How the Way People Think Makes It Difficult to Learn . . .

and Complicates Teaching

Bill Cerbin
Center for Advancing Teaching & Learning
Things You Might Learn From This Talk

• How the human mind works!

• How the same mental processes that lead to insights and understanding can also lead us to misconceptions and misunderstanding—even when we are trying to get it right

• What we already know and believe has a profound influence on what we get out of any new learning experience

• Teachers need *theories of difficulty* to help us understand what is difficult for students to learn and why those things are hard

• Examples of teaching practices that can take learning difficulties into account

• How to light a bulb with a battery and a wire

• Why it is cold in winter and warmer in summer

• How a big tree can grow from a tiny seed
Part I. Big Ideas about Learning
Learning—a pre-modern view

Stuff to be learned

Human mind as recording device

Stuff the person knows--replica
Learning—a modern view

Stuff to be learned

Stuff the person knows

Human mind as a sense making device
Take Home Idea

People construct knowledge. We learn by trying to make sense out of new information. We do this by using what we already know to discern connections and relationships among facts and ideas.
A Recent Entering Class of MIT Freshmen

97% of first year MIT students graduated in top 10% of HS class

Percent of first-year MIT students with scores in each range

<table>
<thead>
<tr>
<th>SAT Critical Reading</th>
<th>SAT Math</th>
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</thead>
<tbody>
<tr>
<td>700-800</td>
<td>61.0%</td>
</tr>
<tr>
<td>600-699</td>
<td>32.0%</td>
</tr>
<tr>
<td>500-599</td>
<td>7.0%</td>
</tr>
<tr>
<td>400-499</td>
<td>N/A</td>
</tr>
<tr>
<td>300-399</td>
<td>N/A</td>
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<tr>
<td>200-299</td>
<td>N/A</td>
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</tbody>
</table>
Highly Regarded MIT Teachers

MIT Physics Professor Walter Lewin★

MIT Mathematics Professor Gilbert Strang★
Professor Lewin demonstrates the physics of pendulums
According to Professor Lewin

- “. . . what really counts is to make them love physics, to make them love science.”

- Spends 25 hours preparing each new lecture, choreographing every detail and stripping out every extra sentence.

- “Clarity is the word,” he said.

Sara Rimer, *NYT*, December 19, 2007
But. . . what have students learned?
How do you explain their responses?
Conference participants viewed excerpts of two films, *A Private Universe* and *Minds of Our Own*, which depicted Harvard and MIT graduates having difficulty answering questions about basic science concepts.
Take 2 minutes at your tables identify some plausible explanations for students’ responses.
Reasons for Students’ Answers

• Forgot

• Something strange or especially difficult about the subject matter

• Students did not really understand the concepts when they learned them
The Importance of Prior Knowledge

Students come to every learning situation with prior knowledge, skills, beliefs, and concepts that significantly influence what they notice about the situation, how they organize and interpret it. This affects their ability to remember, reason, solve problems, and acquire new knowledge.

Naturally Occurring Learning Events

• Students’ preconceived ideas and beliefs can impede new understanding

• Students know so little that understanding new information is especially tedious, halting, slow going

• Students’ develop misconceptions as they learn a subject

• Students learn without understanding
  – easily forgotten
  – not easily applied to new situations
In even the most mature person, understanding is a mixture of insight and misconception, knowledge and ignorance, skill and awkwardness

Grant Wiggins, *Understanding by Design*
Part II. Teaching that Takes Student Learning into Account
Teaching that Takes Student Learning Difficulties Into Account

• Make student thinking visible—gain access to student thinking before and during instruction

• Respond to student thinking when it matters most (teachable moments)

• Show novices how to think more like an expert

• Instruction that focuses on difficulties in learning your subject
Making Student Thinking Visible

“Oh, wait! Wait, Cory! ... Add the cereal first and then the milk!”
Making Student Thinking Visible
(Problem-based learning in large biology lectures)

- Students work in small groups on a problem in class
- Collect solutions
- Project several solutions to class
- Analyze and comment on solutions

UW-La Crosse Biology
Professor Scott Cooper

Problem Solving Modules in Large Introductory Biology Lectures Enhance Student Understanding
Respond to student thinking when it matters most

Students write answers to questions about the readings and submit them electronically to me the day before class.

I scan/skim the responses and use them to organize the next class period.

Easy to identify patterns of understanding, misunderstanding, undeveloped ideas, etc.
Helping Students to Think More like a Mathematician

Think Aloud Podcasts of calculus problems

UW-La Crosse Mathematics Professor Bob Hoar
Bottlenecks to Learning History

- Misunderstanding the role of facts
- Interpreting primary sources
- Maintaining appropriate emotional distance
- Understanding the limits of knowledge of historical actors
- Identifying with people in another time/place
- Constructing & evaluating arguments
- Linking specific details to a broader context

### On the Reading of Historical Texts by Sam Wineburg

<table>
<thead>
<tr>
<th>How EXPERTS read historical texts</th>
<th>How NOVICES read historical texts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seek to <em>discover context and know content</em></td>
<td>Seek only to <em>know content</em></td>
</tr>
<tr>
<td>Ask what the text <em>does</em> (purpose)</td>
<td>Ask what the text <em>says</em> (&quot;facts&quot;)</td>
</tr>
<tr>
<td>Understand the <em>subtexts</em> of the writer's language.</td>
<td>Understand the <em>literal meanings</em> of the writer's language.</td>
</tr>
<tr>
<td>See any text as a <em>construction</em> of a vision of the world</td>
<td>See texts as <em>descriptions</em> of the world</td>
</tr>
<tr>
<td>See texts as <em>made by persons with a view of events</em></td>
<td>See texts as <em>accounts of what really happened</em></td>
</tr>
<tr>
<td>Assume <em>bias</em> in text</td>
<td>Assume <em>neutrality, objectivity</em> in text</td>
</tr>
<tr>
<td><em>Consider word choice</em> (connotation, denotation) and <em>tone</em></td>
<td><em>Ignore word choice, tone</em></td>
</tr>
<tr>
<td><em>Compare</em> texts to judge different, perhaps divergent accounts of the same event or topic</td>
<td><em>Learn the right answer</em></td>
</tr>
<tr>
<td>Get <em>interested in contradictions, ambiguity</em></td>
<td>Resolve or ignore <em>contradictions, ambiguity</em></td>
</tr>
<tr>
<td>Check <em>sources</em> of document</td>
<td>Read the <em>document only</em></td>
</tr>
<tr>
<td>Read like <em>witnesses to living, evolving events</em></td>
<td>Read like <em>seekers of solid facts</em></td>
</tr>
<tr>
<td>Acknowledge <em>uncertainty and complexity</em> in the reading, with qualifiers and concessions</td>
<td>Communicate the <em>truth</em> of the reading, sounding as certain as possible</td>
</tr>
</tbody>
</table>
Pedagogical Content Knowledge

... the most useful forms of representation of [topics], the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject that make it comprehensible to others ... Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons. ... (Shulman, 1986)
Excellent Books and Articles about Student Learning

*How People Learn: Brain, Mind & Experience* by Bransford, Brown, & Cocking (full text online)

*How Students Learn: History, Mathematics & Science in the Classroom* by Donovan & Bransford (eds.) (full text online)

*Historical Thinking and Other Unnatural Acts* by Sam Wineburg

*Taking Learning Seriously* by Lee Shulman (full text online)

*Making Differences: A Table of Learning* by Lee Shulman (full text online)

*Teaching the Mind Good Habits* by Sam Wineburg (full text online)

*Understanding by Design* by Grant Wiggins & Jay McTighe