

Case studies, problem-based learning, and other methods of engaging students

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ASBMB
Student-Centered Education in Molecular Life
Sciences 2009

Topics for today

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- Why active learning?
 - Social constructivism
 - Importance of prior knowledge
- Active learning pedagogies
 - Case-based learning
 - Problem-based learning
 - Process-oriented guided inquiry learning

Social constructivism

- Constructivism
 - Knowledge is constructed in the mind of the learner by the learner.
- Social constructivism
 - This process is enhanced in a socially cooperative environment.

“As the cognitive load increases, the need for student engagement increases.”

Eberlein, T. Kampmeier, J., Minderhout, V., Moog, R., Platt, T., Varma-Nelson, P., and White, H. B. *Biochemistry and Molecular Biology Education* **36**, pp. 262–273, 2008.

Importance of prior knowledge

- Prior knowledge plays a large part in what students will be able to learn in a given context.
- Students make sense of new ideas by connecting them to what they already know.
 - Misconceptions held by the students can be difficult to change.
 - Misconceptions persist, and can interfere with learning.
 - Good students can earn high grades without really understanding the material.

Importance of prior knowledge

- In the Harvard University/Smithsonian *Minds of Our Own* series, researchers show fourth-graders a seed and a log and ask them where the mass comes from.
 - Answer: Sun, soil, water.
- Researchers ask MIT graduates the same question.
 - Answer: Sun, soil, water.
- Students “learn” photosynthesis, but miss the main idea.
 - The misconception? Carbon dioxide has no mass.

DVD: Minds of Our Own—Into Thin Air, Harvard University/Smithsonian

Importance of prior knowledge

- “[Physics education research]..has..established that (1) commonsense beliefs about motion and force are incompatible with Newtonian concepts..(2) conventional physics instruction produces little change in these beliefs, and (3) this result is independent of the instructor and the mode of instruction.”

Hestenes, D., Wells, M., and Swackhamer, G. *The Physics Teacher* 30, pp. 141-158 (1992).

The force concept inventory

- Designed by three physics instructors to probe student beliefs.
 - The central concept of Newtonian mechanics is force, so questions were written to test student knowledge of forces.
 - Without an understanding of force, students cannot understand mechanics.
- Students are given a series of multiple choice questions in which they need to choose between the correct Newtonian concept and commonsense beliefs.
- The test is not meant to test intelligence, but to serve as a means to identify commonly held misconceptions.

Using the force concept inventory

Hake, Richard R. *Am. J. Phys.* 66(1), January 1998

- A study was conducted with students in 62 introductory physics courses enrolling 6542 students.
 - Fourteen “traditional” (T) courses (n = 2084)
 - Little or no IE methods
 - Passive student lectures
 - Recipe labs
 - Algorithmic problem exams
 - Forty-eight “interactive engagement” (IE) courses (n = 4458).
 - “Heads on” and “hands on” activities that yield immediate feedback through discussion with peers and/or instructors.

Using the force concept inventory

- Students took the 29-item multiple choice test on the first day and then again on the last day of the course.
- An average normalized gain, $\langle g \rangle$, for a course was calculated:

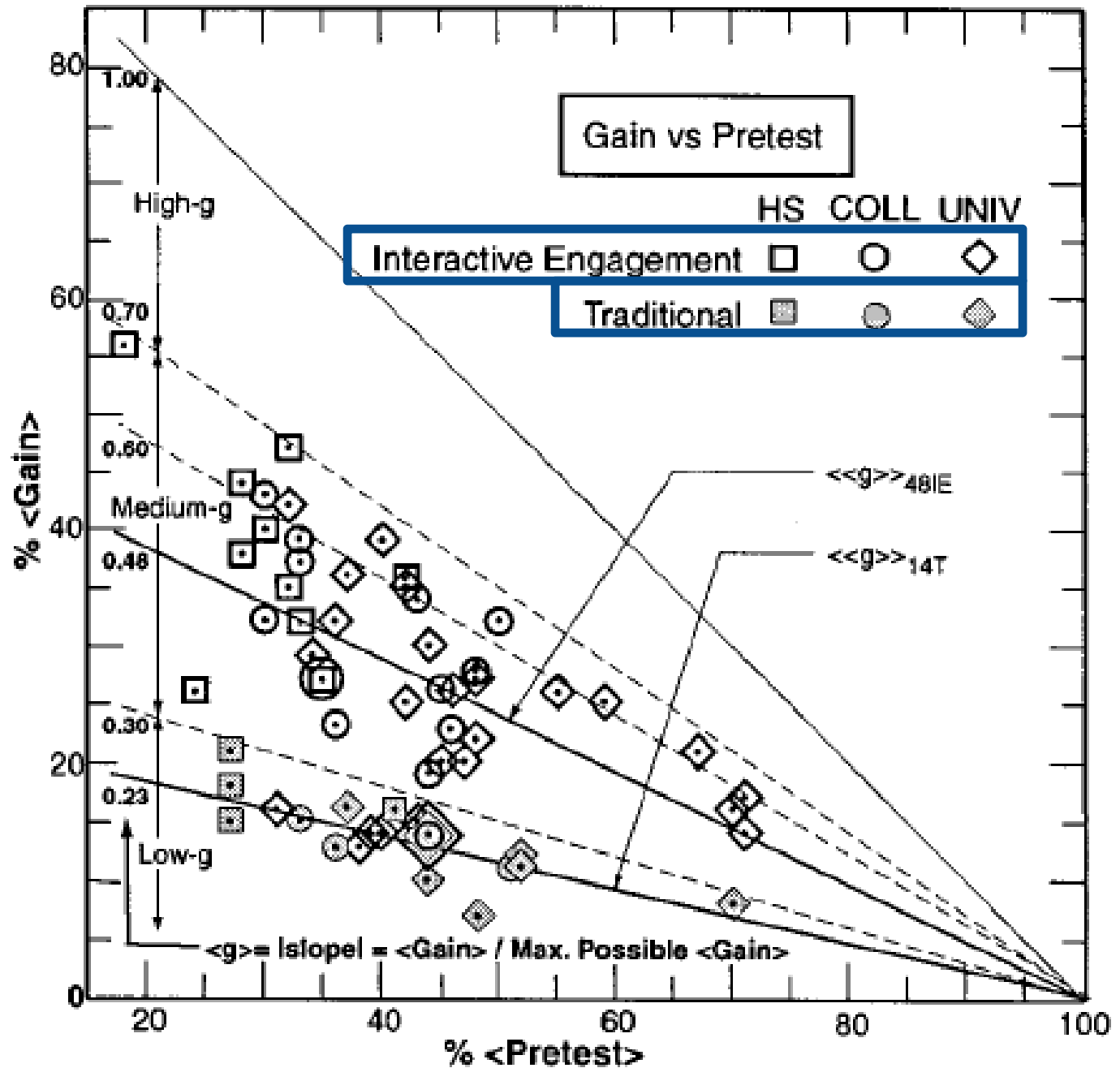
$$\langle g \rangle = \frac{\% \langle G \rangle}{\% \langle G \rangle_{\max}} = \frac{(\% \langle S_f \rangle - \% \langle S_i \rangle)}{(100 - \% \langle S_i \rangle)}$$

