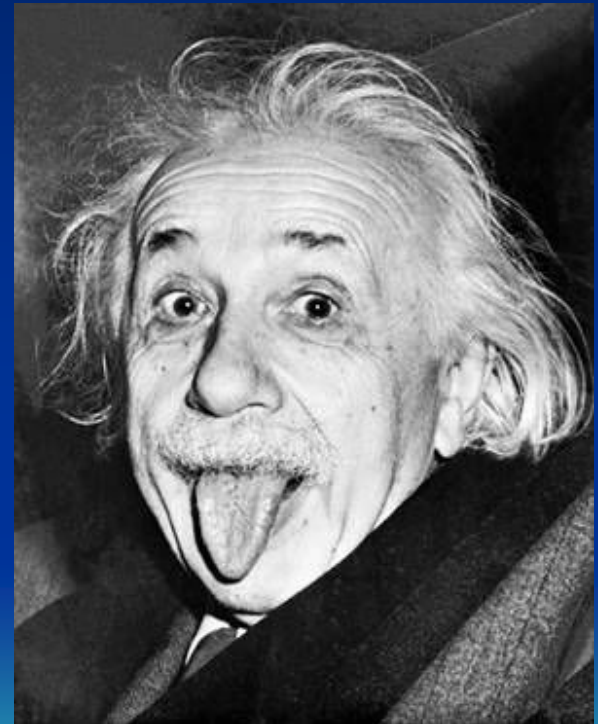


Milton meets Einstein
Inquiring Minds want to Know
Drs. Mary Hynes-Berry and Gordon Berry
at the University of Nebraska - 9 April 2009



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

Open-ended question concerning
the nature of the physical
universe

Uses causal reasoning
Result is **reproducible**
Solution can be validated by
reproducing the proof and is
verified by other/new
experiments or demonstrations

Einstein : Why the passage of
time depends on our relative
speeds?

