Pedagogy

A. Selecting It
B. Learning Best Practices
C. Refining It

What Do Good Teachers Do?

- Know their discipline inside and out
- Start with the students rather than the discipline
- Create a natural critical learning environment
  - Pose intriguing problems
  - Ask important and/or provocative questions
  - Help students understand the significance of the question
  - Give students authentic tasks

See: Bain, Ken (2004). *What the Best College Teachers Do.* Harvard University Press.

A Few More Things

- Engage students in higher-order intellectual activity
- Provide challenging but supportive conditions where
  - Learners have a sense of control
  - Believe their work will be considered fairly
  - Work collaboratively
  - Can fail, receive feedback, and try again
- Assess their own efforts

Lecture Basics

- Plan lectures based on learning objectives
- Use a logical organizational plan
  - Classification hierarchy
  - Problem centered
  - Chaining
  - Comparison
  - Thesis
- Keep number of points to a minimum: Avoid “mental dazzle”

Basics, cont.

- Work between levels of abstraction
  - Between simple and complex
  - Between concrete and abstract
  - Between familiar and unfamiliar
- Make transitions explicit; use “markers”
- Use techniques that “play to the ear”
  - Repetition and redundancy
  - Internal summaries
  - Analogies
  - Visual representations

Three Common Mistakes in STEM Lectures

- Forgetting what is difficult for novice learners
- Forgetting that math is just the language nature uses to communicate
- Not making problem solving itself explicit

Introductions and Conclusions

- Introductions should
  - Motivate and arouse curiosity
  - Preview and build framework
  - Make connections from last lecture
- Conclusions should
  - Summarize
  - Restate the one main point
  - Link to the next lecture

Delivery

- Verbal techniques
  - Be enthusiastic
  - Vary pitch, rate, and tone
- Nonverbal techniques
  - Make eye contact
  - Look away from the board
  - Use gestures comfortably
  - Plan for well-placed pauses
  - Avoid distracting mannerisms

Use Visual Aids Strategically

- What is your purpose?
  - Explain?
  - Demonstrate?
  - Unfold?
- What are your constraints?
  - Space?
  - Time?
  - Your capabilities?
- What are the norms in the context?

