
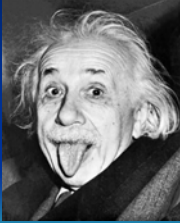


**Milton meets Einstein**  
**Inquiring Minds want to Know**  
 Drs. Mary Hynes-Berry and Gordon Berry  
 at the University of Nebraska - 9 April 2009



**INQUIRY** In  
Science and  
Literature



**Failure produces learning**

A paradox (a more gentle form of failure) can help learning –

The incompleteness of mathematics:  
 Godel (1933) strikes down the completeness of axiomatic set theory postulated by Whitehead and Russell in "Principia Mathematica" (1912)

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!**

**From Sorensen (2005)**  
 G. G. Berry was one of the first individuals to produce new **semantic paradoxes**. Berry's paradox was first presented to Russell (1905) in the following sentence: "The least integer not namable in fewer than nineteen syllables" is itself a name consisting of eighteen syllables; hence the least integer not namable in fewer than nineteen syllables can be named in eighteen syllables, which is a contradiction"

**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.

ELEGANT SOLUTIONS	
>Concise synthesis >Deceptively "simple" but comprehensive in what they explain >Compelling	
Physics/sciences	Poetry/arts
Open-ended question concerning the nature of the physical universe	Open-ended question concerning Human nature
Uses causal reasoning Result is <b>reproducible</b> Solution can be validated by reproducing the proof and is verified by other/new experiments or demonstrations	Uses inference, analogy, metaphor Result is <b>unique, irreproducible</b> Truth or validity resonates with the human experience Imitations lose the elegance of the solution
<b>Einstein</b> : Why the passage of time depends on our relative speeds?  (scientists in general)	<b>Milton</b> : How does imagery of the sun shining on a man-centered universe justify God's ways to man?  (artists in general)

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 2

Learning

INQUIRY

Play

Quality Intellectual Work

Quality intellectual work, learning, and play  
are different angles in the process of  
**INQUIRY**

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.

cf: Newman, F. and associates. (1996) *Authentic achievement: Restructuring  
schools for intellectual quality*. San Francisco: Jossey-Bass.

One of the  
richest sources  
for learning is the  
learner herself

**The SIP Principle**

Play is

✓ Satisfying

✓ Intentional

✓ Problem solving

Do you feel the same way about your work?

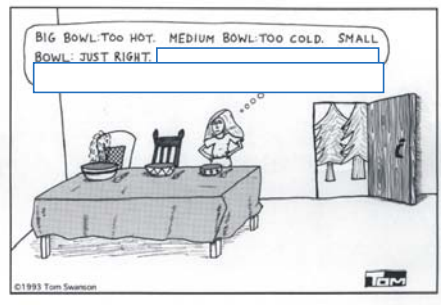
Learning **INQUIRY** Play

**Quality Intellectual Work**

**Every child is a scientist at play:**  
Wondering and problem-solving about how the world works.

**Every scientist was a child at play.**

**Goldilocks and the Three Bears**



Has the science in this story ever worried you?

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

Exploration

Evaluation

**What makes Guided Inquiry**

Engagement

**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

**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

**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 raises 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)


**NOT:** *Is this the teacher's right answer?*

## Mis-Guided Inquiry

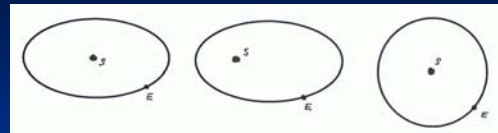




**Ptolemaic**  
vs  
**Copernican**  
**Universe**  
Better Poetry  
vs  
Better Science



## 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....

## 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?

## A more personal view of one's UNIVERSE



Consider

The science you **do**

The science you **teach**

IS IT WORK?  
or  
IS IT PLAY?

Do you consider  
Quality Intellectual Work  
Important?

- Which is a more serious concern?
- ✓ The students don't work hard enough.
  - ✓ The students are only interested in the right answers, not in reasoning or playing with the ideas?

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.

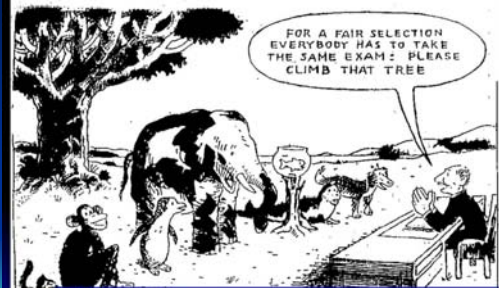
Chinese Students Greatly Outperformed American Students On Factual Knowledge Of Physics - Averaging 90 Percent On One Test, versus The American Students' 50 Percent

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.

Does your testing of students follow this model?

Best Practices from the Far Side



- Assessment
- It's not one size fits all..... at least it shouldn't be.

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

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A pdf file of this presentation can be found at the website: <http://www.opt.edu/~hpkerry/turkey1.html>

### Love Song from a Hollow Cathode

LINES WRITTEN AFTER SEEING WARREN KREYE'S  
SPECTROSCOPY EXPERIMENT TO MEASURE THE  
DOPPLER PROFILE OF THE SPECTRUM OF GOLD FROM  
AN ARGON-FILLED GOLD HOLLOW CATHODE.

Ares' fleece is too solid sullied stuff for  
Love the golden light has an airy  
Function we cannot do without.  
If this present argonaut would seek  
To know the warmth of golden thrust  
In hollowness and thus to find the peak,  
Some alchemy must breathe through his air,  
A colorless odorless element  
That penetrates but will not bind—  
Argon makes such golden atmosphere.  
So breathe you argon on these my golden walls  
And gold to airy thinness beat.

The poem has literary as well as spectroscopic allusions: the Golden Fleece sought by Jason and the Argonauts hung in the temple of Ares, the Greek god of war and strife. The first line is an experimental application of a theoretical debate on Shakespeare's spelling. Critics cannot decide whether Hamlet said: "O that this too solid flesh would melt/Thaw and resolve itself into a dew" or "too too sullied. . ." Either is possible and both are meaningful. The last line echoes John Donne, from *A Valediction Forbidding Mourning*:

Our two souls therefore, which are one,  
Though I must go, endure not yet  
A breach but an expansion  
Like gold to airy thinness beat.

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University of Wisconsin

Submitted by Gordon Berry, Department of Physics

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W. C. Kreye and F. L. Roesler, J. Opt. Soc. Am. 60, 1100 (1970). For preliminary observations, see also M. Hynes, Appl. Opt. 7, 1809 (1968)