2005 National AAPT Meeting – Summer
Notes from August 8-11
Salt Lake City, UT

The following notes were taken by Dr. Van Domelen during the regular sessions of the 131st National Meeting of the American Association of Physics Teachers.

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Abbreviations: There are a few concepts that came up frequently enough in the talks I attended that I gave them their own abbreviations. (Not all will appear this time; I just pasted in the 2004 glossary and added to it as necessary.)

CSEM – Conceptual Survey of Electricity and Magnetism

ECR – Elicit, Confront, Resolve. The UWash method.

FCI – Force Concepts Inventory, a common mechanics test.

FMCE – Force and Motion Concept Exam, a common mechanics test. I may sometimes type it as FCME.

GG – Gender Gap, a disparity between male and female results, usually to the detriment of the women.

IE – Interactive Engagement, one of many strategies that get students more involved in their own learning.

ISLE – Investigative Science Learning Environment

MBL – Microcomputer Based Labs

MPEX – Maryland Physics Expectations Survey, a test of student expectations about physics and physics courses. MPEX2 is a recent revision.

N1L, N2L, N3L – Newton's First Law, Second, Third.

PRS – Personal Response System, a means of letting students answer multiple choice questions in class using a remote control.

SPS – Society of Physics Students

TIMSS – Originally "Third International Math and Science Survey", but they changed what the acronym means in order to keep using all the logo stuff as they move on. ☺

I will sometimes add personal comments in [brackets]. I will try to withhold value judgments most of the time...if you feel the need to argue a point about a paper, please contact the author, not me (email addressed provided).

Monday, August 8, 2005

AD – Classroom Strategies

AD01: Physics of Wind Energy – Cancelled.

AD02: Correcting Student Misconceptions about Electrical Safety – John Tansil, Southeast Missouri State University, jtansil@semo.edu

Faculty and students have various misconceptions about about electrical shocks [I have since gotten into arguments with people clinging to these misconceptions, they're very resistant to change. – DVD].

1. Current is deadly, but voltage isn't, independent of context. This one is reinforced on TV a lot.
2. A car battery can deliver a lethal jolt.
3. You must be grounded to receive a lethal shock.

These misconceptions reveal a disconnect between current and the voltage that causes a current in your body, as well as between the current of a circuit and the current that would go through your body. For instance, just because 10A is flowing through a wire does not mean that grabbing hold of the wire would put 10A through your body.

Tansil advocates teaching effects based on voltage, rather than current, and teaching about anatomical differences and their effect on the lethality of electric shocks.

AD03: Movie Physics: Transfer of Learning to the Real World – Corina Poltera, Kansas State University, carina@phys.ksu.edu

This was a study of how students view physics through the lens of movie clips. It looked at transfer via Lobato's "Actor Oriented" perspective, which is to say all possible transfers were considered, not just a chosen one.

The clips used showed both plausible and questionable physics (sometimes deliberately questionable for comedic or dramatic effect). Student interviews were videotaped.

Students generally had good physical intuition and caught the bad physics. However, when asked to describe things formally, they tended to resort to a laundry list of terms and demonstrated a lack of genuine understanding of what they were saying.

Expert interviews showed more structure and formalism in their themes and concepts.

Phase II brought in demos, toys, and drawings as additional stimuli, and used situations based on Newton's Laws to evaluate the goodness of clips as diagnostic tools.

There was good inter-rater phenomenographic coding.

Two groups were studied: EP1 (Engineering Physics 1, calculus-based introductory physics) and PW2 (Physical World 2, a math-light conceptual class). EP1 students tended to rely on intuition, while PW2 students relied on personal experience. As the sessions progressed, EP1 students tended to shift towards self-generated concepts, and PW2 students shifted towards use of intuition.

A tentative conclusion is that videos help students rely less on received knowledge.

AD04: Arithmetic Skill: An Endangered Species – Michael Ponnambalam, University of the West Indies (Jamaica), ponnambalam@uwimona.edu.jm

Thesis: students can't even perform simple arithmetic, much less the more complex math we ask of them. While students still learn arithmetic in grade school, once they're allowed to use calculators they tend to purge their minds of such skills.

