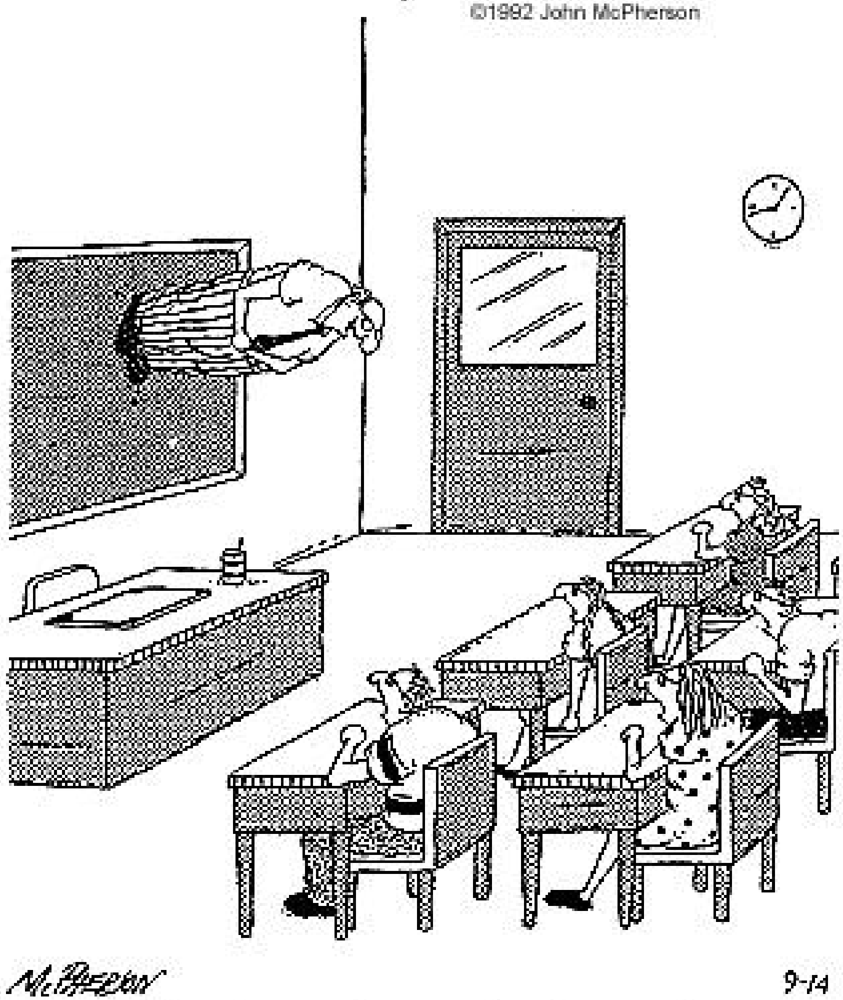
CLOSE TO HOME By John McPherson



"Good morning, and welcome to The Wonders of Physics."

Human behavior in all realms is beset by wishful thinking—the tendency of people to really believe that what they <u>want</u> to be true <u>is</u> true.

Edward F. Redish
Millikan Lecture, 1998

How can you distinguish science from junk?
Science posits hypothesis and tests them.
Pseudoscience assumes conclusions and finds evidence to back them up.

Wendy Kaminer
***Sleeping with Extra-Terrestrials*, 1999**

The first principle is that you must not fool yourself – and you are the easiest person to fool.

Richard Feynman

It's not what you don't know that hurts you. It's what you know that ain't so.

Mark Twain

Don’t Believe Everything You Think

6 Basic Mistakes We Make in Thinking
(There are many more)

- We prefer stories to statistics (data).
- We seek to confirm, not to question, our ideas.
- We rarely appreciate the role of chance and coincidence in shaping events.
- We sometimes misperceive the world around us.
- We tend to oversimplify our thinking.
- We have faulty memories.

The Hidden Curriculum
(Perry-Belenky Scheme)

1. Binary / Received Knowledge Stage
   - Everything is true or false, good or evil, right or wrong, etc.
   - "Truth" is learned from authorities
   - Student wants to be told the "right" answer
   - Memorization
     - Long lists of uninterpreted facts
     - Algorithmic solutions to problems
       - w/o thought
       - w/o making sense
     - Efficient route to knowledge
       - Declarative, Superficial
       - Received from "authority", without evidence or support
       - Situation dependent
       - Quickly forgotten

2. Subjective / Multiplist / Relativist Stage
   - Nothing is true or false, good or evil, right or wrong, etc.
   - Every view has equal value
   - Knowledge is a matter of opinion

3. Constructivist Stage

- Weigh evidence, evaluate the merit of various positions
- Recognize contextual nature of knowledge
- Recognize that perspective, assumptions, and method of inquiry colors what one knows or concludes.