Using the force concept inventory

$$\langle g \rangle = \frac{\% \langle G \rangle}{\% \langle G \rangle_{\max}} = \frac{(\% \langle S_f \rangle - \% \langle S_i \rangle)}{(100 - \% \langle S_i \rangle)}$$

- “High g” courses have a $\langle g \rangle$ value greater than 0.7.
- “Medium g” courses have $\langle g \rangle$ values between 0.3 and 0.7
- “Low g” courses have $\langle g \rangle$ values less than 0.3

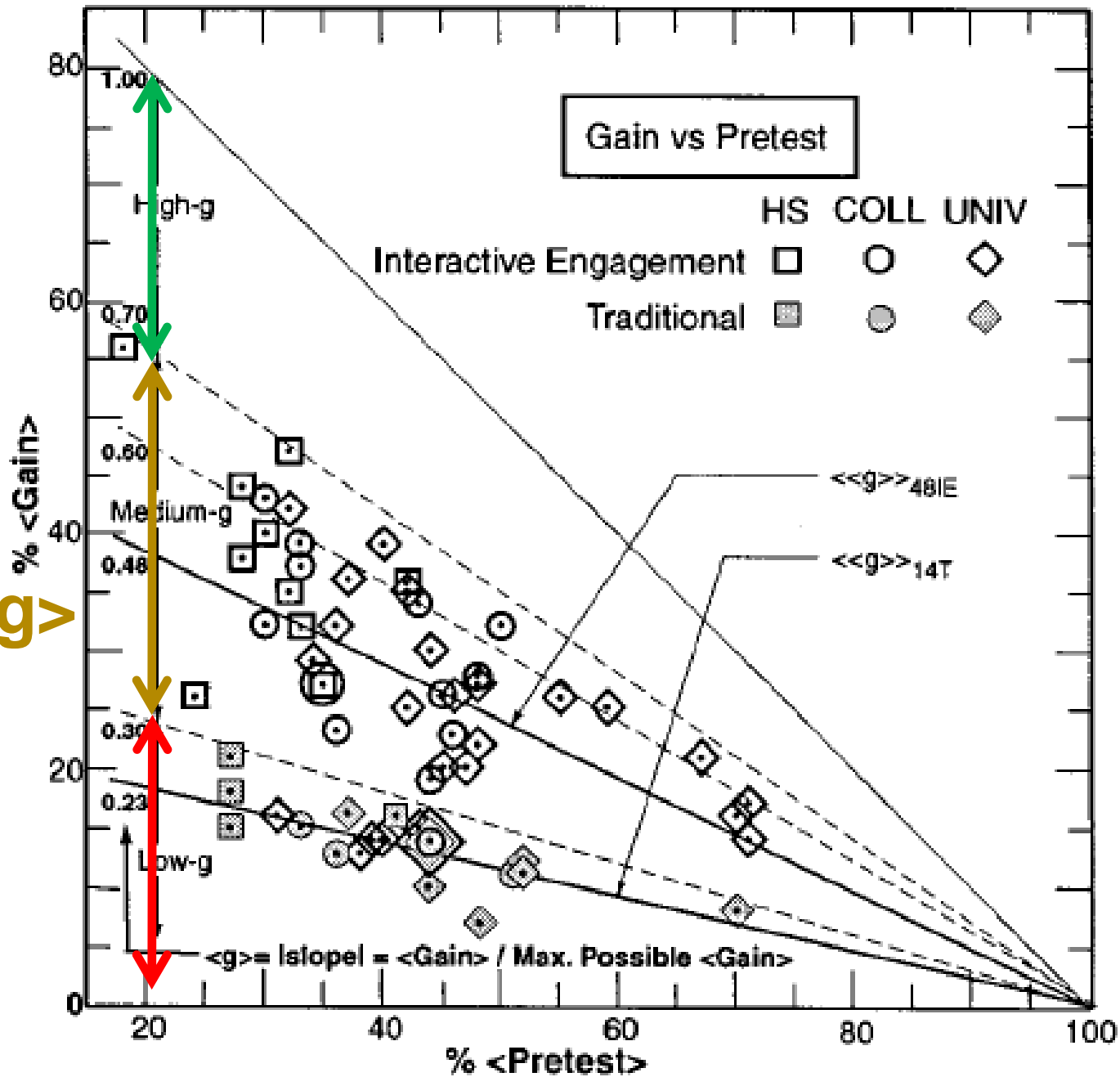
- IE courses are shown by open squares, circles or diamonds.
- T courses are shown by filled shapes.



