The Hidden Curriculum
(Perry-Belenky Scheme)

1. Binary / Received Knowledge Stage

2. Subjective / Multiplist / Relativist Stage

3. Constructivist Stage

4. Consciously Constructivist Stage
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
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
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.
Consciously Constructivist Stage
(Need to be here to be a creative scientist)
(\textbf{Can not} be achieved if the instructor does all or most of the talking)

- Takes charge of building own understanding

- 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
  - Recognizes when a decision is made in absence of complete information.
  - Understands and tolerates ambiguity and uncertainty
  - Recognizes when one is taking something on faith

- Probes for assumptions behind a line of reasoning (particularly implicit, unarticulated assumptions)
Consciously Constructivist Stage
(continued)

• 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
Consciously Constructivist Stage
(continued)

• 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
Desired Qualities in Westminster College’s Graduating Seniors

**Scientific Literacy**
- Think Critically
- Use Resources
- Distinguish Science from Pseudoscience

**Math Literacy**
- Graphing Skills
- Statistics Skills
- Understanding Scale and Ratios
- Precision and Accuracy

**Technology Literacy**
- Instruments
- Data Reduction
- Handling of Information
- Computer Modeling

**Communication**
- Verbal
- Written
- Graphical
- Terminology
- Read Critically

**Problem Solving**
- Synthesize, Link Information
- Self Assess Knowledge
- Make Informed Decisions

**Scientific Method**
- Hypothesize, Predict
- Observe, Describe
- Recognize Patterns
- Infer
- Design and Perform Experiments
- Compare Models and Theories
- Develop Conclusions

**Ethics**
- Social Responsibility
- Social Environment
- Natural Environment
- Global, International Concerns

**Awareness of Ideas**
- Shaped Past
- Future
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.
Human behavior in all realms is beset by wishful thinking—the tendency of people to really believe that what they want to be true is 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

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

Mark Twain
# Workshop Physics Curriculum

Differs from conventional teaching methods:

<table>
<thead>
<tr>
<th>Constructivist</th>
<th>vs.</th>
<th>Transmissionist</th>
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<tbody>
<tr>
<td>Cooperative inquiry</td>
<td>vs.</td>
<td>Lecture/demonstration</td>
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<td>Student-centered</td>
<td>vs.</td>
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<td>Active engagement</td>
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<tr>
<td>Student activity</td>
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<tr>
<td>Student articulation</td>
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<td>Lab-based</td>
<td>vs.</td>
<td>Textbook-based</td>
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</table>
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 Curriculum

Helps students to attain several educational goals:

- To develop a conceptual understanding of physics phenomena and to be able to relate that understanding to a mathematical representation of phenomena.

- To develop skills in the use of contemporary apparatus and computer tools for the collection and analysis of scientific data.

- To achieve wider scientific literacy.

- To be motivated to learn more science both formally and informally.
Workshop Physics Curriculum

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.
Figure 1. Normalized gain vs. pre-test score on the Force Concept Inventory diagnostic for traditional courses surveyed by Hake.
Figure 2. Normalized gain vs. pre-test score on the Force Concept Inventory diagnostic for interactive engagement 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.

Years in parenthesis indicate courses taught by adjunct professors.

High-$\langle g \rangle$

Medium-$\langle g \rangle$

Low-$\langle g \rangle$