(scientists in general)

Poetry/arts

Open-ended question concerning
Human nature

Uses inference, analogy, metaphor
Result is **unique, irreproducible**
Truth or validity resonates with
the human experience
Imitations lose the elegance of
the solution

Milton : 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

Play



INQUIRY

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:

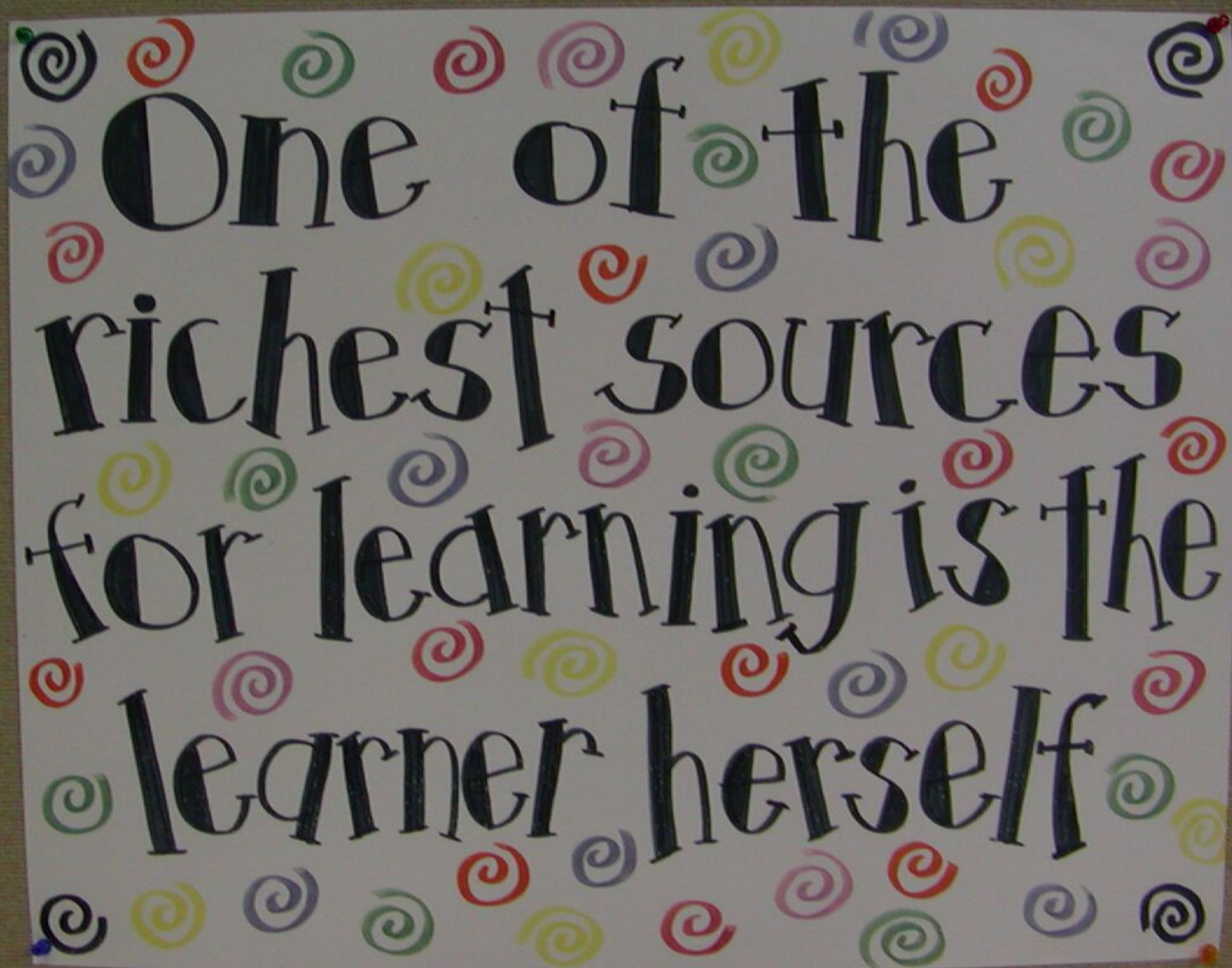
Construction of knowledge that actively involves the learner in developing his/her understanding