High $\langle g \rangle$

Medium $\langle g \rangle$

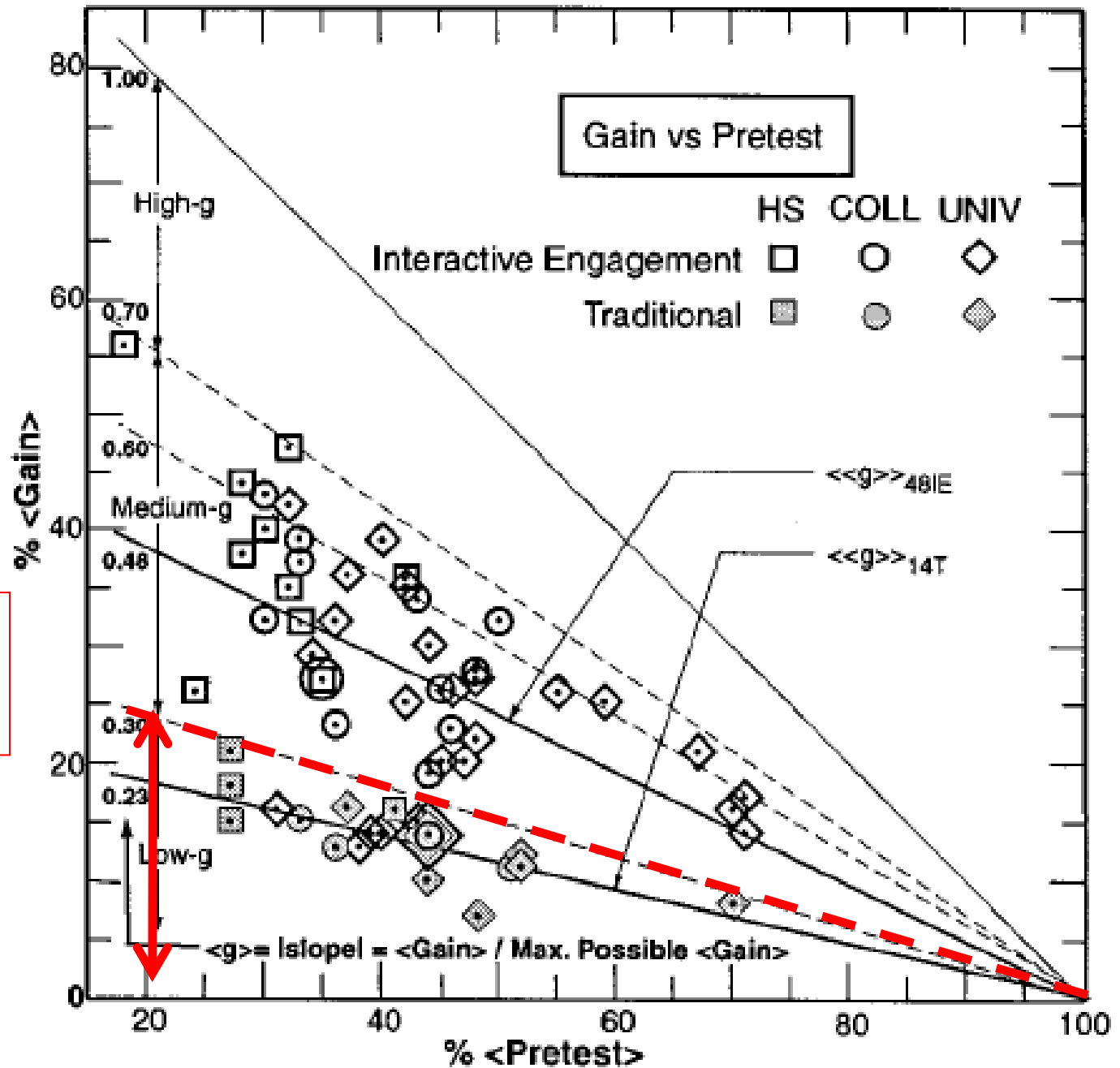
Low $\langle g \rangle$



All points for the fourteen "T" courses fall in the low $\langle g \rangle$ region.

