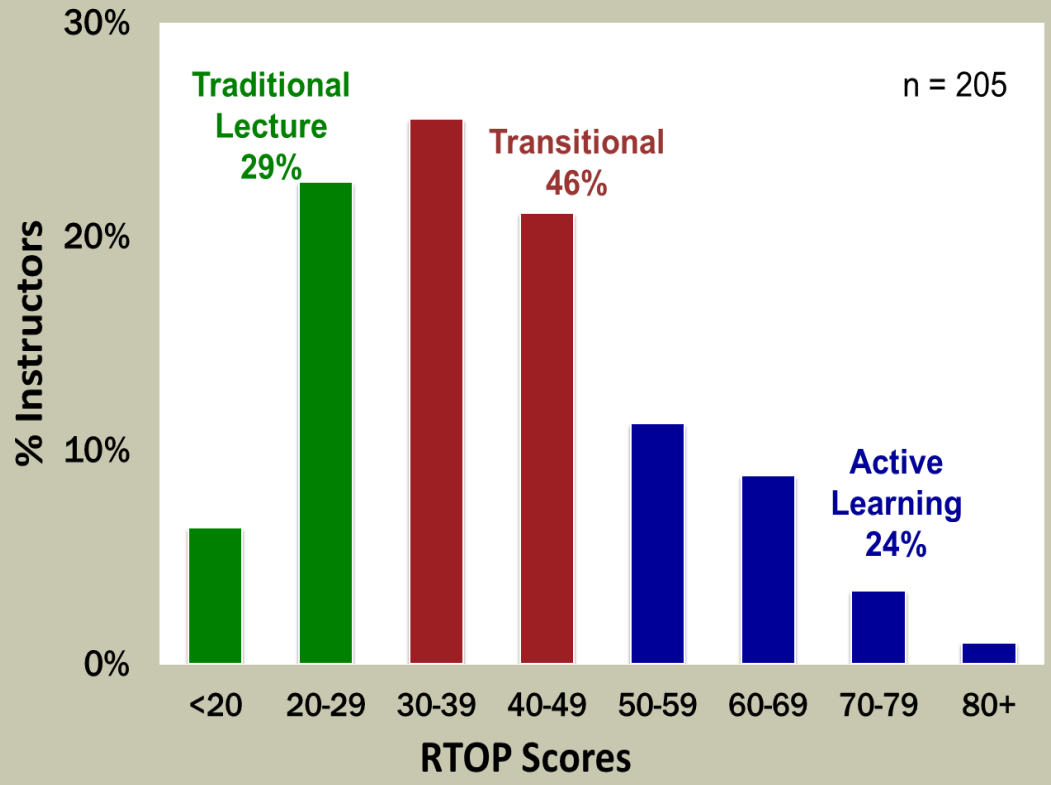



# MEASURING TEACHING PRACTICE

## Reformed Teaching Observation Protocol[1]

- Reformed classrooms featuring more active learning practices have higher RTOP scores