4. Consciously Constructivist Stage

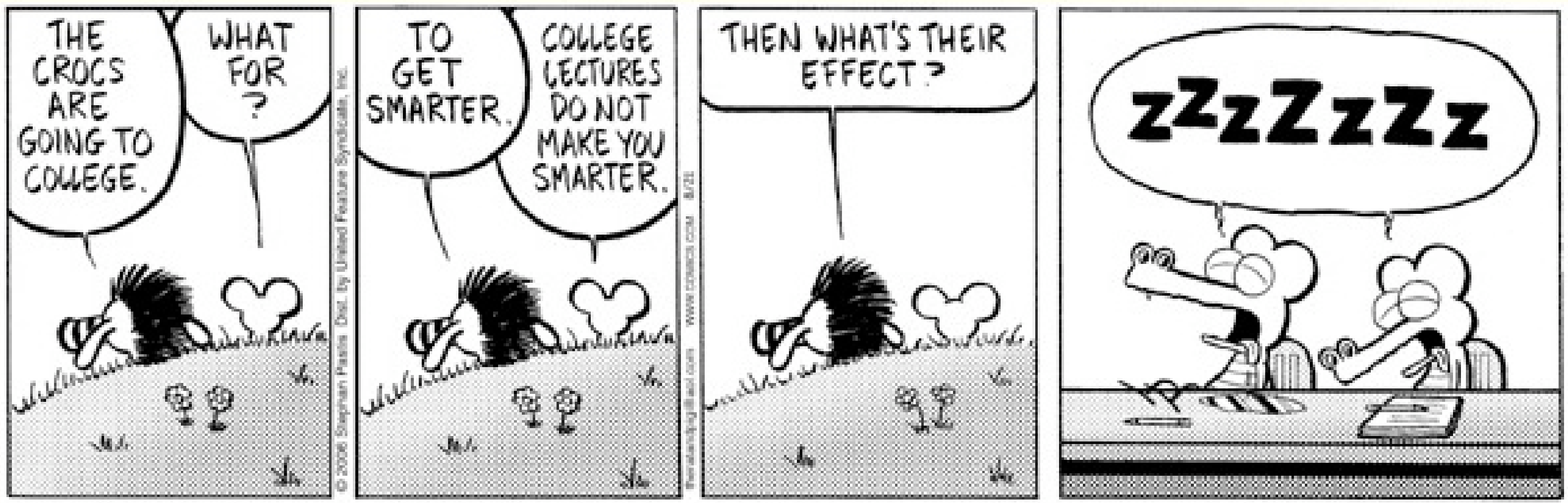
(Need to be here to be a creative scientist)
(Can <u>not</u> be achieved if the instructor does all or most of the talking)

- Accept personal role in deciding productive and useful views
- Nothing can be perfectly known
- Integrate knowledge with own experiences and perspective
- Takes charge of building own understanding
- Carries out own evaluation of
  - Approach
  - Result
- Understands conditions of validity
- Understands fundamental principles
- Consciously raises questions:
  - What do we know …?
  - How do we know …?
  - Why do we accept or believe …?
  - What is the evidence for …?
- Is clearly and explicitly aware of gaps in available information

Consciously Constructivist Stage (continued)

- Probes for assumptions behind a line of reasoning (particularly implicit, unarticulated assumptions)
- Recognizes that words are symbols for ideas, not the ideas themselves
  - Uses only words of prior definition, rooted in shared experience, in forming a new definition
  - Avoids being misled by technical jargon
- Discriminates between observation and inference, between established fact and subsequent conjecture
- Draws inferences from data, observations, or other evidence
  - Recognizes when firm inferences cannot be drawn
  - Recognizes when relevant variables have or have not been controlled
- Discriminates between inductive and deductive reasoning
  - Inductive: Argument made from the particular to the general
  - Deductive: Argument made from the general to the particular
- Performs hypothetico-deductive reasoning
  - Given a particular situation, applies relevant knowledge of principles and constraints to visualize in the abstract the plausible outcomes of changes imposed on the system
- Tests one's own line of reasoning and conclusions for internal consistency
  - Develops intellectual self-reliance
- Develops self-consciousness concerning one's own thinking and reasoning processes
  - Recognizes the reasoning process one is using
  - Invokes the most appropriate reasoning process for the circumstances
  - Transfers reasoning methods from familiar to unfamiliar contexts


What we say to dogs
Okay, Ginger! I've had it! You stay out of the garbage! Understand, Ginger? Stay out of the garbage, or else!
What they hear
blah blah GINGER blah blah blah blah blah blah blah blah GINGER blah blah blah blah blah...
Larson


THE CROCS ARE GOING TO COLLEGE.
WHAT FOR ?
TO GET SMARTER.
COLLEGE LECTURES DO NOT MAKE YOU SMARTER.
THEN WHAT'S THEIR EFFECT ?
zzzZzzZz

Learner Attentiveness

Lecture presented by a brilliant scholar with an outstanding topic to a highly competent audience.

Elapsed time after start of lecture	**Audience**	**Behavior**
15 min.	**10%**	**inattentive**
18 min.	**33%**	**inattentive**
35 min.	**100%**	**inattentive**
45 min.	**20%**	**transitive**
47 min.	**18%**	**asleep**

- 24 hrs. later: 50% could recall only insignificant details about the lecture and these were generally incorrect.

Verner, C. and Dickinson, G. (1967) *The Lecture, an Analysis and Review of Research*, Adult Education, 17, 85-100

Shortcomings of Traditional Lecture-Based Instruction

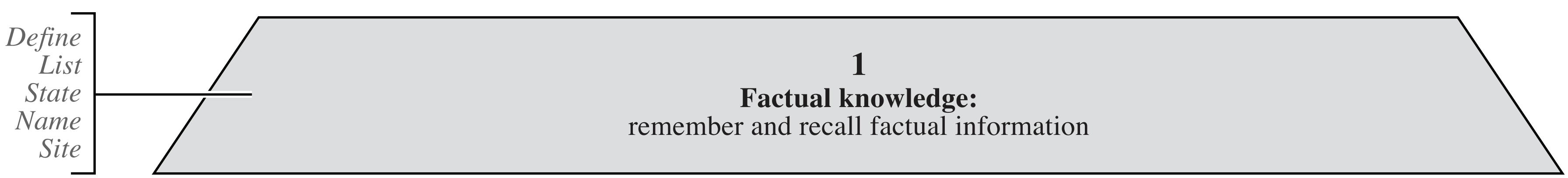
1. Lectures are best for inspiration and an alternative to reading the textbook for the transmission of information, but are ineffective for teaching concepts.