$$\langle\langle g \rangle\rangle_{14T} = 0.23 \pm 0.04$$

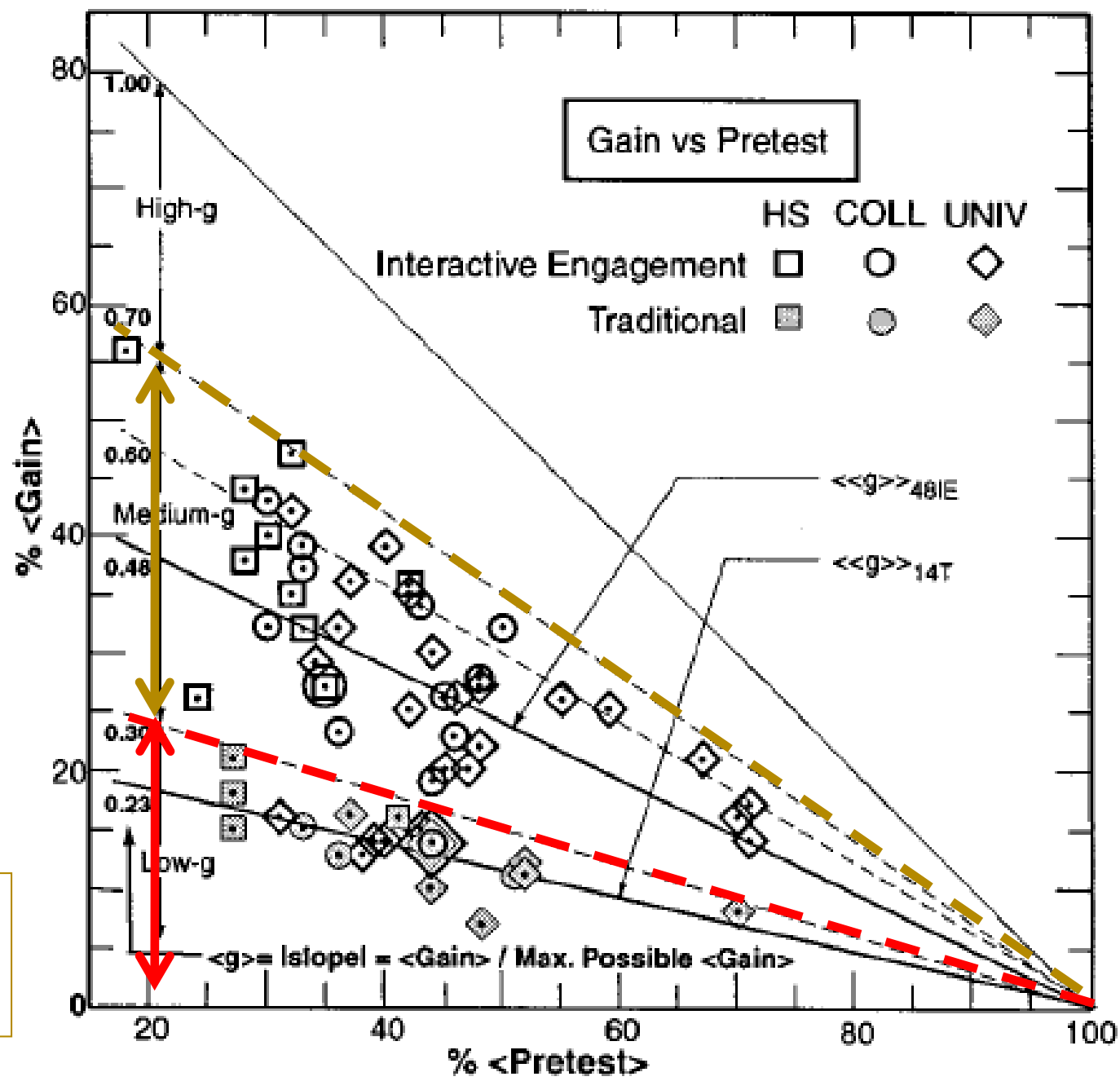
Low $\langle g \rangle$



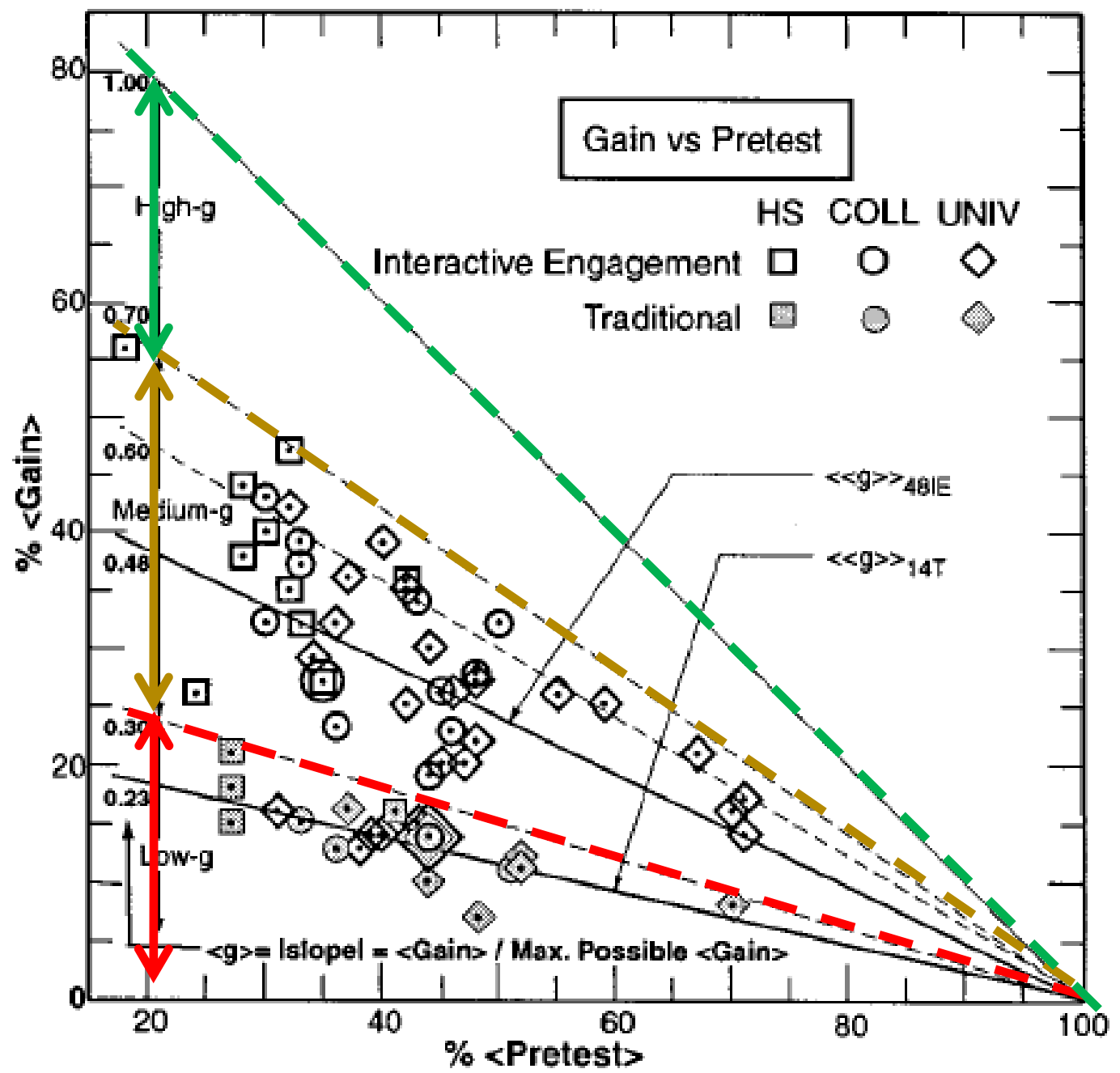
41 of the 48 IE courses fall in the medium-g region.

