In the incompleteness of mathematics: Gödel (1933) strikes down the completeness of axiomatic set theory postulated by Whitehead and Russell in “Principia Mathematica” (1912). This is a parallel to the incompleteness of science: Refinement of Newtonian theory (the Principia, 1702) by Einstein’s theory of relativity (1905).

Incompleteness in literature too! A paradox (a more gentle form of failure) can help learning – Failure produces learning. A more recent paradox (Douglas Hofstadter) is “What is the smallest uninteresting integer?”

What do you think it might be? – Is it different from mine?

As part of the answer you can note:
1 is interesting – it is the smallest positive integer, 2 is interesting – it is the smallest even number, 3 is interesting – it is the smallest prime-number, 7 is interesting – it is a prime-number …..

These Inquiring Minds both want to know BUT… They ask different questions!

**Key Concept 1**

Elegant Solutions are the highest order of what might be termed Quality Intellectual Work

To produce good scientists, good humanists, good world citizens, our goal must be to support quality intellectual work in teaching and learning at all levels, i.e. from earliest childhood til’ death do us part.

<table>
<thead>
<tr>
<th>ELEGANT SOLUTIONS</th>
<th>Physics/sciences</th>
<th>Poetry/arts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-ended question concerning the nature of the physical universe</td>
<td>Open-ended question concerning Human nature</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Uses causal reasoning</th>
<th>Uses inference, analogy, metaphor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result is reproducible</td>
<td>Result is unique, irreproducible</td>
</tr>
<tr>
<td>Solution can be validated by reproducing the proof and is verified by other/new experiments or demonstrations</td>
<td>Truth or validity resonates with the human experience</td>
</tr>
</tbody>
</table>

**Einstein:** Why the passage of time depends on our relative speeds?
**Milton:** How does imagery of the sun shining on a man-centered universe justify God’s ways to man?
Inquiring minds may want to know different answers to the same question:

In Physics, Literature, Life

The **two body** problem has satisfactory solutions
The **three body** problem remains challenging

Key Concept 3:

Inquiry calls for deep engagement with the question;

Misconceptions and error are essential to the process of problem-solving

Quality intellectual work has three essential features:

- **Construction of knowledge** that actively involves the learner in developing his/her understanding
- Through the use of **Guided/disciplined Inquiry**
- To produce discourse, products, or performances that have **Value beyond** the classroom.


The SIP Principle

- **Play** is
  - Satisfying
  - Intentional
  - Problem solving

Do you feel the same way about your work?
Every child is a scientist at play: Wondering and problem-solving about how the world works. Every scientist was a child at play.

How could the porridge in the Bears’ bowls be too hot, too cold and just right?

Working with 1 or 2 others: write an explanatory scenario in your “blue book” that is consistent with your scientific understanding.

Do we have any volunteers with solutions....!

What makes Guided Inquiry?

**Engagement** is triggered by posing an interesting, open-ended question about a specific problem that does not have a unique solution.

Whatever the solution, it must be well-supported.

What Makes Guided Inquiry?

**Exploration** is carried out by the learners, drawing on prior knowledge and experience, using methodology appropriate to the discipline (in this case, physics - the laws of thermodynamics).

The Teacher facilitates by raising clarifying, probing questions.

**NOT** full frontal lecture, cookbook science lab, fill-in-the-blank worksheets.
What Makes Guided Inquiry?

EVALUATION is intrinsic.

Is this a sufficient answer to the problem, as far as I'm concerned? Possibilities include:

- Yes, it's Good—or at least it's good enough
- Yes, but it raised a new question/problem I now want to pursue.
- No, I need to decide if
  - the question needs revising or
  - there was a problem with the investigation (identify new variables, refine data collection, use tools better or use better tools)

NOTE: Is this the teacher's right answer?

Ptolemaic vs Copernican Universe
Better Poetry vs Better Science

How do preconceptions/misconceptions affect the ability to learn?

How do Harvard Professors and students compare with Nebraska professors and students?

Graduation at Harvard….. The Reasons for the Seasons

Notes:
1. Why are these misconceptions so strong? (even after taking several physics courses)
2. How do you verify prior learning or mislearning of your students?

Representations of the Solar System

A B C

Which of these three figures best represents the earth moving in orbit around the sun?

Let's VOTE....

A more personal view of one’s UNIVERSE
Consider
The science you **teach**

**IS IT WORK?**
or
**IS IT PLAY?**

---

Science Daily (Feb. 1, 2009)

Researchers Tested Nearly 6,000 Students Majoring In Science And Engineering At 7 Universities -- 4 In The United States And 3 In China.

- Chinese Students Greatly Outperformed American Students On Factual Knowledge Of Physics -- Averaging 90 Percent On One Test, versus The American Students' 50 Percent
- But In A Test Of Science Reasoning, Both Groups Averaged Around 75 Percent -- Not A Very High Score, Especially For Students Hoping To Major In Science Or Engineering.

---

Experience is a better teacher than the voice of experience.

We tend to remember Inquiry - Based Learning.

---

Two questions for you about this presentation

1. What surprised /interested/ delighted you?
2. What applications do you see this having to you own teaching

Please write your answers in your blue book

They will help us in our research on Learning how to learn

- Thank you

The END
References / Bibliography


Science Media Group, Harvard-Smithsonian Center for Astrophysics. A Private Universe - Minds of our own (DVD).


A pdf file of this presentation can be found at the website:  http://www.nd.edu/~hgberry/berry1.html