Tips for Working at the Board

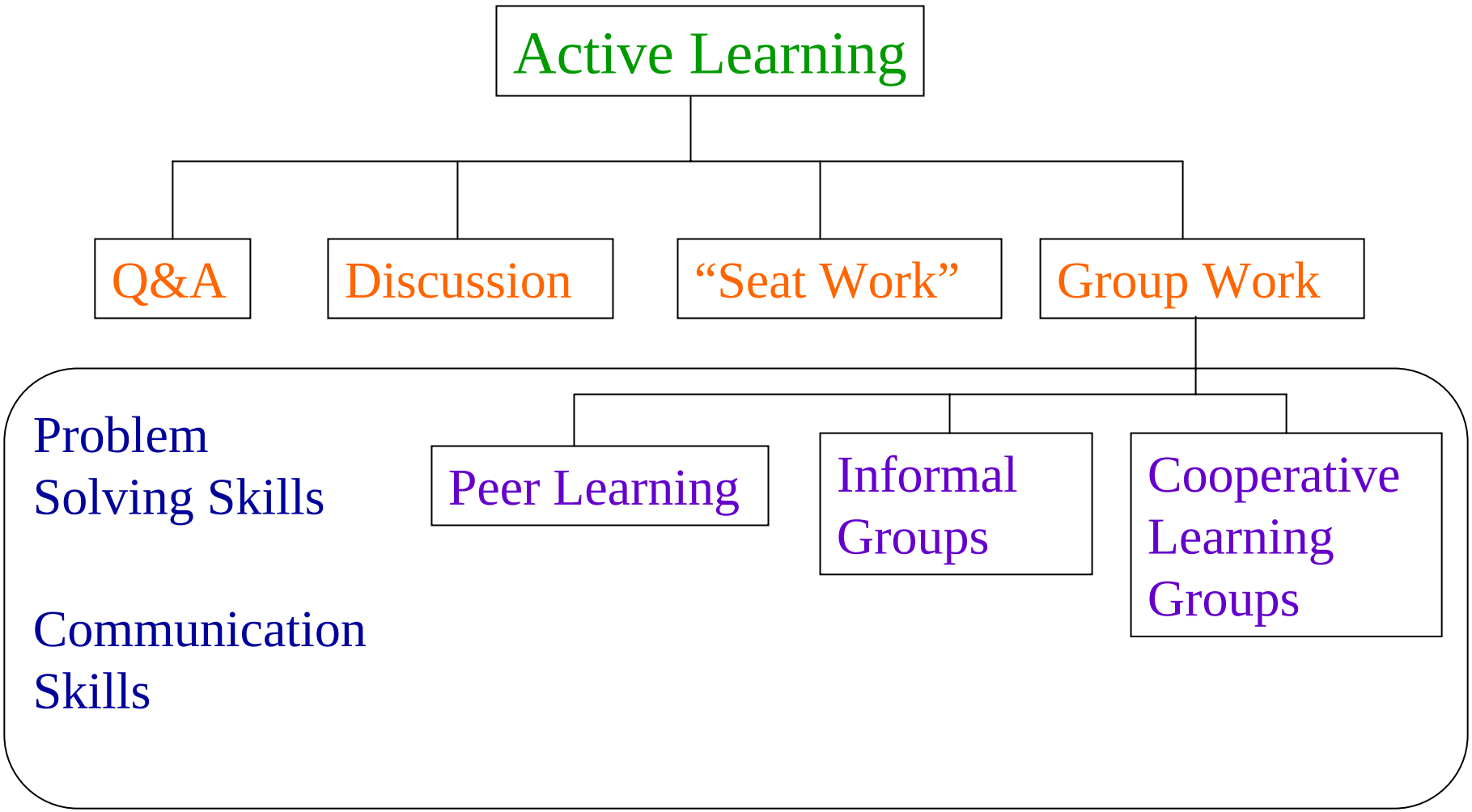
- Plan your boards
  - Think about what shouldn't be erased
- Write large, write legibly
- Use color only for a purpose
- If you make a mistake, put a line through it, don't erase it
- If the boards are stacked, start with the middle board
- Remember the students are your audience, not the board!