Seven of the 48 IE courses fall in the low-g region.

$$\langle\langle g \rangle\rangle_{48IE} = 0.48 \pm 0.14$$



None of the courses fell in the high-g region.



Using the force concept inventory

- “Assuming, then, that $\langle g \rangle$ is a valid measure of course effectiveness in promoting conceptual understanding, it appears that the present interactive engagement courses are, on average, more than twice as effective in building basic concepts as traditional courses.”

Hake, Richard R. *Am. J. Phys.* 66(1), January 1998

Other concept inventories

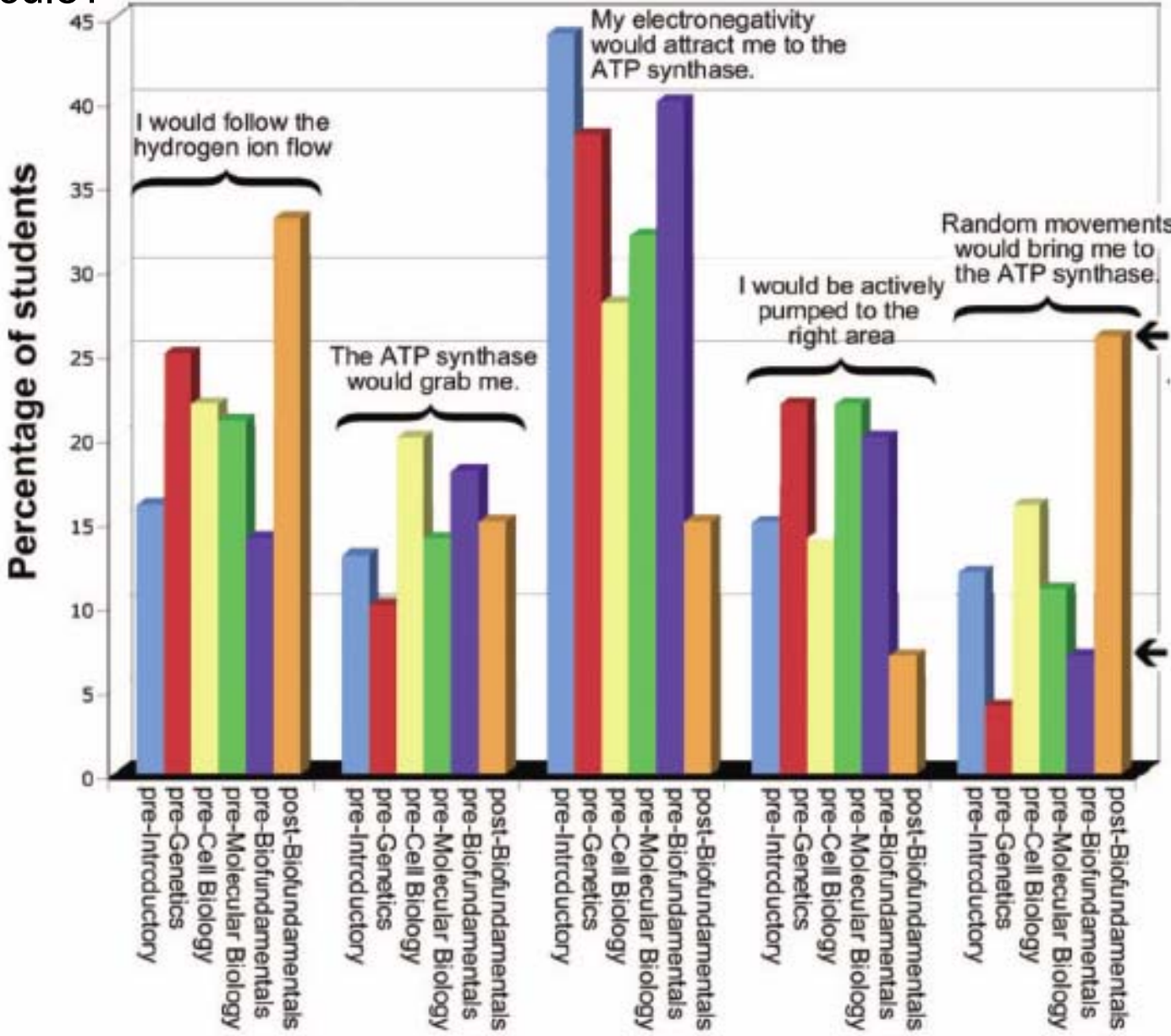
- The Biological Concept Inventory (BCI) was developed by Garvin-Doxas and Klymkowsky.
- Students believe that biological processes are efficient and random processes are inefficient.
 - This misconception hampers understanding of biological processes from diffusion to evolution.

The Biological Concept Inventory

Garvin-Doxas, K., and Klymkowsky, M., *CBE—Life Sciences Education* Vol. 7, 227–233, Summer 2008

Imagine that you are an ADP molecule inside a bacterial cell. Which best describes how you would manage to “find” an ATP synthase so that you could become an ATP molecule?

- Pre-Introductory
- Pre-Genetics
- Pre-Cell Biology
- Pre-Molecular Biology
- Pre-Biofundamentals (“transformed” Intro Bio)
- Post-Biofundamentals



The biochemistry concept inventory

[Link to article on-line](#)



Special Technical Feature

A CONCEPT INVENTORY FOR MOLECULAR LIFE SCIENCES: HOW WILL IT HELP YOUR TEACHING PRACTICE?

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Why active learning in biochemistry?

- The Education and Professional Development Committee (EPD) of the American Society for Biochemistry and Molecular Biology (ASBMB) has prepared a list of skills that all students should have when they graduate with a degree in biochemistry.