Ponnambalam tried a "no calculators allowed" course, although he was unable to negotiate with the department for a pure no-calc course, and had to allow them on the final exam. There was much internal resistance to what was deemed "going backward".

In designing the course, it was hoped to "free the students from the shackles of calculators", and emphasize the physics rather than the numbers. This required redesigning problems so that they could be done by hand (i.e. make sure any terms using π cancel, only give perfect squares when a square root is required, etc.). Instead, emphasize working with the algebra and with variables. This had the added benefit of helping emphasize the idea that you shouldn't put numbers into the equations until th every end.

By the end of the semester, 70% of the students felt it wasn't harmful to them (on a Likert-like scale of five points from "very harmful" to "very beneficial"). The class averages on exam scores were roughly the same as in previous terms. On other survey items, 45% thought the method was helpful, 25% thought it was not helpful, and 70% recommended doing it again (all percentages in this paragraph rounded to the nearest 5%).

AD05: What Makes A Good Crib Sheet? – Kathy Harper, the Ohio State University, harper.217@osu.edu

This study compared student-made crib sheets to those made by the instructor and provided alongside the test. The study group was a calculus-based introductory electricity and magnetism course.

Common wisdom ascribes many benefits to having students make their own equation sheets for an exam, but could they be illusory? Student-made sheets were collected, analyzed, and compared to their exam scores to see if there were trends. Some students simply printed out a sample sheet provided by the instructor, some modified the sample sheet, and some built their own from scratch.

There was no correlation between how well the sheet was organized and the students' exam scores. Nor between the "crowding" of the sheet and exam scores. However, organization correlates negatively with crowding (-0.37...the more crowded it is, the more poorly organized it is, not exactly surprising).

9 of 22 students included example problems, including many solved integrals. Some students printed out the entire multiple choice section of a sample exam (conceptual problems) in tiny font. There was no correlation between picking good examples (i.e. ones that matched problems on the exam) and doing well.

There are some areas that still need to be explored, but it appears that the quality of a crib sheet does not predict student performance on exam scores.

AD06: Divergent Teaching Styles Among GTAs or Reforming GTA Behavior – James Little, University of Arizona, jlittle@physics.arizona.edu

Before the recent intervention, the TA training system could be described as a "Dilberted" Modeling system [my description, not Little's]. It seemed based on the Modeling system, but implementation had been poor. TAs were given short directions and very general Modeling-based advice and then told to run labs where students designed their own experiments. There were an 8 hour initial training course, 4 more hours of in-service training, and short weekly meetings. TAs were told to hold discussion sessions and not simply lecture.

However, the system was open to abuses. Students learned that if they didn't bring any discussion questions, there would be no discussion session and they'd get out earlier. TAs often resorted to lecturing anyway.

The recent intervention vastly expanded the TA notes (to about 20 pages per week), revised the topics, added pre-lab exercises, dropped context-rich problems (due to student complaints about them being irrelevant) and did more to enforce the discussion sessions.

The new TA notes include many exemplars now, reducing the amount of ad-libbing required of the TA. The TA meetings include more training in Socratic dialogue, and advice on making the inevitable lectures more concise. Sample discussion questions were provided in case students failed to bring any of their own.

After implementation, TA methods were still too non-Socratic, as they just answered questions directly. Also, the new training still needs to be institutionalized, so that it survives the eventual departure of the reformer.

AD07: Mathematical Conflict in Physics: Computation vs. Representation – Eugene Torigoe, University of Illinois at Urbana-Champagne, torigoe@uiuc.edu

The course under study was a remedial physics course intended for those who wished to be engineering majors (or similar disciplines) but lacked the background.

There was a perceived disconnect between "doing the work" and "understanding it". This led to the creation of a math diagnostic, with some problems that could be performed in a purely numerical way, while others required symbolic representation. In the case of the symbolic problems, students often used brute-force trial and error methods.