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.



A piece of white paper with a decorative border of colorful swirls in red, green, yellow, purple, and blue. The text is written in a black, calligraphic font. The text reads: "One of the richest sources for learning is the learner herself".

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

Play

INQUIRY

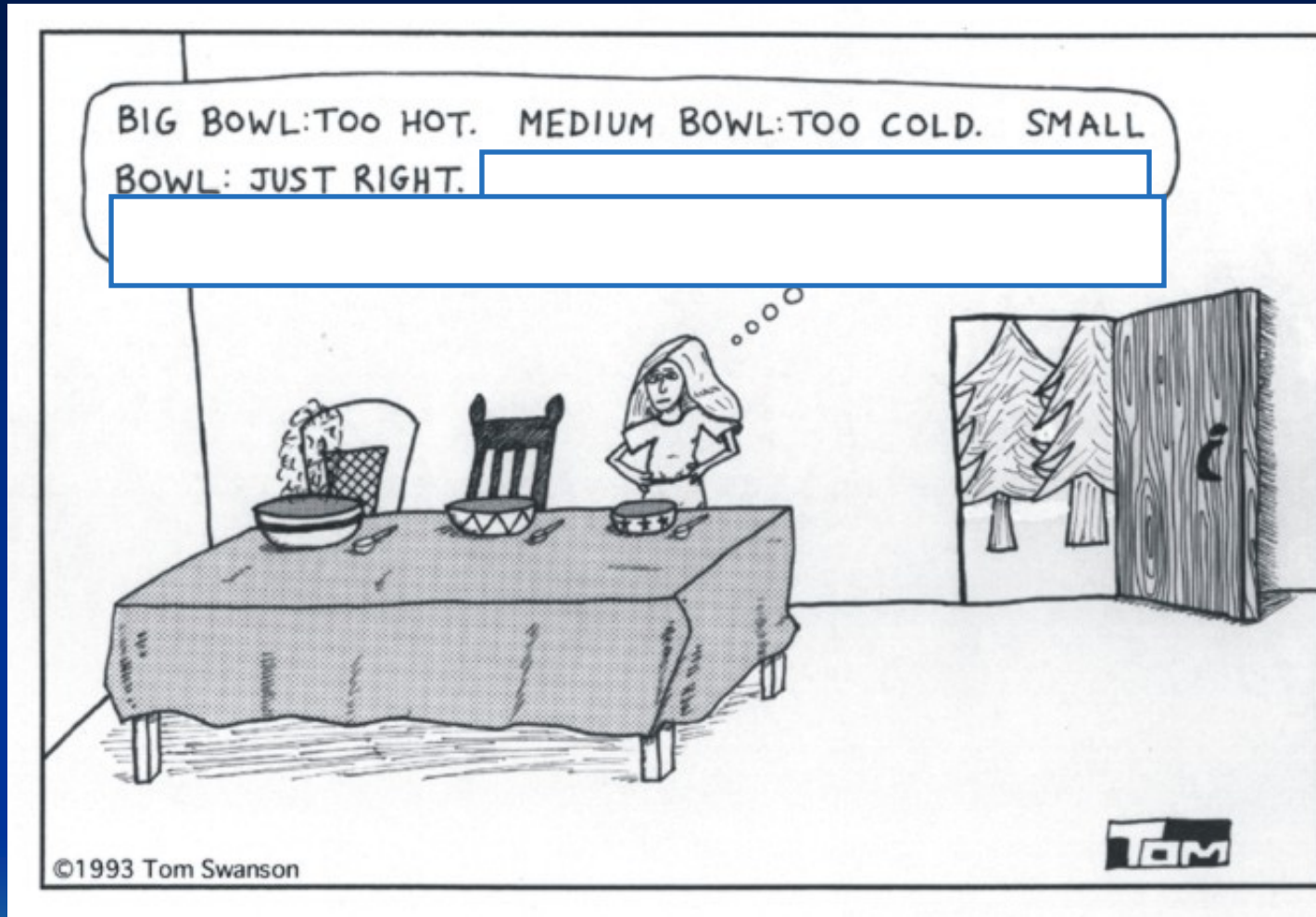
Quality Intellectual Work

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)

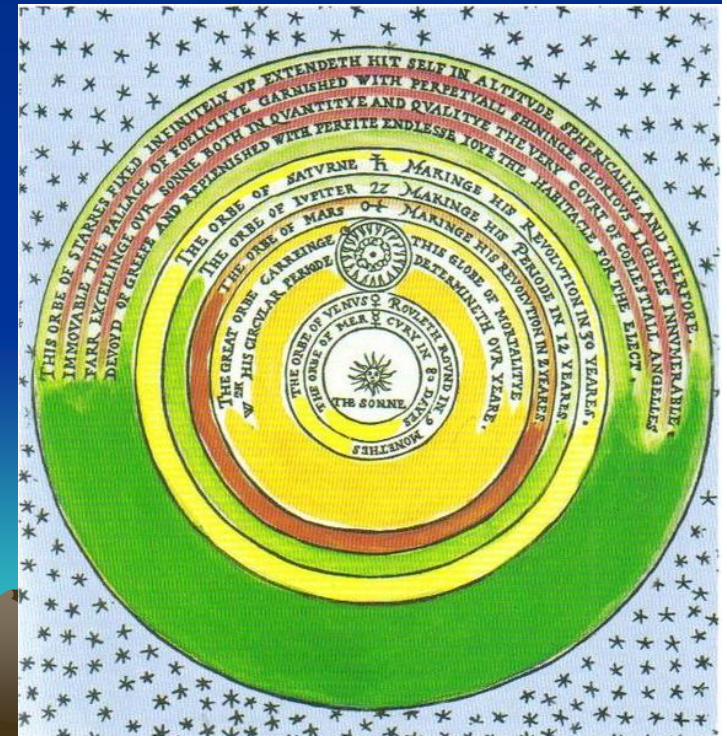
NOT: *Is this the teacher's right answer?*

