Approaching Teaching as We Approach Research:

Establishing Goals, Collecting the Evidence, and Measuring Achievement

Reinvention Center

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A motivation!

YouTube link to this movie here!

TOP-TEN INFLUENCES

10) Cognitive Blending
9) Research Principles
8) Traditional Lecture Structure
7) Educational Goals
6) Remarkable Teaching Failures
5) New Cognitive Approaches, Technological Help, and Paradigm Shifts
4) An Example of Education Research
3) Recycling, a Cognitive Blend of Research and Teaching?
2) The Best Thing I ever did!
1) GOAL: YOUR FINAL WORDS/SUGGESTIONS

10) COGNITIVE BLENDING*

A) Combine different mental input spaces:

This is called a “blend”

B) Example: Bill Gates Knocks out Steve Jobs**

(means MS beats Apple in the marketplace by offering a cheaper product)

i) Boxing mental space blended with a business mental space

ii) But no business person is literally knocked out

iii) And Gates or Jobs are not boxers

But the blend is a very effective communicator!

* G. Fauconnier, M. Turner “The Way We Think” 2002

** T. Bing and E. Redish, AAPT paper 2006

10) COGNITIVE BLENDING (continued)

C) Another example: air drag*

The blending of

i) a mathematical mental space (positive and negative numbers, multiplication, algebra symbols)

with

ii) a physical world mental space (directions, viscosity and gravity, velocity)

gives wonderful statements in the blend

e.g., $F = - b v$

This is powerful as it gives us new mathematical representations and new physical predictions

* T. Bing and E. Redish, AAPT paper 2006

10) COGNITIVE BLENDING (continued)

D) THE BLEND OF INTEREST HERE

Blending in some way i) the research world and ii) the undergraduate teaching world may give us a powerful new learning environment.

At the present time, I feel that certain new initiatives may be considered to be “conceptual blending” of research and teaching. I am not, however, referring to undergraduate research or undergraduate teaching assistants in this regard (although those very popular developments are enormously effective). And blending does not simply refer to research as a metaphor for learning. Let us see what I mean by what I have been doing.

FEEDBACK 1) E.g., comment on conceptual/cognitive blending?

9) RESEARCH AND EXPERIMENTS

A) Create Knowledge

B) Scientific Method

Principles and procedures for creating knowledge

i) Recognize and formulate problem

ii) Collect data with observations and experiments

iii) Formulate and test hypotheses

C) Example by Tim and me in MRI

Trying to make them quieter

8) TRADITIONAL LECTURE STRUCTURE

A) Lecture Format
B) Homework Assignments
C) Intermediate Hour Exams
D) Final Examination

Feedback 2)

Comments about traditional lecturing on your campus?

7) EDUCATIONAL GOALS

- “Expert competence”
  Factual knowledge
  Organizational structure
  (to help retrieve and apply facts)

- “Critical thinking”

Feedback 3)

What am I missing here?

6) REMARKABLE INTRODUCTORY PHYSICS FAILURES*

A) Students master far less than half of concepts presented

B) Students' qualitative understanding is much worse than their calculational ability

C) Very low retention of new nonintuitive explanations

D) Very poor performance on exit polls from classes when asked what the lecture was about

E) After taking introductory courses, students are less expert-like in their thinking than before, on the average

F) Students do learn one thing really well:

Physics is boring!

And this is not restricted to introductory physics!

*C. Wieman, K. Perkins Physics Today Nov. 05

Feedback 4) Other examples of failures, or other comments?