Having the correct representation correlated positively with good scores. Even **trying** to use a non-numerical representation correlated positively with good scores.

AD08: Students May Misuse SI Because We, Their Teachers, Do – Gordon Aubrecht, the Ohio State University, aubrecht@mps.ohio-state.edu

The correct way to do things is to use **only** SI's allowed symbols and prefixes. Avoid non-SI units like inches, and non-SI symbols like hr.

But which units are SI? There is come confusion in usage between an abbreviation (like sec, hr, nt) and a unit (like s, h, N). Also, some subfields use jargony non-SI units of convenience, such as the barn (10^{-28} m^2) or the sverdrup (10^6 m/s).

Even the standards committees are slipping in places, such as having "Electric Field Strength" mean something other than the magnitude of the electric field vector.

The IEEE ISO committee's accepted terminology and units are divorced from the vast majority of textbooks, exacerbating the problem. Their standards cling to a pre-Quantum Mechanical set of assumptions, such as the fundamental nature of **D** and **H** fields rather than the current knowledge that **E** and **B** are fundamental. These are pre-20th Century views that are being encoded in standards.

Another example is the "var", or "Volt-Ampere", which IEEE clings to despite the fact that it is exactly a Watt (as opposed to Nm for torque, which is accepted to be different from Joules).

AD09: Investigation of Change of Students' Achievement Through Science Conceptual Models Completion Activity – Younghwa Kim, Puson National University (Korea), thysics@yahoo.co.kr

Students at an all-girls high school were given "fill in the blanks" representations of various physical processes, such as the photoelectric effect. The activities seemed to help. (There was more, but it was very difficult taking notes at this talk, between mumbling speaker and rapid-fire slides.)

AP – Klopsteg Memorial Award Lecture

AP01: The Accelerating Universe – Wendy Freedman, Director of Carnegie Observatories (Pasadena CA), wfreedman@ociw.edu

Discussed the state of research into the issues of dark energy and the accelerating expansion of the universe. [My notes are a bit spotty because I tended to take down only stuff that I didn't already know about the topic. I'll try to fill in enough gaps from memory to make this sensible.]

The total Ω (ratio of the density of the universe to the density required for a Euclidean or flat universe) is thought to be 1, when you add up the contributions of matter, curvature and Λ, the cosmological constant. $\Omega_{baryonic}$ is very small, but observations place the Hubble constant H_0 around 72, consistent with a total Ω of 1.

The theory of Inflation (at some point in the early universe, things expanded VERY rapidly, smoothing out most lumpiness and setting Ω=1 to a large number of decimal places) correctly predicts the sort of remaining fluctuations in density found by COBE and other, more detailed, surveys of the cosmic background radiation. It predicts $\Omega_{total}=1.02\pm0.02$, with cold dark matter contributing 0.23±0.04, dark energy from Λ contributing 0.73±0.04, and $H_0=71\pm4$. These are all consistent with both observations (where we CAN observe things, that is) and a flat universe.

Type Ia Supernova peak brightnesses have turned out to be excellent standard candles (i.e. we know how bright they should be in absolute terms, so comparing to measured brightness tells us how far away they are), and recent new measurements add weight to the idea that the expansion of the universe is accelerating. This is notable because a purely W-based prediction would only allow for expansion remaining constant ("open" universe, low density), slowing asymptotically (flat universe, critical density) or slowing at an increasing rate ("closed" universe, high density). Normal matter and energy do not allow for an increase in the rate of expansion. Dark energy clearly behaves in an abnormal fashion.

Predictions of the vacuum density (dark energy) based on various modern theories fall short of the Ω=0.73 result by **60** orders of magnitude. So something is clearly wrong somewhere. Also, we live in an age where the density of the vacuum is of the same order as the density of matter (well, mostly dark matter). Is there something special about that near equality (i.e. life cannot exist when the two are radically different), or was it just chance? Plus, could the vacuum energy density be changing with time, as some think? This would lead to the acceleration of the expansion increasing over time, until it was strong enough to overcome gravity and even electromagnetism and the nuclear forces, tearing everything apart in a "Big Rip".