Mis-Guided Inquiry

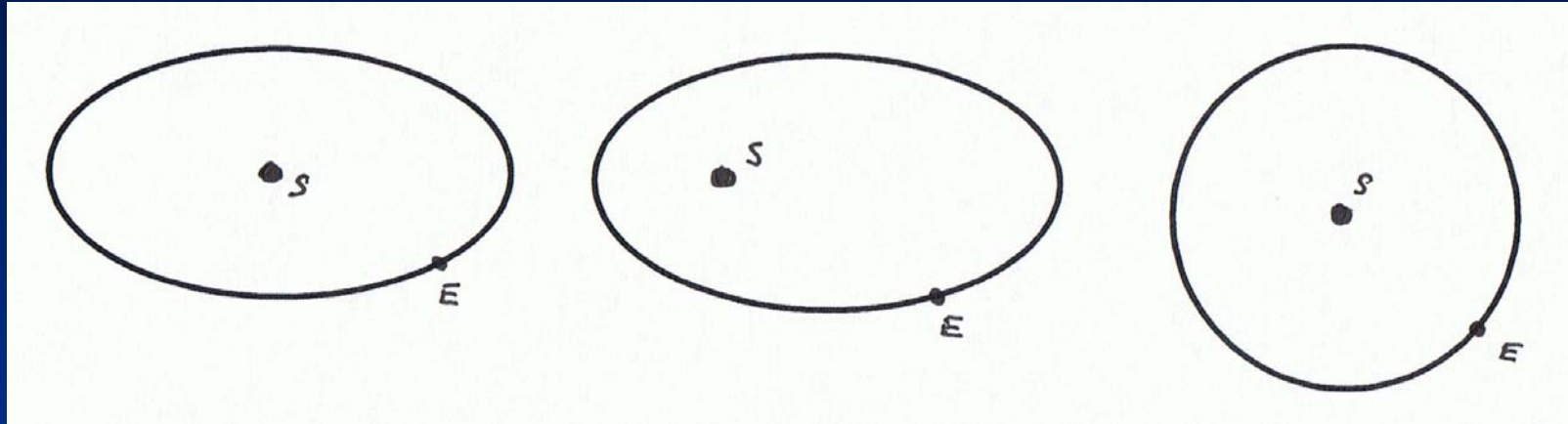




Ptolemaic
vs
Copernican
Universe
Better Poetry
Vs
Better Science



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?

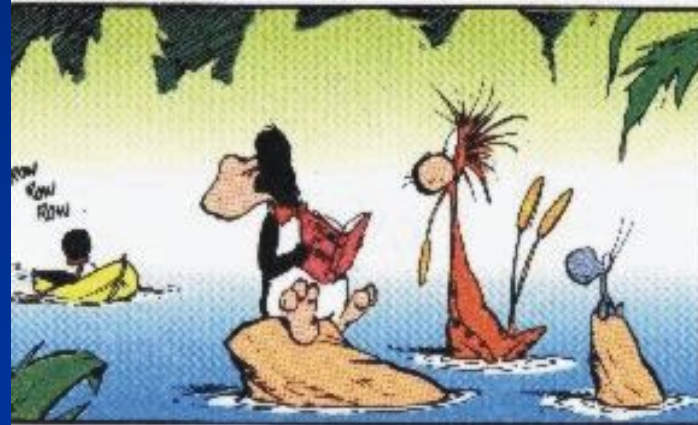
Graduation at Harvard..... The Reasons for the Seasons