Even lectures can be interactive

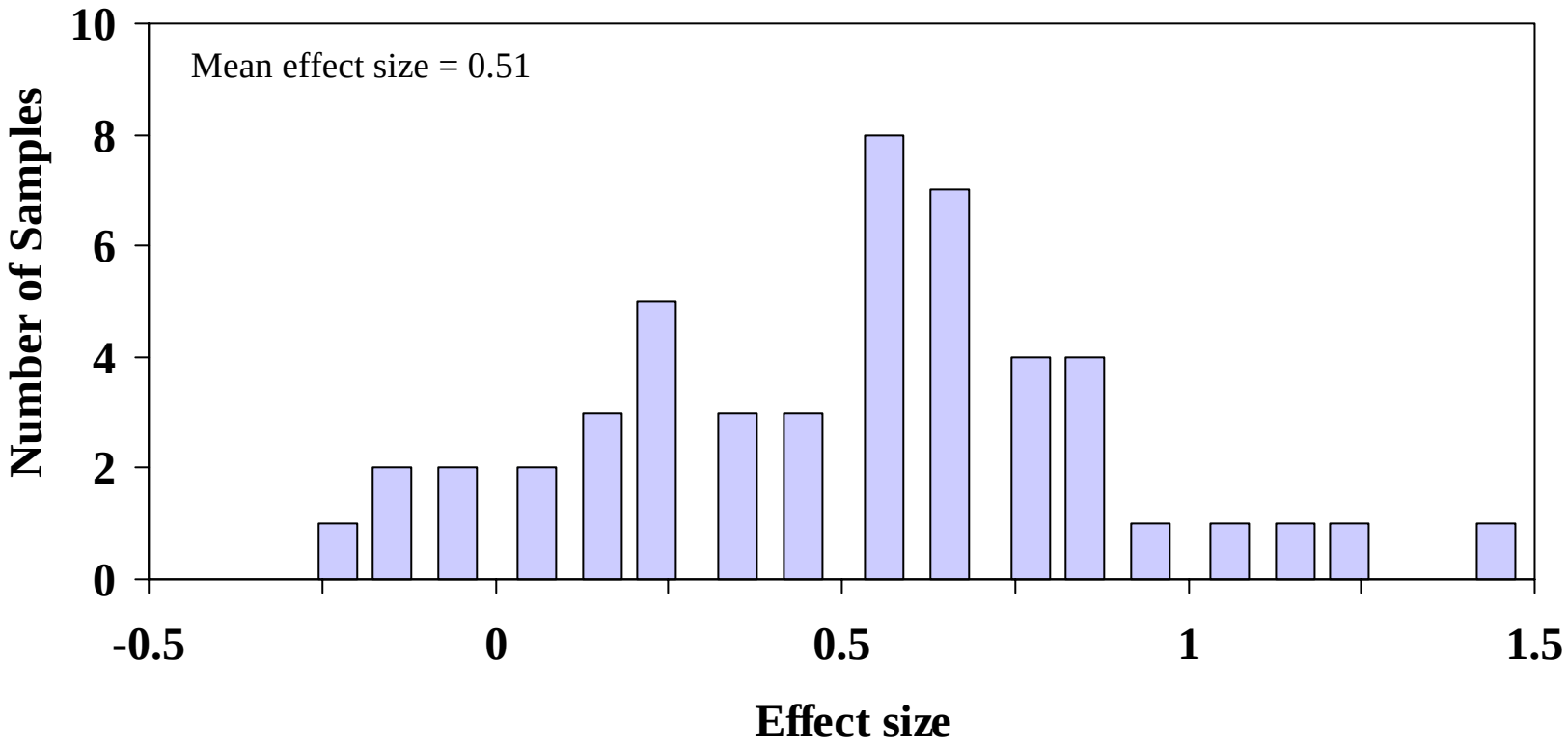
What is Active Learning?

". . . Interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussions with peers and/or instructors." (Richard Hake, professor emeritus, department of physics, Indiana University)