5) NEW AND PROMISING APPROACHES*

A) LIMIT "COGNITIVE LOAD"

Limit material, be clear, link to familiar ideas, and avoid unknown jargon … and avoid digressions

B) ADDRESS "WHY" AND NOT JUST "WHAT"

This targets the organization goal (but we must probe the students' existing organization and knowledge because their prior experience/thinking may be wrong and deeply ingrained and must be brought out and examined)

C) CONNECT TO: THE REAL WORLD, FAMILIAR THINGS, AND USEFUL RESULTS

D) GROUP EFFORTS (Group homework)

* BASED ON EDUCATION AND COGNITIVE RESEARCH OUTCOMES

5) NEW APPROACHES CONTINUED

E) TECHNOLOGICAL HELP

i) ELECTRONIC LEARNING ENVIRONMENT

I was gobsmacked in 1988 when a computer network was constructed at Case. The result was a major upheaval in my introductory courses, and got notoriety in one of Sheila Tobias' books.*

* Revitalizing Undergraduate Science 1992

Case Fiber-Optics Network History

- 1988 Case dormitories wired first
- 1988 my first student email - Hellooooooooo!
- 1989 email - email - email
  HW hints, share answers, lecture corrections
- 1990 Electronic bulletin board => popular website
- 1991 Digital movies
- 1991 Shared software/computational project
  Facilitated the group homework
- 1992 Invited talks
  Preaching to the atheists!
- 2006 “ho hum”

Feedback 5) New features that are effective?

5) NEW APPROACHES CONTINUED

E) TECHNOLOGICAL HELP CONTINUED

ii) "CLICKER PARADE"

The student response system with remote transmitters and multiple choice problems - results totaled and shown - students and teacher discuss - vote again

- For 200 seats, ~$5000
  (several receivers, computer, projector)
- Engagement and communication - not just more tests
- We are using this in our introductory physics classes
- Research shows this is very effective in learning.

FEEDBACK 6) What is your experience with clickers?

5) NEW APPROACHES CONTINUED

E) TECHNOLOGICAL HELP CONTINUED

3) INTERACTIVE SIMULATIONS

EXAMPLE: virtual electrical circuit with realistic looking meters and light bulbs that light up - and little electrons can be cartooned as the current carriers

BETTER THAN REAL LAB EXPERIMENTS???: eliminates distractions and irrelevant information.

(I would never have believed this - and I used to go around disparaging virtual labwork. There is the issue of all the errors that arise in the real laboratory!)

5) NEW APPROACHES CONTINUED

F) PARADIGM SHIFT IN MY OWN TEACHING

i) HOMEWORK HINTS

"HW advice" email saying what
I would say if they came to my office

Major result: More students do not give up!

Recent research* supports this approach.

* AAPT abstract 2004

5) NEW APPROACHES CONTINUED

F) PARADIGM SHIFT IN MY OWN TEACHING (continued)

ii) Post-Exam Syndrome

Exams that made me ill! I still carry the scars of my own poor exam performances, leaving me reluctant to go on to new material.

Nowadays, after a test, my students' next homework is to correct their test mistakes AND to explain in detail the thinking behind their original effort.

ii) “Post-Exam Syndrome” continued

Treatment Benefits

- Address mistakes before going on to new material
- Avoid delay in returning to study it (in fact, a student may otherwise never look at an old exam again!)
- AND detect defects in the exam itself!

4) Testing the Teaching!

I always have to be careful - What I think is great may not be!

MY UNDERGRADUATES AS RESEARCHERS IN TEACHING

- From Kathy Andre Harper 1989
  - Undergraduate Teaching Assistant 1990
  - Ph.D. in Physics Education Research 2002
  - Teaching me PER 2004-2006

    How do we test effectiveness?
- To Matt Finnerty, Sarah Lehrian, Alyxx Treat (seniors last two years)

  Presented PER papers at research conferences

CONNECTION TO PER

- WE SEE CONNECTIONS TO, AND WE ARE LEARNING FROM

Physics Education Research

- Assessment and Statistics
- Active Learning, Reflective Thinking
- Cooperative Learning
- Physics by Inquiry
- Peer Instruction
- Concrete versus Abstract Learning
- Experiential Learning
- Etc.

Our PER Example

PES Study in More Detail

- Test effectiveness of having the students correct exams and analyze mistakes
- Compared two groups - one that “corrected” and one that did not
- The experiments are hard!
- Found “statistically significant” difference!

3) Avoiding A Teflon Education by Recycling!

Students seem to forget lots of what they have studied in the past, even when it was just the previous semester!