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



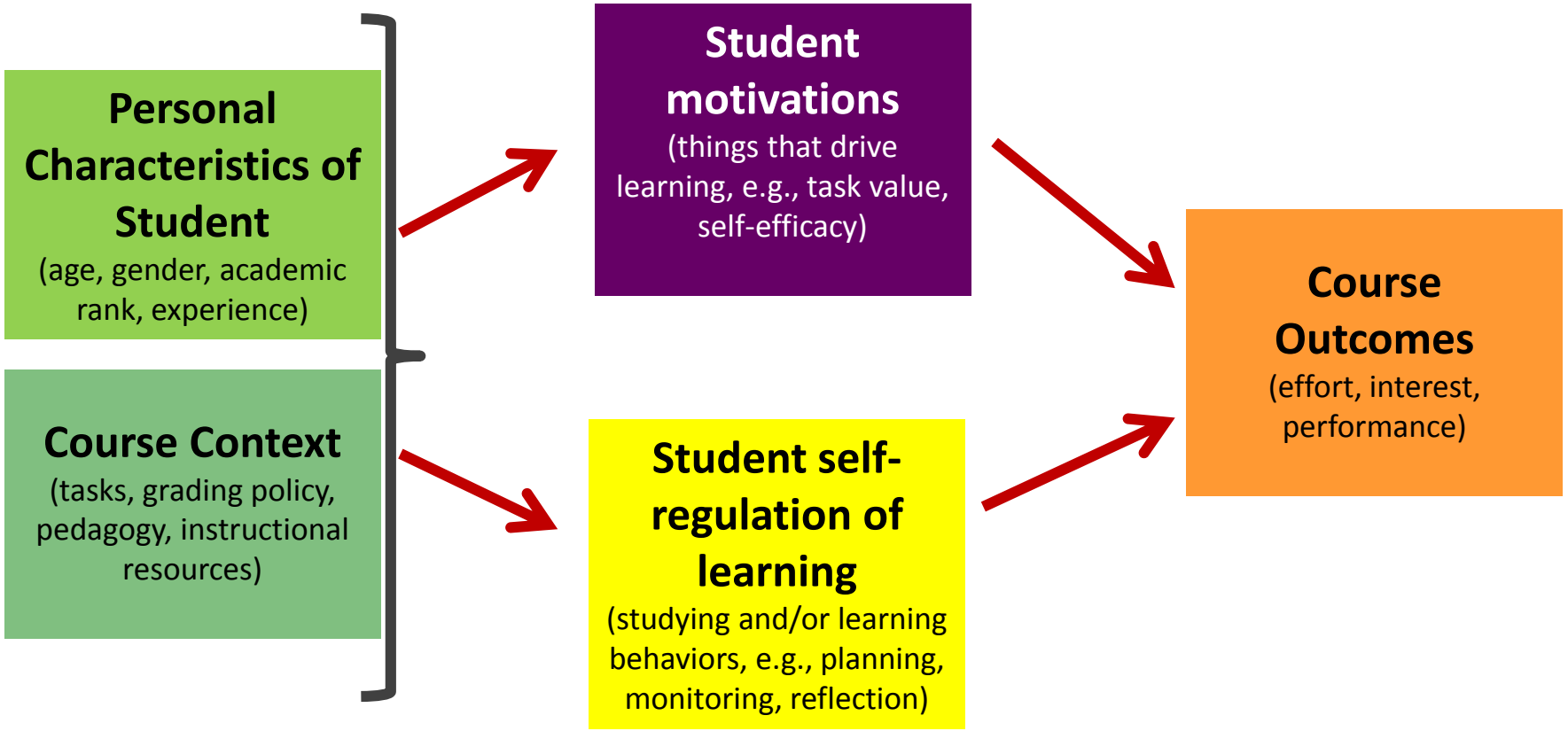

[1]Sawada et al., 2002; MacIsaac and Falconer, 2002

# Observed Teaching Practices

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

Data courtesy of Rachel Teasdale

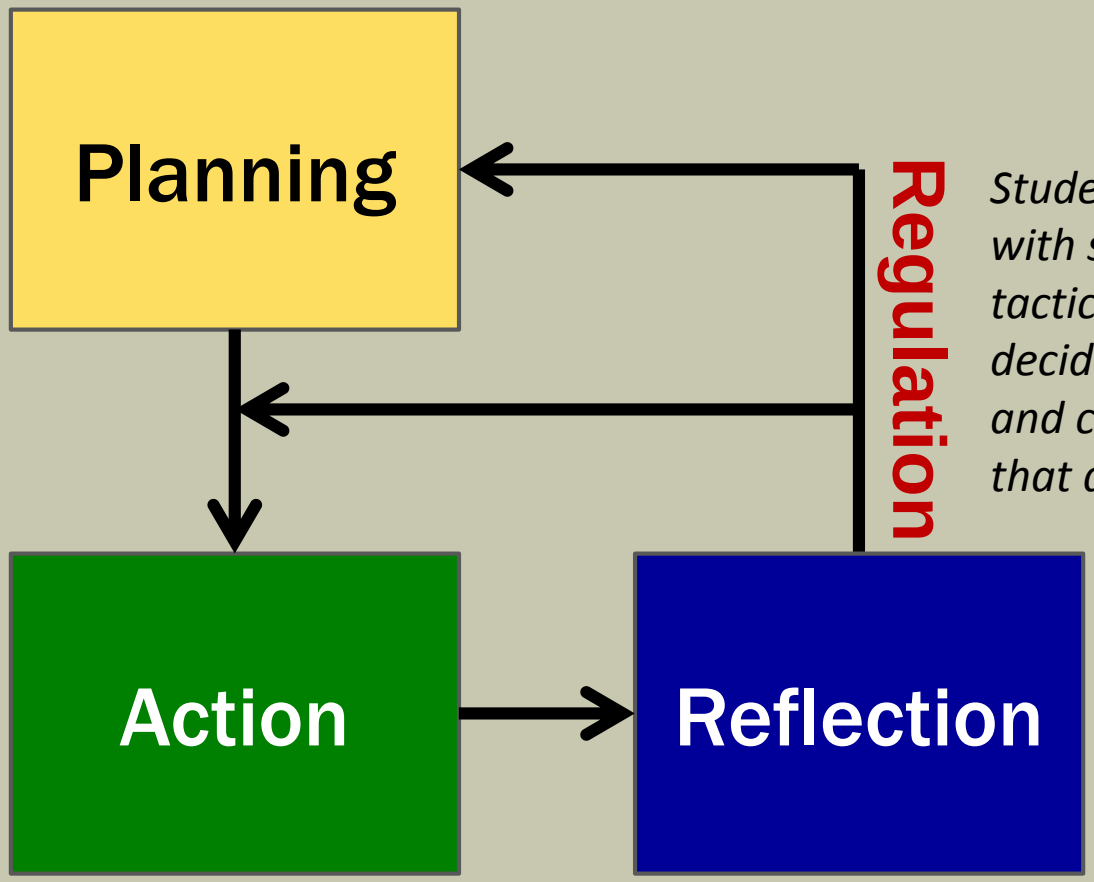
# Factors that influence learning




*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

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




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