<http://www.faseb.org/asbmb/epd/Curriculum.html>

Skills that biochemistry students should obtain

- Understanding of the key principles of biochemistry and molecular biology.
- Ability to dissect a problem.
- Ability to interpret experimental data.
- Awareness of how to use available resources.
- Ability to collaborate with other researchers.
- Ability to think in an integrated manner and look at problems from different perspectives.

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The “process vs. content” debate

- Core knowledge...
 - Boyer (*BAMBED* **28** (2000), pp. 292-296) has suggested a list of “core topics” that should be covered in an intro biochemistry course.
- Or core skills?
 - Ross Feldberg (*BAMBED* **29** (2001), pp. 222-224) suggests that instructors make up a skill set.
 - Then address how each topic contributes to the acquisition of that skill.

“Content” or “directed” case studies

- First described by physiologists Cliff and Wright (*Am. J. Physiol.* **270**: S19-S28 (1996))
 - They wrote clinical cases designed to teach students basic principles of anatomy and physiology.
 - The cases were built around very specific learning objectives, rather than being open-ended.
 - Questions are straightforward and emphasis is on information that is available to the student.
- The case study method is used as an alternative to the lecture to convey scientific content to the students.
 - Some instructors are reluctant to use the case study method because they feel that doing so would decrease the amount of coverage of the material.

Why use case studies in biochemistry?

“The difficulty of engaging learners in the processes and problems of science is most likely to occur in the first year courses dealing with fundamental topics, as the learners are not yet prepared to perceive the relationship between these topics and the practice of their careers.”

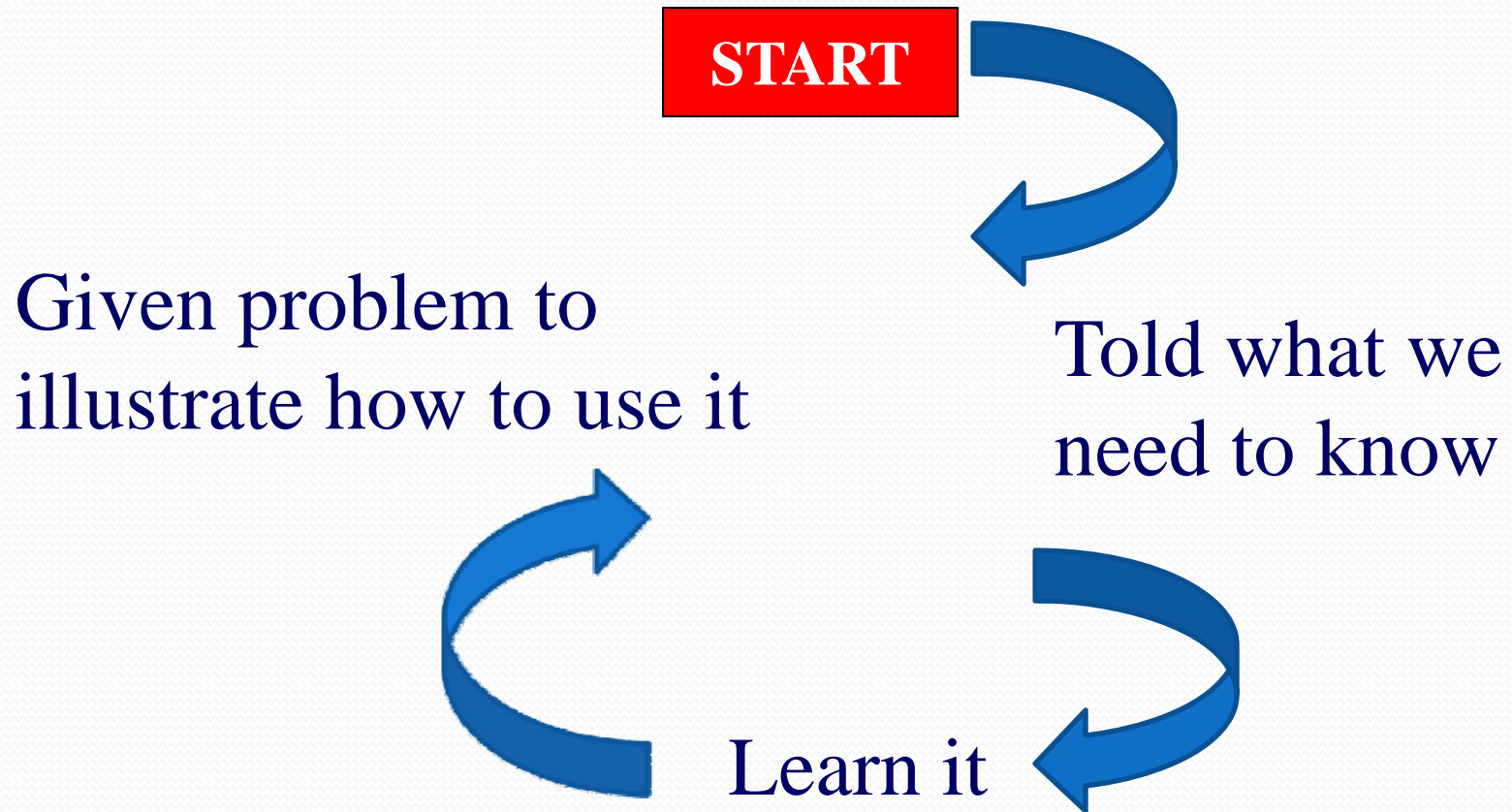
Types of biochemistry case studies

- Metabolic case studies
 - Inborn errors of metabolism
- Analysis of “real” scientific data
 - Taken from introductory biochemistry concepts found in the current literature