Helping my students prepare for the GRE, I think that they have forgotten everything!

TOWARD A VELCRO EDUCATION?

To see what I could do about this, I've reorganized my classes so that everything is introduced in simple context, then revisited in two more increasingly integrated and sophisticated cycles.

One cycle

Two cycles

Three cycles

Introductory Physics Fall 2004

- Completely reshuffled and rewrote my old mechanics notes

- Introduced everything from velocity to forces to torque to angular momentum to the Coriolis effect in the first four weeks

- Then I revisited the whole shebang two more times in new contexts, in integrated ways, and with more sophistication

PROPOSED BENEFITS OF RECYCLING

- Gives students early picture of the whole course and how everything fits together
  - Hope that this revisiting will improve their ability to recall what they have learned
- The three one-hour exams at end of each cycle are practice for the final exam early and often!
  - Students don't forget the first part of the semester, and don't get overwhelmed by new and difficult stuff at the end
- When the teacher sees that students are having trouble, no problem - we're coming back to that material!

EVIDENCE THAT RECYCLING WORKS

- Final exam score for 2004 compared with the average for five previous years:

  2004 final (average) = 85
  Average for five previous years = 81

- Overwhelmingly positive responses in 2004 questionnaire

- 2005: 85 average again and overwhelmingly positive responses in 2005 questionnaire

- 2005: Colleague used this approach for his big intro Class and got the same overwhelmingly positive response