“Hierarchy” of Active Learning

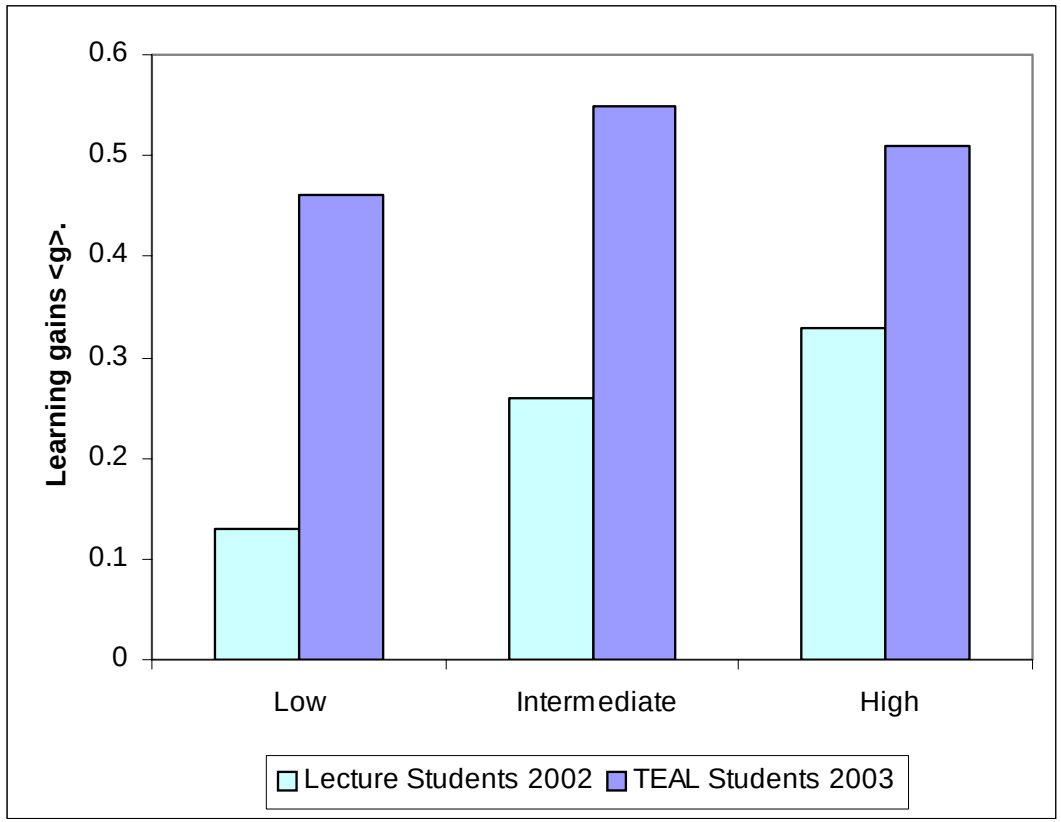


Students Using IE Showed More Achievement



Springer, L., et al. (1997). *Effects of Small-Group Learning on Undergraduates in Science, Mathematics, Engineering, and Technology: A Meta-Analysis.