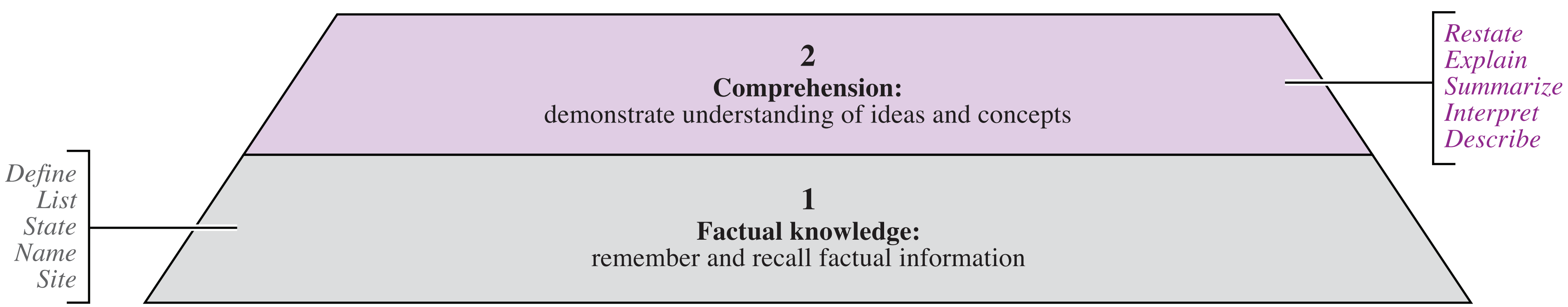
2. Students lack sufficient concrete experience with physical phenomena to comprehend the theories and mathematical derivations presented in lectures.

3. Passive learning fails to confront and deal with students' misconceptions about physical phenomena.

4. Cognitive overload that comes when too much material is covered leads to rote memorization.

5. Students are not engage in scientific reasoning, in particular in the process of abstraction and generalization.


Define
List
State
Name
Site
1
Factual knowledge:
remember and recall factual information


2
Comprehension:
demonstrate understanding of ideas and concepts
Restate
Explain
Summarize
Interpret
Describe
1
Factual knowledge:
remember and recall factual information
Define
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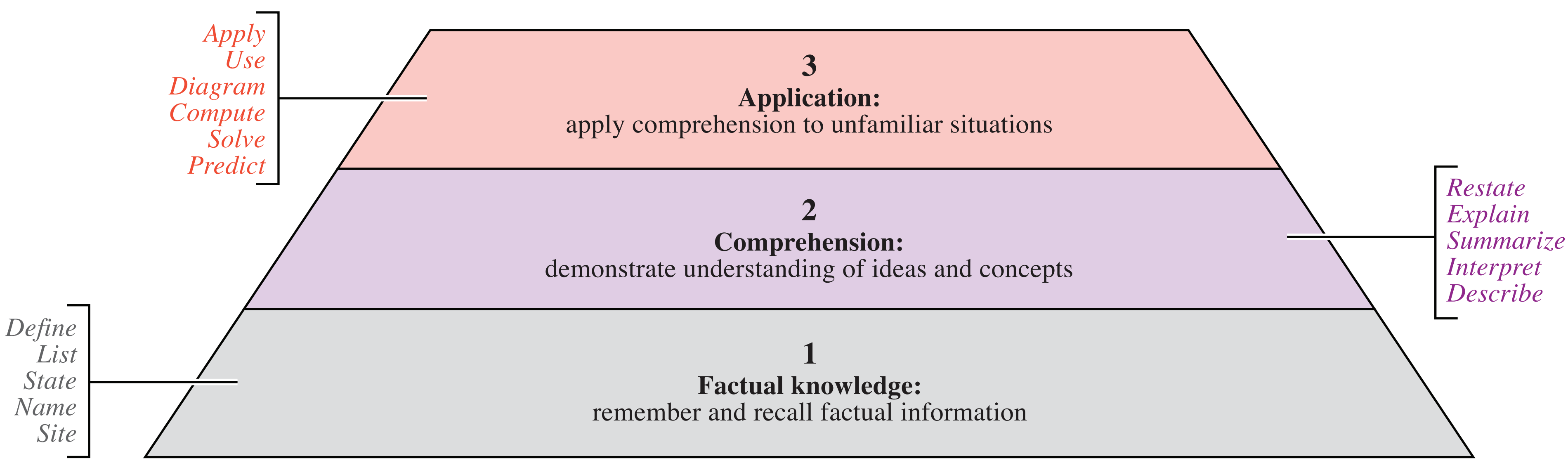
Site