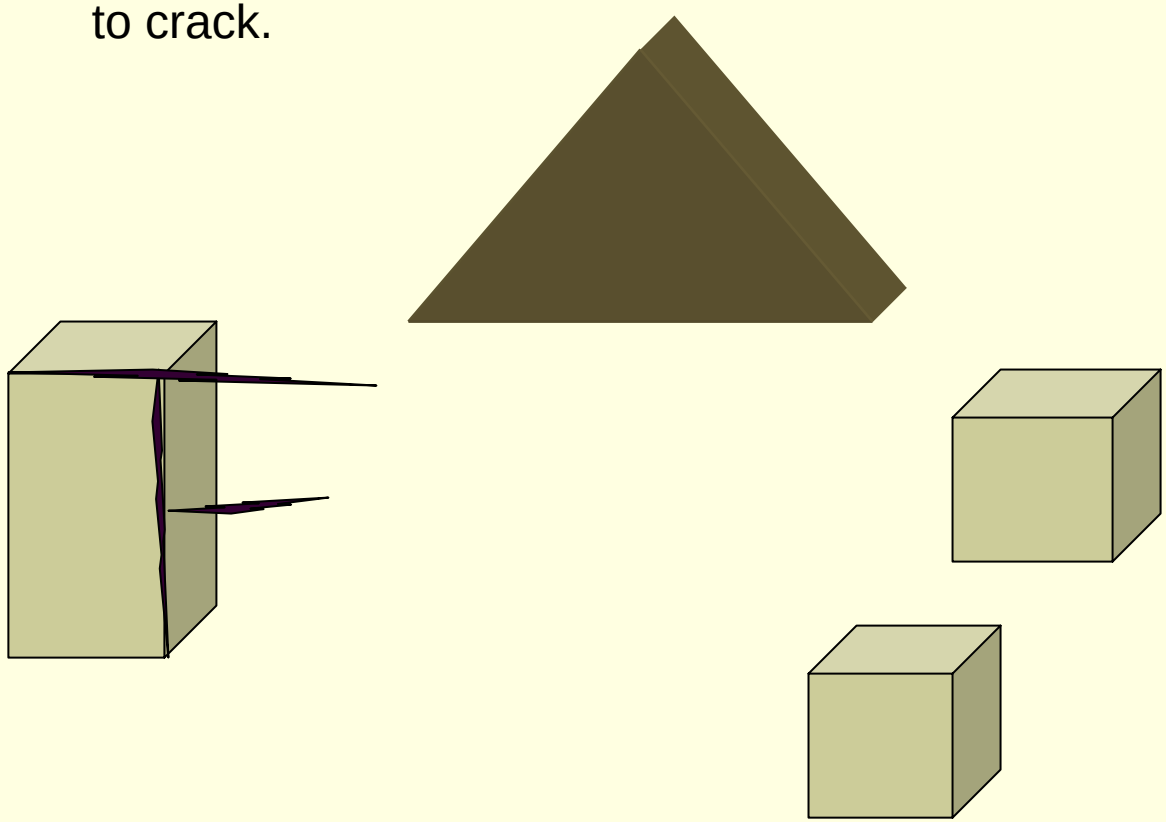
REVISIT RECYCLING

Old fashioned instruction is like building a house by completely doing all the work on each room before going on to another room.

Matt Finnerty tells me that what we are doing is instead building a shack, and then moving to a bungalow, and then to a …

Standard Method of Teaching

1. Build every room thoroughly but separately.
2. Connect the pieces together at the end.
3. Result: the foundation isn't strong and begins to crack.



Our Repetition Method

Begin with a simple but complete structure, a shack.

Build a more complex, but similar structure, using what you learned building the shack.

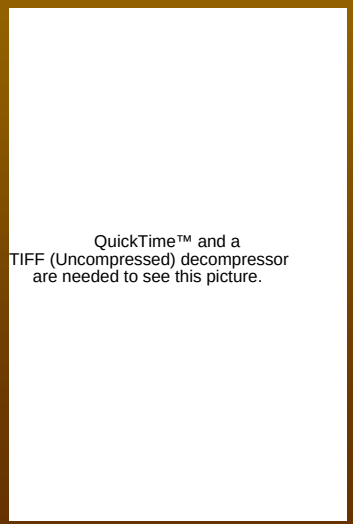
Finish with a complex and complete structure, the castle.

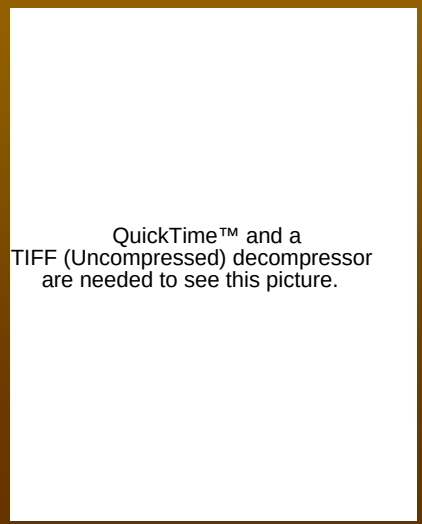
WHAT WILL HAPPEN?

YouTube link to this movie here!

WHAT WILL HAPPEN?

- What if recycling my class continues to be attractive?
- What if it keeps working in another class?
- What if we can prove this with the methods of PER?
- What if we write books this way (we are)?
- What if we can extend its effectiveness by exploiting what we know about cognitive blending?
- What if this can conquer ignorance, and disease, and bigotry, and hatred, and …





In-san-i-ty

Definition:
Repeating the same action over and over expecting different results.

WHAT WILL HAPPEN?

- Or what if we're wrong and Garrison Keillor of Lake Woebegone is right, namely, that we should go back to the way things were, doing lectures the old way, the way that

"… time forgot and decades cannot improve!"

FEEDBACK 7)
Recycling/spiralling/Revisiting
E.g., have you heard of repetition efforts, and how has it worked out?

2) The Best Thing I Ever Did!

Every Fall, as I stroll around our campus during the week before classes start, I go through a ritual …

Benefits: engagement, engagement, engagement!

1) Finally! Your suggestions!!

Feedback 8) (Other side of the worksheet)

- What TWO OR THREE specific ideas or recommendations should be incorporated into the final conference report? These will have an impact on the Reinvention Center's agenda for the next two years. The report will be published in the conference proceedings.
- These can pertain to anything we have discussed OR you can feel absolutely free to roam around with possible connections to other topics.
- In short, what would you want a research university to do more of?

ACKNOWLEDGMENT

- I am very grateful to the Reinvention Center and to Director Katkin for the opportunity of discussing these important issues with you today.