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

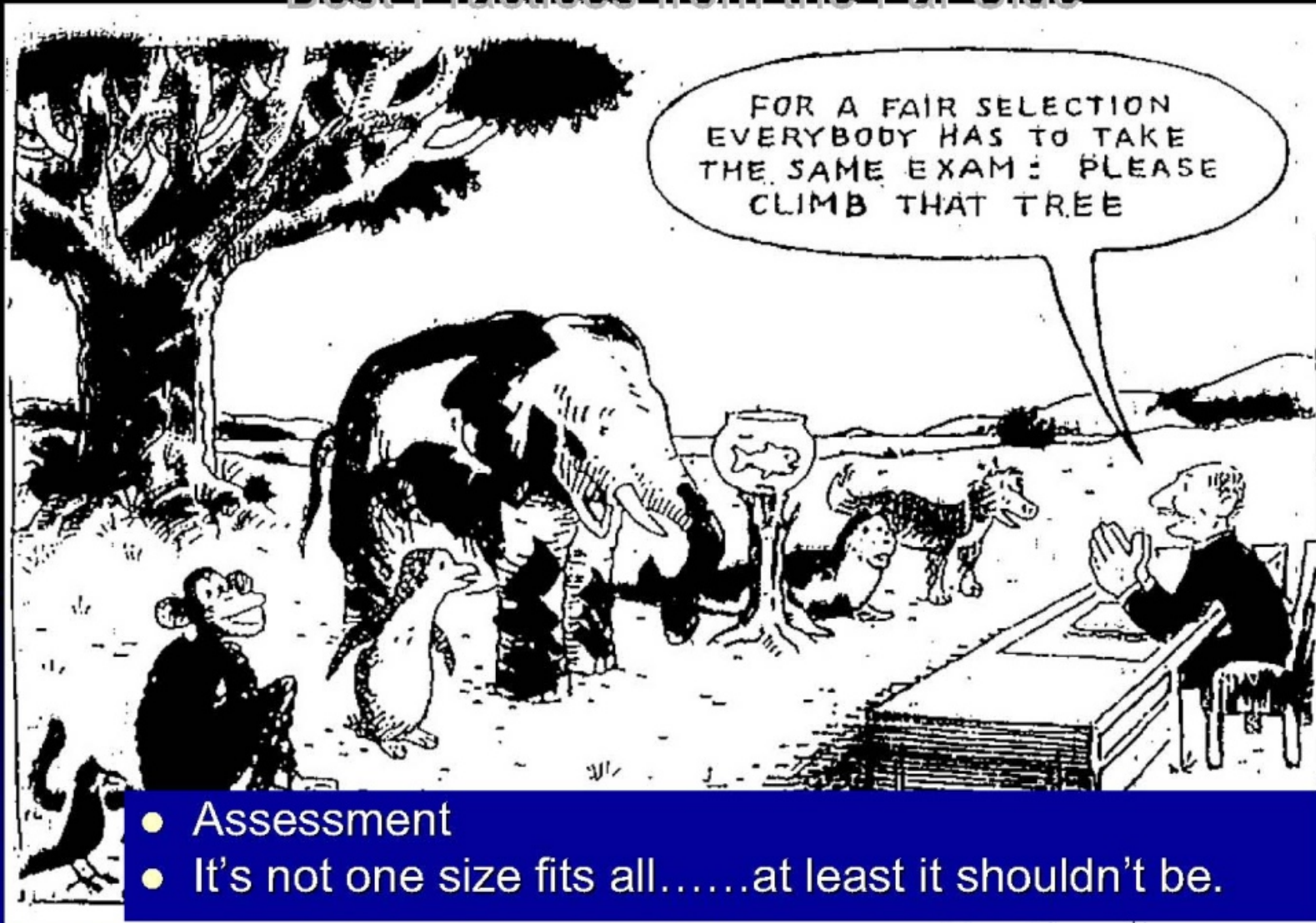
But **In A Test Of Science Reasoning**, Both Groups Averaged Around 75 Percent -

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



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

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

Richard F. Elmore (2008) *Improving the Instructional Core*. Preprint form

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

W. C. Kreye and F. L. Roesler, *Analysis of Hollow-Cathode-Discharge-Excited Ar I, Ar II, and Au I Spectral-Line Profiles Measured with a Fabry-Perot Interferometer* J. Opt. Soc. Am. 60, 1100 (1970). For preliminary observations, see also M. Hynes, *Love Song to a Hollow Cathode* Appl. Opt. 7, 1809 (1968)

Gregory Chaitin (2005) *Meta Math!* Vintage Press

Roy Sorensen, (2003) *A Brief History of the Paradox - Philosophy of the Labyrinths of the Mind*. Oxford University Press

Sherry Turkle, (2008) *Falling for Science: Objects in Mind*. Cambridge: MIT Press

A pdf file of this presentation can be found at the website: <http://www.nd.edu/~hgberry/berry1.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 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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Submitted by Gordon Berry, Department of Physics
University of Wisconsin

September 1968 / Vol. 7, No. 9 / APPLIED OPTICS 1809

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)