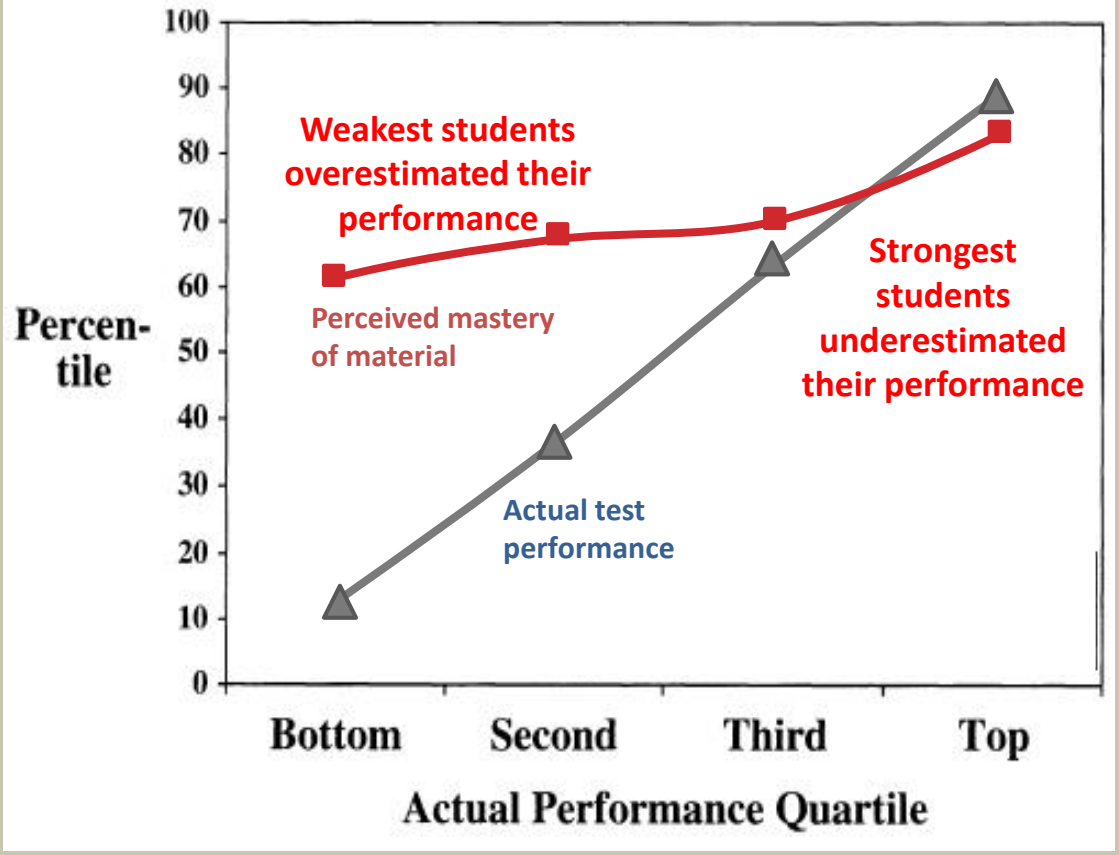
*Students apply specific strategies and tactics to learn material.*

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

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

Dunning et al., 2003. Current directions in psychological science, v.12 #3, p.83-87


EARTH EDUCATORS' RENDEZVOUS

Join us for the

# Earth Educators' Rendezvous

July 18-22, 2016

University of Wisconsin, Madison

http://serc.carleton.edu/112085

**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