Apply
Use
Diagram
Compute
Solve
Predict
3
Application:
apply comprehension to unfamiliar situations
2
Comprehension:
demonstrate understanding of ideas and concepts
Restate
Explain
Summarize
Interpret
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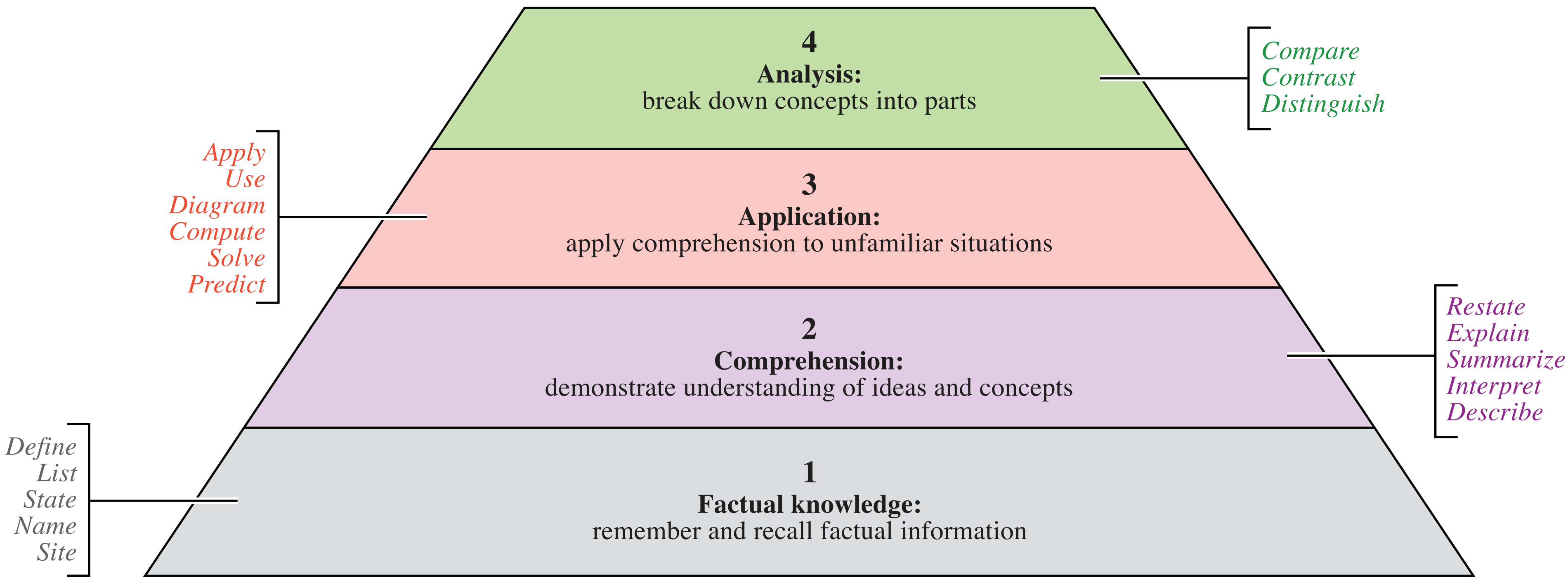

4
Analysis:
break down concepts into parts
Compare
Contrast
Distinguish
3
Application:
apply comprehension to unfamiliar situations
Apply
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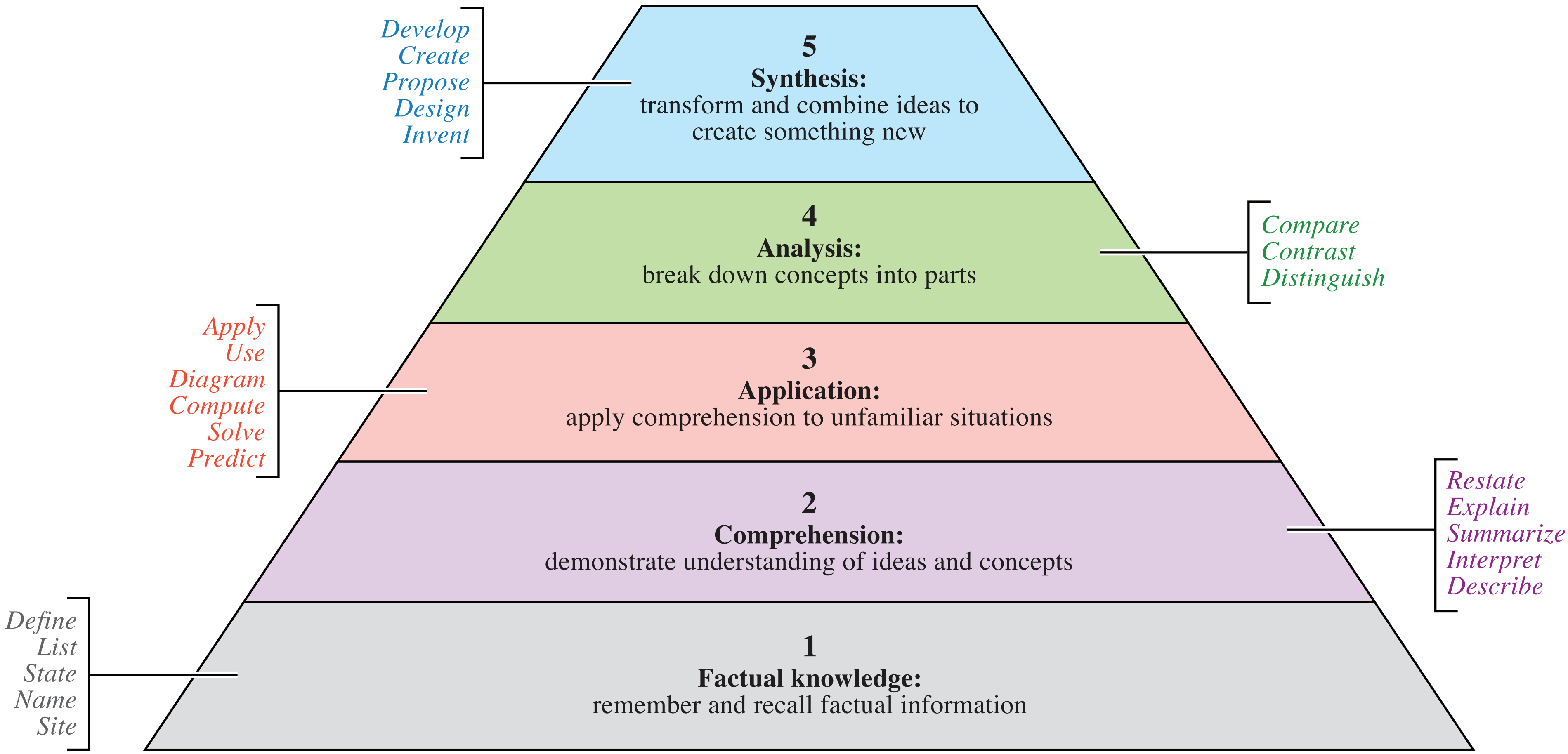