* Madison: University of Wisconsin, Research Monograph No. 11, National Center for Improving Science Education.

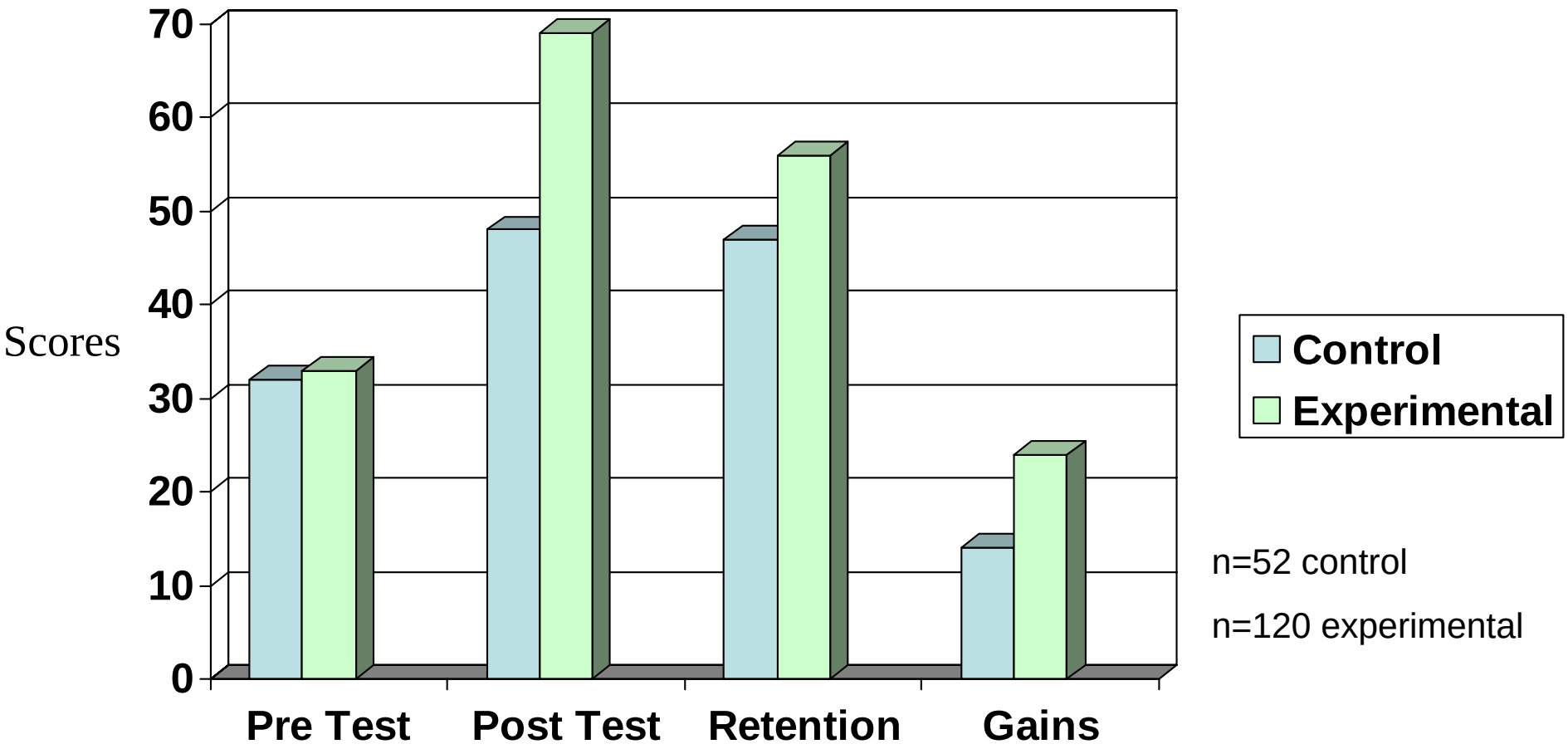
Technology-Enabled Active Learning Increased Learning Gains