Directed case studies—resources

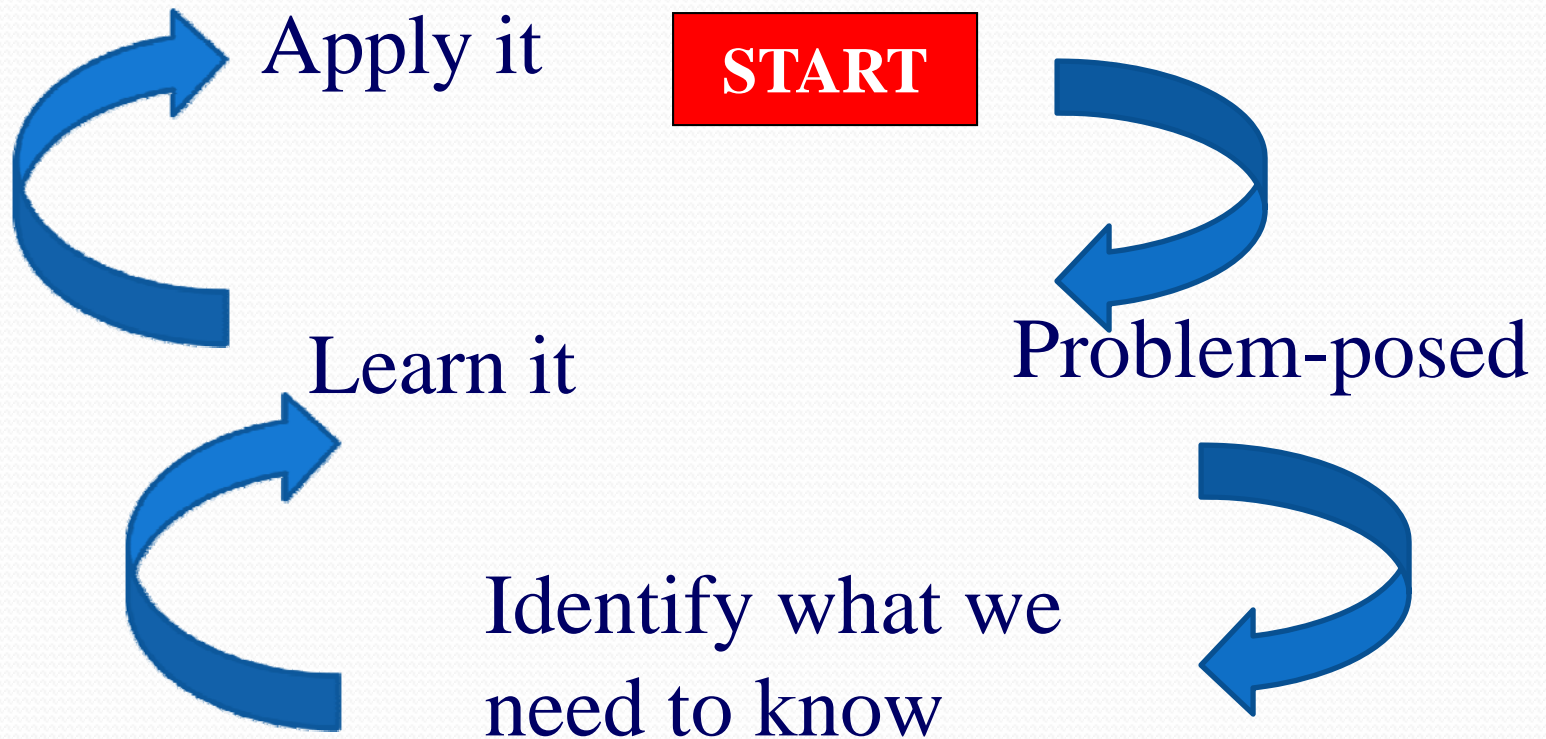
- *Cases in Biochemistry*, published in 1999 by John Wiley & Sons, has been updated and can be found on [my web site](#). The cases are also available on WileyPLUS.
- J. Szeberenyi regularly publishes these types of exercises in [BAMBED](#).
- Clyde Herreid and Nancy Schiller have compiled a bank of case studies developed at their annual case-writing workshops held at [University of Buffalo](#).

PBL vs subject-based learning



From Smith et al, 2005. Pedagogies of engagement: Classroom-based practices. J. Engineering Education, January 2005. 87-101.

PBL vs subject-based learning



From Smith et al, 2005. Pedagogies of engagement: Classroom-based practices. J. Engineering Education, January 2005. 87-101.

PBL: The process

Resolution of Problem;
(How did we do?)



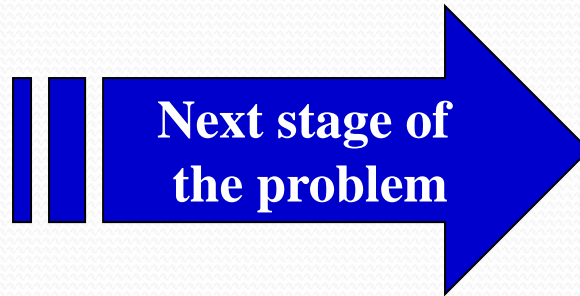
Integrate new
Information;
Refine questions



Reconvene, report
on research;



Research questions;
summarize;
analyze findings



Presentation of Problem



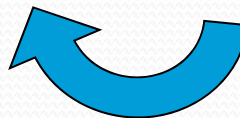
Organize ideas and
prior knowledge
(What do we know?)



Pose questions (What do
we need to know?)



Assign responsibility
for questions; discuss
resources



A typical day in a PBL course



University of Delaware

PBL problems—resources

- Hal White has compiled a list of articles published in *Biochemistry and Molecular Biology Education* (formerly *Biochemical Education*) and has posted the citations on [his web site](#).
- [PBL Clearinghouse](#) at University of Delaware.
- P. K. Rangachari of McMaster University has posted several of his case studies on [his web site](#).

What is POGIL?

- “Process Oriented Guided Inquiry Learning (POGIL) is a research-based learning environment where students are actively engaged in mastering course content and in developing essential skills by working in self-managed teams on guided inquiry activities”.

<http://www.pogil.org>



What is POGIL?