Develop
Create
Propose
Design
Invent
5
Synthesis:
transform and combine ideas to create something new
4
Analysis:
break down concepts into parts
Compare
Contrast
Distinguish
Apply
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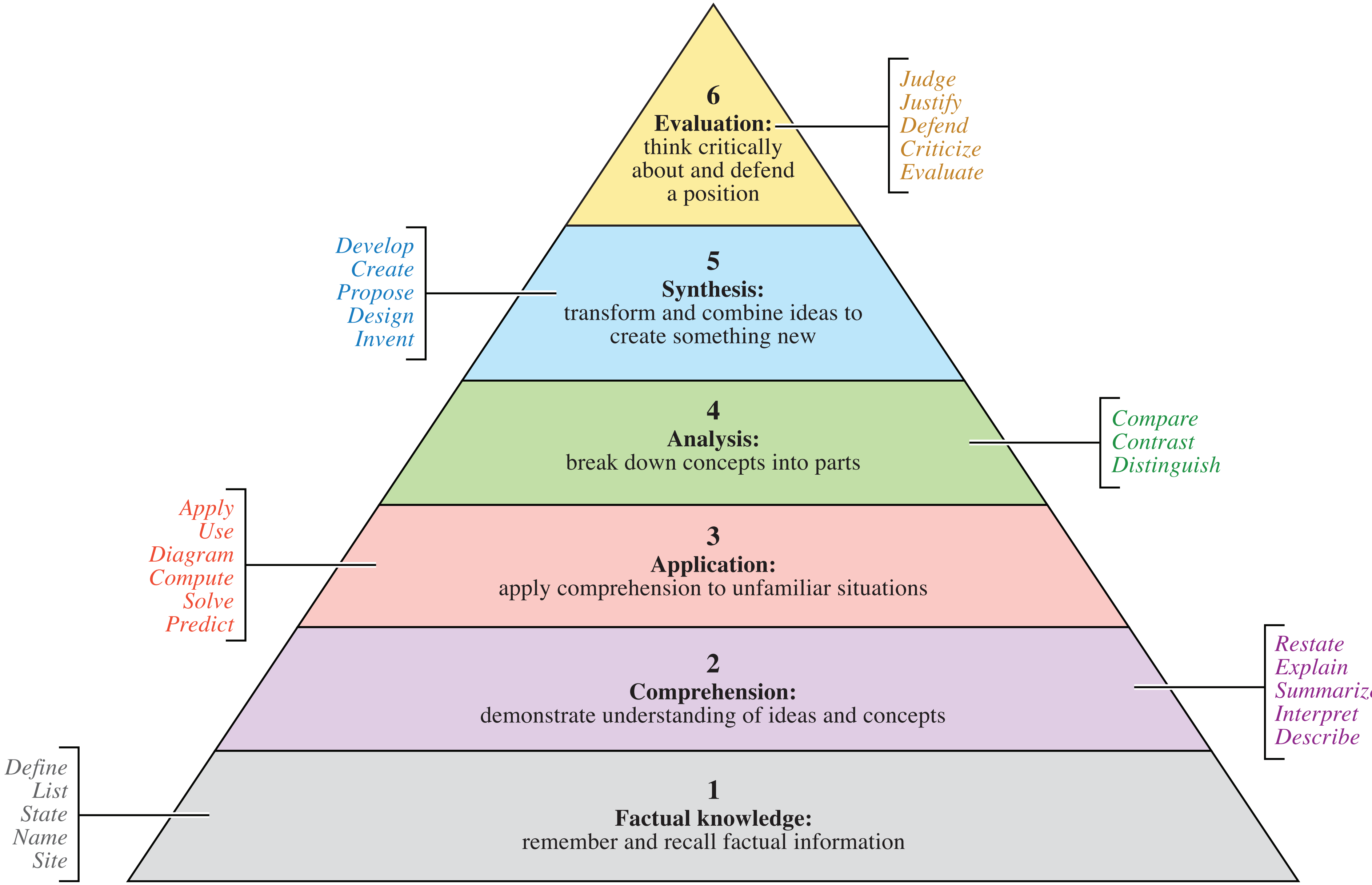
6
Evaluation:
think critically about and defend a position
Judge
Justify
Defend
Criticize
Evaluate
5
Synthesis:
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Bloom’s Taxonomy

Educational objective	Brief description of objective
1. Knowledge	**Remembers facts, conventions, classifications, methods, and principles.**
2. Comprehension	**Understands and interprets phenomena when presented in verbal, pictorial, diagrammatic, graphical, or symbolic form.**
3. Application	**Applies knowledge productively to new problems without prompting concerning the principles to use. Uses productive problem solving strategies.**
4. Analysis	**Breaks material into its constituent parts. Detects relationships between these parts. Recognizes organizing principles and knowledge structures.**
5. Synthesis	**Combines previous conceptual and procedural knowledge with new to form a well integrated whole. Designs investigations and products — creative work.**
6. Evaluation	**Judges the value of work—its accuracy, effectiveness, and reasonableness. Are assumptions warranted? Are ideas supported by observations and consistent with each other?**

Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook I Cognitive Domain, B.S. Bloom

Cognitive Attitudes

(Dimensions of student "expectations")

	Favorable	Unfavorable
Independence	**Learns independently, believes in their own need to evaluate and understand**	**Takes what is given by authorities (teacher, text) without evaluation**
Coherence	**Believes physics needs to be considered as a connected, consistent framework**	**Believes physics can be treated as separated facts or "pieces"**
Concept	**Stresses understanding of the underlying ideas and concepts**	**Focuses on memorizing and using formulas**
Reality link	**Believes ideas learned in physics are useful in a wide variety of real-world contexts**	**Believes ideas learned in physics are unrelated to experiences outside the classroom**
Math link	**Considers mathematics as a convenient way of representing physical phenomena**	**Views the physics and the math as independent with no strong relationship between them**
Effort	**Makes the effort to use information available to them to modify and correct their thinking**	**Does not use available information about their own thinking effectively**

- Student attitudes can be at either extreme or somewhere in between.
- Research at UMD (MPEX) and ASU (VASS) has shown that, on the average, the percentage of students with favorable attitudes tends to deteriorate as a result of traditional instruction.

Traditional vs. Learning-to-Learn Strategies

Conventional	Developing learning skills
Skills of learning are covert (hidden)	Skills of learning are made overt and discussed
The instructor explains concepts	Learners develop concepts
Learner is passive	Learner is active
Mistakes are mostly avoided	Mistakes are viewed as useful learning opportunities
Instructor poses questions and provides solutions	Instructors poses problems and discusses learner's solutions
Assessment concerns primarily the product	Concerned with the product and the process—both are important

Learning Management: Emerging Directions for Learning to Learn in the Workplace, S. S. Downs
Learning How to Learn, J. D. Novak and D. B. Gowin

Table 2.1 of the AAAS's Vision and change in undergraduate biology education (VCUBE).

Core Competency	Ability to apply the process of science	Ability to use quantitative reasoning	Ability to use modeling and simulation	Ability to tap into the interdisciplinary nature of science	Ability to communicate and collaborate with other disciplines	Ability to understand the relationship between science and society
Instantiation of ability in disciplinary practice	Biology is an evidence-based discipline	Biology relies on applications of quantitative analysis and mathematical reasoning	Biology focuses on the study of complex systems	Biology is an interdisciplinary science	Biology is a collaborative scientific discipline	Biology is conducted in a societal context
Demonstration of competency in practice	Design scientific process to understand living systems	Apply quantitative analysis to interpret biological data	Use mathematical modeling and simulation tools to describe living systems	Apply concepts from other sciences to interpret biological phenomena	Communicate biological concepts and interpretations to scientists in other disciplines	Identify social and historical dimensions of biology practice
Examples of core competencies applied to biology practice	Observational strategies	Developing and interpreting graphs	Computational modeling of dynamic systems	Applying physical laws to biological dynamics	Scientific writing	Evaluating the relevance of social contexts to biolog--ical problems
	Hypothesis testing	Applying statistical methods to diverse data	Applying informatics tools	Chemistry of molecules and biological systems	Explaining scientific concepts to different audiences	Developing biological applications to solve societal problems
	Experimental design	Mathematical modeling	Managing and analyzing large data sets	Applying imaging technologies	Team participation	Evaluating ethical implications of biological research
	Evaluation of experimental evidence	Managing and analyzing large data sets	Incorporating stochasticity into biological models		Collaborating across disciplines	
	Developing problem-solving strategies				Cross-culture awareness	

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Workshop Physics

Priscilla Laws
Dickinson College

I hear, I forget.
I see, I remember.
I do, I understand

Anon

Workshop Physics Curriculum

Underlying Philosophies:

- Eliminate formal lectures.
- Reduce content and emphasize the process of scientific inquiry.
- Emphasize directly observable phenomena, to give necessary experience.
- Use the microcomputer as a flexible tool.

Workshop Physics Organization

Learning sequence mimics the scientific method:

- **Prediction:** examination of own preconceptions.
- **Observation:** make qualitative observations of phenomena.
- **Reflection:** individual/group reflection, discussion, and concept formation.
- **Theory:** group/class development of definitions, concepts, and mathematical models and theories.
- **Application:** quantitative experimentation centered on verification of mathematical models and theories.

Adapted from recommendations of cognitive psychologists (e.g. David Kolb) and physics educators (e.g. Robert Karplus, Roger Osborne)