Learning gains <g> $= \frac{\%\text{Correct}_{\text{post-test}} - \%\text{ Correct}_{\text{pre-test}}}{100\% - \%\text{Correct}_{\text{pre-test}}}$

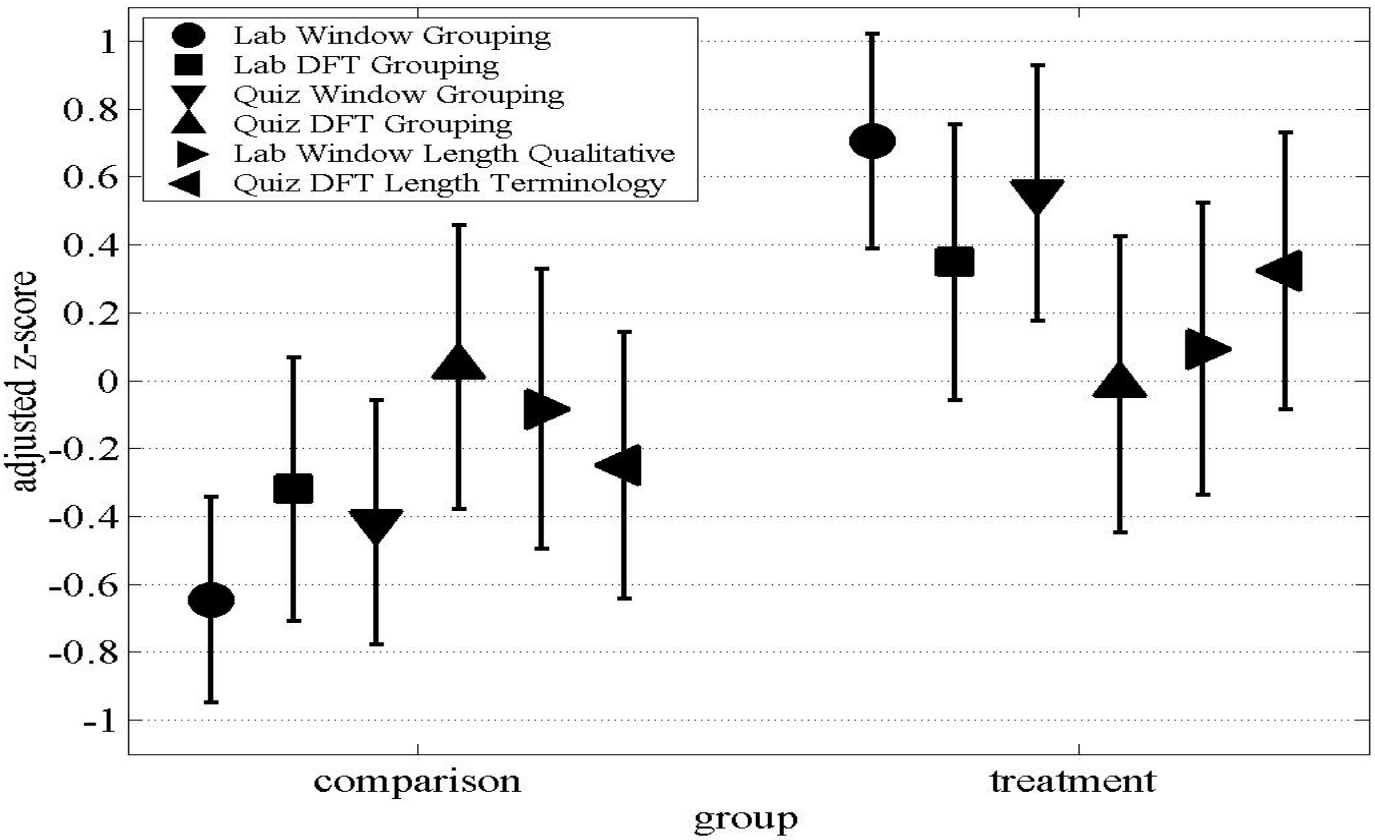
Source: Dori, Y. & Belcher, J. (2004) "How Does Technology-Enabled Active Learning Affect Undergraduate Students' Understanding of Electromagnetic Concepts?" under review at *The Journal of the Learning Sciences*