- “In addition to learning, understanding, and applying new concepts, students ... develop... skills in the areas of information processing, critical thinking, problem solving, teamwork, communication, management, and assessment. The instructor ... guide[s] and question[s] the teams as they work through the specially designed activities.”

<http://www.pogil.org>

What is POGIL?

Loertscher and Minderhout, Seattle U.

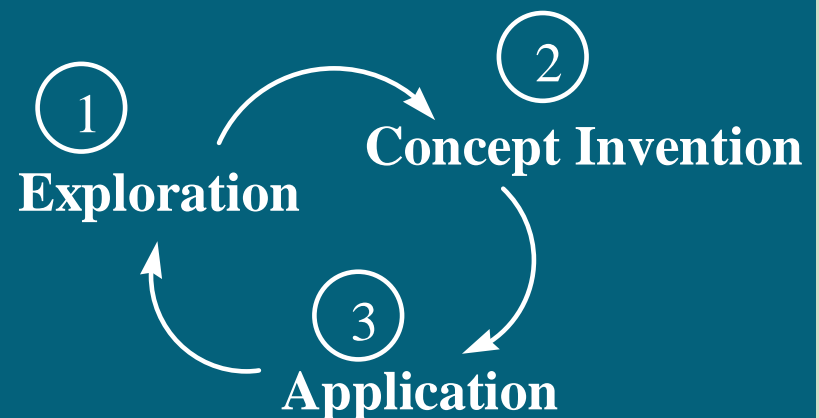
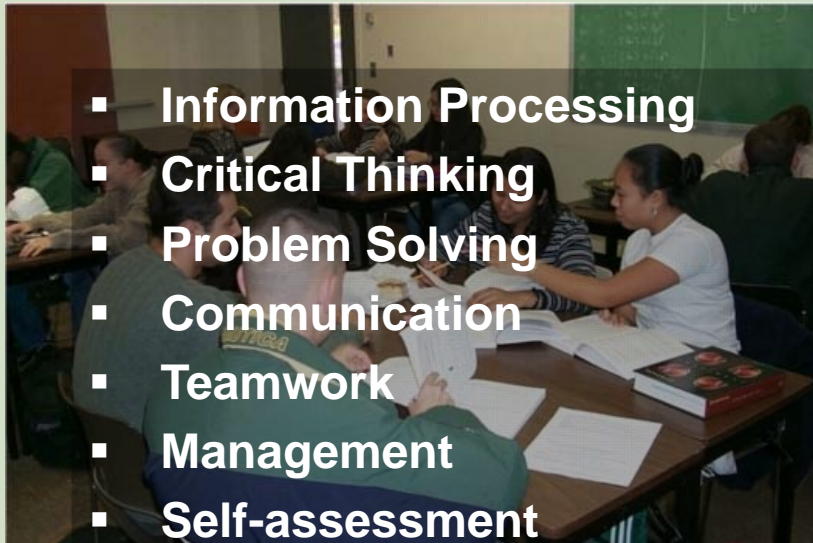
POGIL is a marriage of...

Process **O**riented

Cooperative learning

Guided **I**nquiry

Constructivism



“Concept Formation” activity

The Learning Cycle



- The concepts to be understood are explicitly presented in the Model.
- Key Questions reinforce understanding of presented concepts and develop process skills.

Developing materials

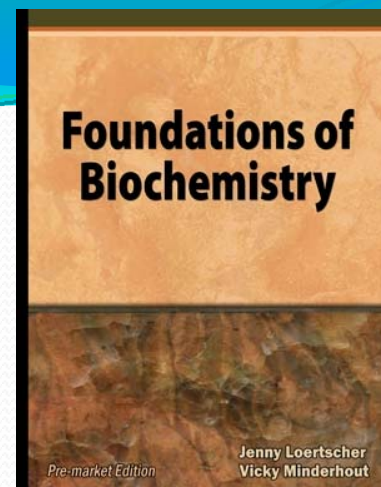
- The activity begins with a model that is used to develop 1-3 key concepts.
 - Key questions guide students to explore desired concepts.
- The students solve exercises, problems, or critical thinking questions in order to apply the concepts learned in the model.
- Specific process skill development takes place in the context of the activity.

Models in biochemistry

- Any figure from the textbook
 - Mechanism
 - Pathway
 - Protein structure
- A graph
- An equation
- A patient
 - Drug overdose
 - Inborn error of metabolism
- A scientific paper

Available materials

- Published materials are available in general, GOB, organic, analytical and physical chemistry.
 - University and high school levels.
- Materials are also available in biology.
- Materials are being developed by the POGIL Biochemistry Core Collaborators group.
 - Vicky Minderhout and Jenny Loertscher at Seattle University are the leaders of this group.
 - Samples available at www.pogil.org.



“Model” resources

- Clarke, J. T. R. (2002) *A Clinical Guide to Inherited Metabolic Diseases*, Cambridge University Press.
- Devlin, T. M. (2006) *Textbook of Biochemistry with Clinical Correlations*, Wiley-Liss.
- Halperin and Rolleston, (1993) *Clinical Detective Stories*, Portland Press.
- Higgins, S. J., *et al.*, (1994) *Biochemistry for the Medical Sciences: An Integrated Case Approach*, Longman Scientific and Technical.
- Glew and Ninomiya (1997) *Clinical Studies in Medical Biochemistry*, Oxford University Press.
- Luduena, R. F. (1995) *Learning Biochemistry: 100 Case-Oriented Problems*, Wiley-Liss.
- Montgomery, *et al.*, (1990) *Biochemistry: A Case-Oriented Approach*, CV Mosby.
- Walmsley, *et al.*, (1999) *Cases in Chemical Pathology*, World Scientific.

Conclusion

“Perhaps the entire conference [PBL 2002] could be summarized by this statement from Ed Wood’s paper presentation: “PBL encourages active learning and the development of higher order thinking skills, so why don’t we just get on with it?”

Cornely, K. *Biochemistry and Molecular Biology Education*, 40 (6) pp. 422-423.

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