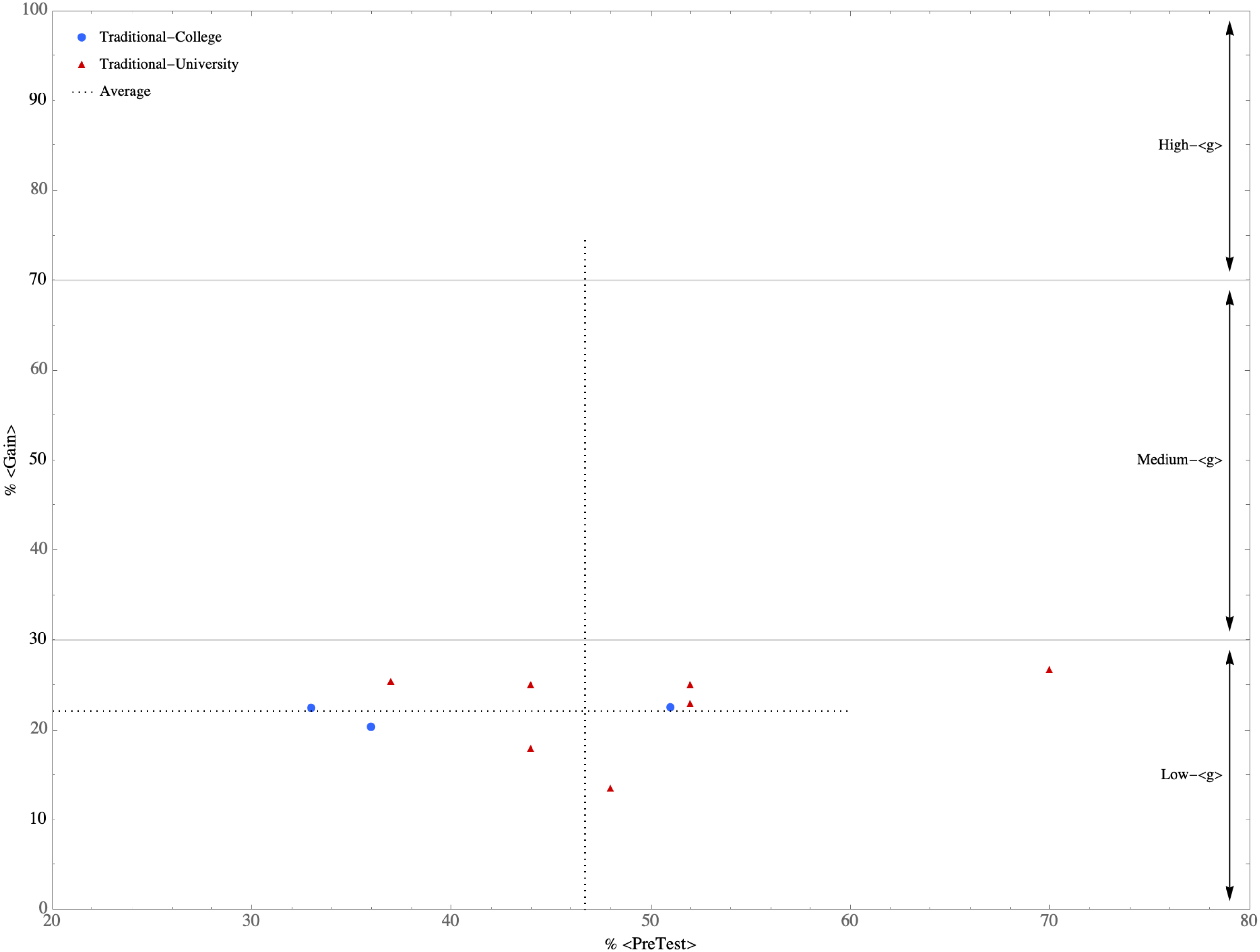

Figure 1. Normalized gain vs. pre−test score on the Force Concept Inventory diagnostic for traditional courses surveyed by Hake.