Increases Seen Long Term



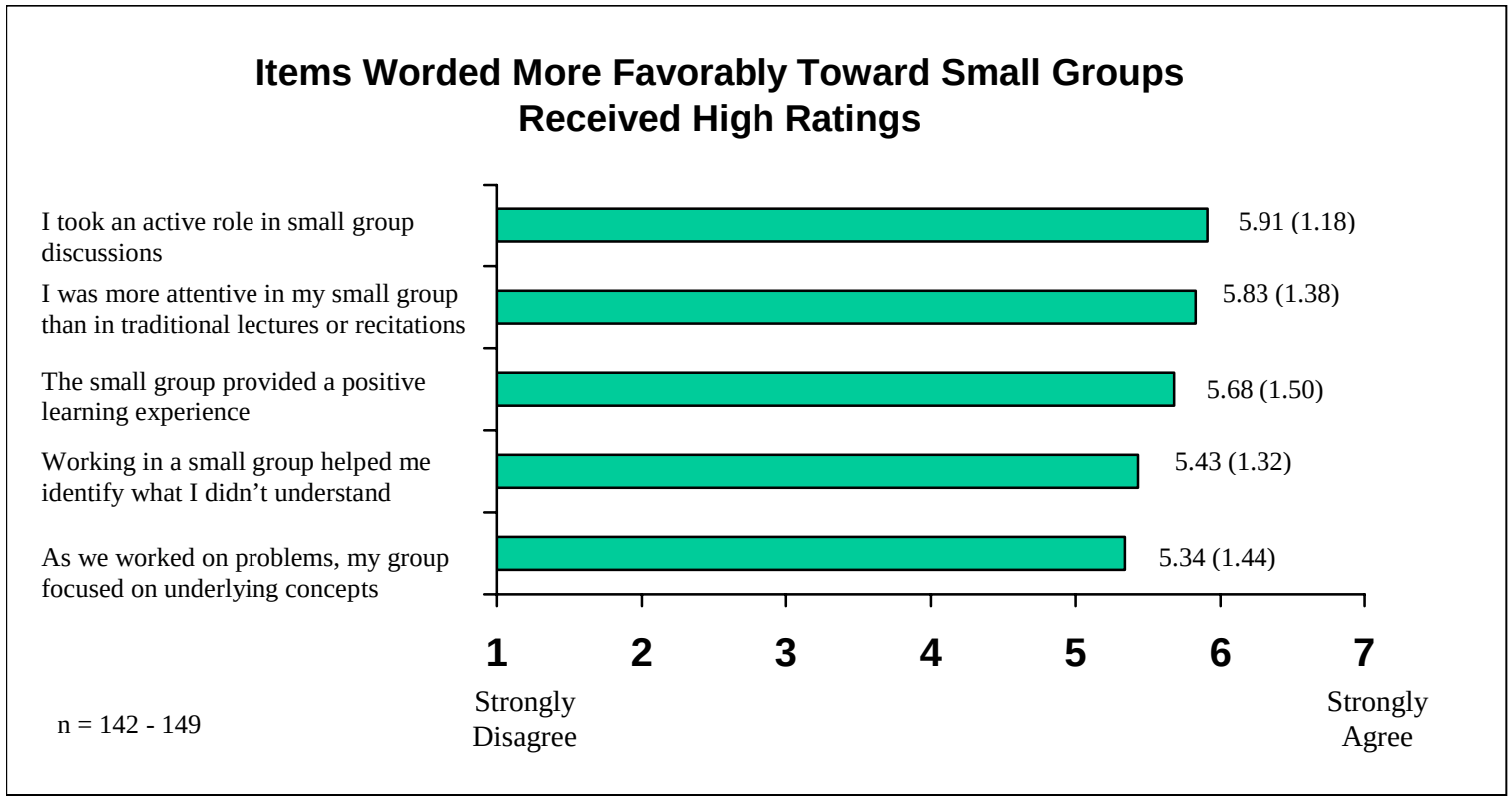
Source: Dori, Y.J., E. Hult, L. Breslow, & J. W. Belcher (2005). "The Retention of Concepts from a Freshmen Electromagnetism Course by MIT Upperclass Students," paper delivered at the NARST annual conference.

A Problem-Based Module Increased Learning Gains



Source: Greenberg, J. Smith, N. & Newman, J. (2003) "Instructional Module in Fourier Spectral Analysis, Based on Principles of How People Learn," *Journal of Engineering Education*

Students Were Positive about Small-Group Experiences



Mitchell, R. & L. Breslow (2005). "Course 2 Summary of Findings: Fall '04 and Spring '05," Unpublished TLL Assessment Report.

Instructors, as well as Students, Benefit from Small-Group Interactions

From an 18.02 small-group leader fall semester 2005:

> These two meetings shook me and, quite bluntly, proved, at least to me, the great benefit of having them. I would never have guessed from looking at the homeworks or from the participation in class of those students that they do not understand basic concepts and notations from the mainstream of the course. It gave me a fantastic opportunity to work with them 1-on-1 and give them specific guidance and suggestions for further work at home . . .

Source: E-mail to 18.02 recitation leaders, September 2005.

“Seatwork”: Assigning the Problem

- Devise criteria for selecting problems
  - Representative of material covered in lecture?
  - Similar to problems on quizzes and exams?
  - Related to the hardest concepts?
  - Solvable in 10-15 minutes?
- Decide on your policy regarding groups
  - Can students work alone?
  - If not, can they form their own groups?

“Seatwork”: Doing the Problem

- Ask students to face one another
- After a bit, circulate among the groups
- Give groups who are having problems hints
- Encourage students with questions to talk to one another
- Give students who find the problem easy a harder one

“Seatwork”: Reviewing the Problem

- Focus on key idea, key skill, etc. in solving the problem
- Ask for student input
  - Discussion
  - Board work
  - “Tell me”
- Be open to all solutions (but remember all solutions are not created equal)