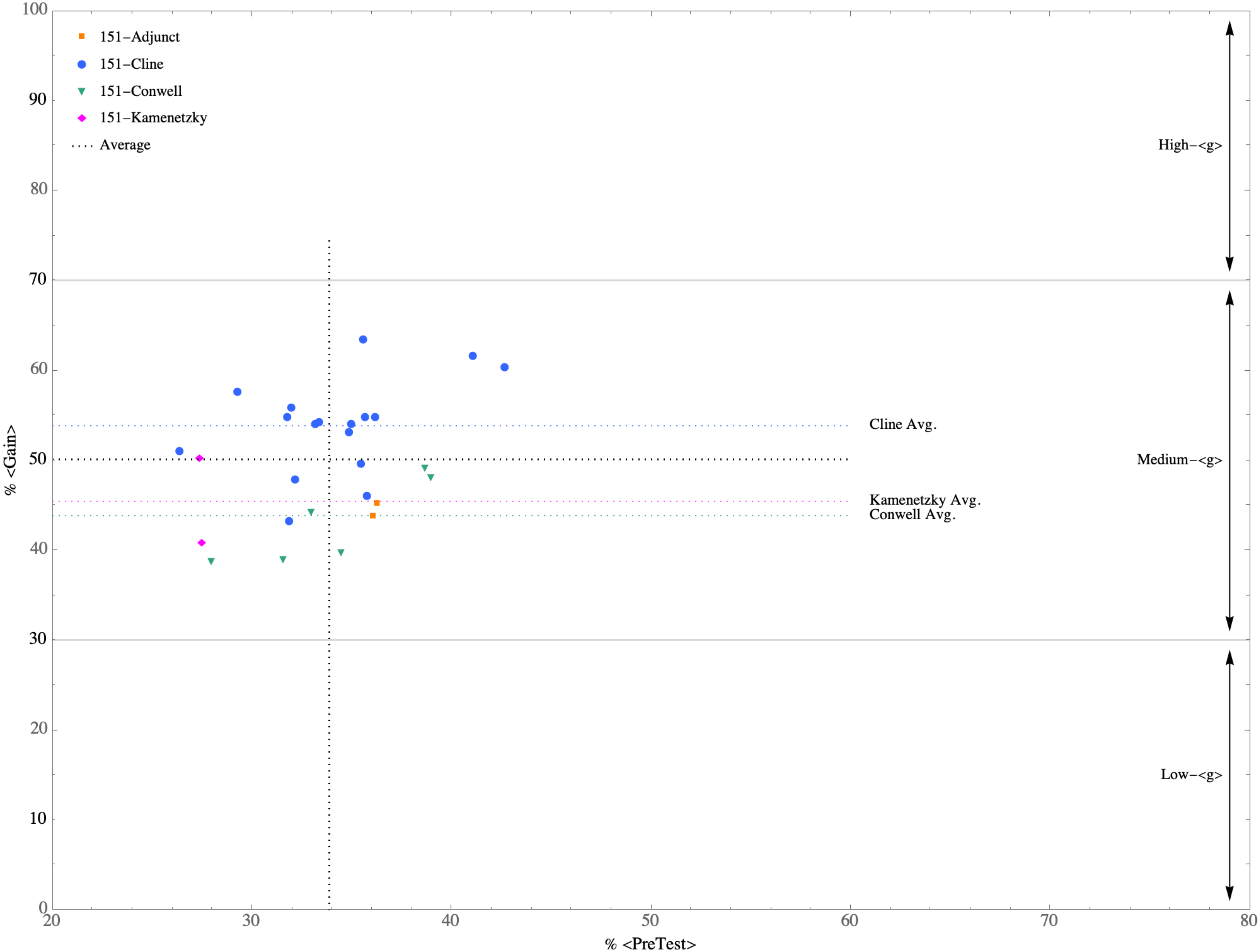

Figure 3. Normalized gain vs. pre–test score on the Force Concept Inventory diagnostic for Physics 151, Westminster College.

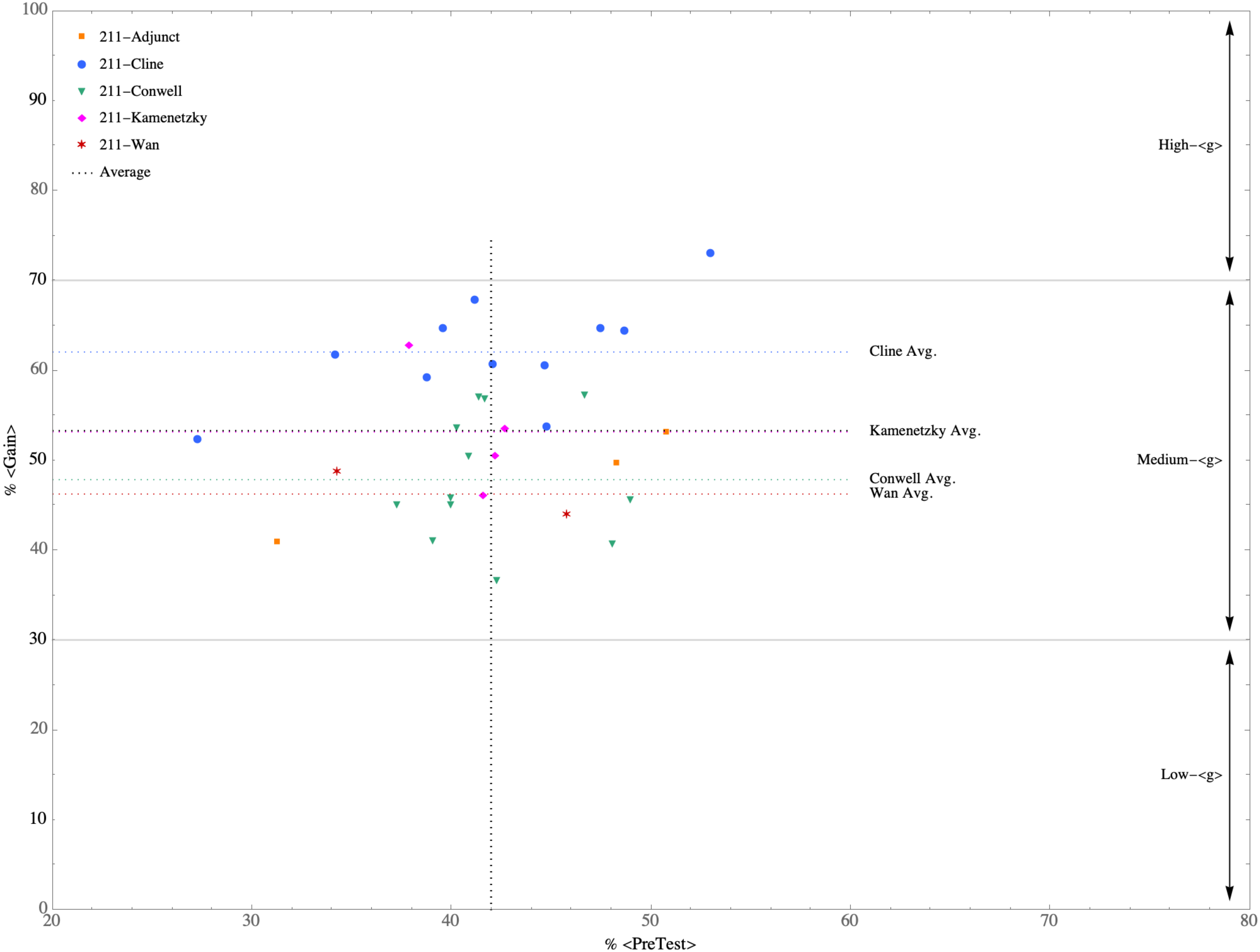

Figure 4. Normalized gain vs. pre−test score on the Force Concept Inventory diagnostic for Physics 211, Westminster College.