Using LIGO (ground-based laser interferometry) and the proposed LISA (space-based laser interferometry) to detect gravity waves should help answer some of these questions. The Giant Magellan Telescope (ground-based) will study gravitational lensing and other ways to directly detect dark matter, starting in 2016 (projected). Also in 2016, there is a scheduled launch of the Dark Energy Probe, a space telescope.

BL – Physics and the Media (Invited)

BL01: Einstein vs. American Idol: Physics on U.S. Television – Evan Hadingham, NOVA WBGH Boston, evan_hadingham@wgbh.org

TV has bad presentation of science, which is only getting worse as funding sources dry up and nominal homes of science programming like Discovery and History Channels shift to reality TV like Monster Garage (Discovery) or Automaniac (History).

Additionally, when science **is** presented on TV, it's easy and tempting to overpack presentations with too much data for anyone to process (an example from Chinese television was presented, and it looked like Mechanical Universe crossed with a student's crammed equation cribsheet).

It's best to take advantage of TV's strengths: storytelling, visualization (of thought experiments). Go deep on a single idea and explore it fully rather than employing a scattershot survey approach. Tell the story. Show the story.

Of course, there's another hurdle to science on TV...some topics just don't pull the ratings, no matter how important they are. [This is why a special on evolution or human sexuality is run during sweeps...controversy and sex sell. But a piece on desert ecology is likely to run on a digital-only station at 3AM.] The following broad topics that are at least broadly related to science tend to pull the eyeballs: military, disasters, mysteries, forensic (crime scene) analysis.

However, it's possible to get good ratings on a topic that doesn't fall into one of those categories. NOVA's recent physics specials have done well in the ratings, and "Elegant Universe" has been a veritable blockbuster by PBS standards. They're trying to keep that ratings ball rolling, with "Einstein's Big Idea" (based on the book $E=mc^2$, coming to PBS the second week of October). This big-budget ($3 Million) production is a series of bio-vignettes about the various giants on whose shoulders Einstein stood (plus a few of his contemporaries, like Lise Meitner), interspersed with bits of the science on which they worked. One goal is to humanize physicists, show them as people rather than as walking equation-factories.

BL02: Reaching Out to the Public: A Necessary Dialogue – James Stith, AIP – jstith@aip.org

On the commercial television side of the aisle, AIP is trying to get short "physics ad" pieces out to local TV stations for inclusion with their news broadcasts. 90 second spots are produced and provided to local stations in an attempt to broaden outreach to the public.

Such outreach is vital for several reasons:

- It is our civic duty to inform the public.
- We need to set visible standards for the scientific community.
- The public has a right to know what we do with what is, in large part, tax money.
- Our future as a field will depend on how well we tell our story!
- Scientists are in danger of losing control of science to the politicians, businessmen, religious activists, etc.

We have to make sure that the public understands what science can and cannot do for them, and why long-range research is important. Public self-perception of their knowledge in science and math is very low, and belief in pseudoscience is growing.

http://www.aip.org/isns has information on the people working on this problem, and http://www.aip.org/dbis is the specific page for the 90 second spots (Discoveries and Breakthroughs In Science). Their goal is not to go after the 8% of the viewing public that already watches science programming, but rather to reach the other 92%. About half the potential audience is at least interested, according to polls, but only about a sixth of them are well-informed.

DBIS has gotten pretty good market penetration, with 80 million potential viewers and 60 million viewers according to Nielsen ratings. The content of the spots is peer-reviewed, and despite an often several month long lag between production and airing, DBIS often scoops major news outlets.

In conclusion, there were a few important points:

- Scientists must get involved.
- Scientists must learn to tell our stories to the public.
- Scientists must take control of science back from non-scientists.
- Scientific societies must take the lead in all of this. It's not enough for just one person to make an effort.

BL03: Science in the News – Kevin Roark, Los Alamos National Lab – knroark@lanl.gov

"News" consists largely of reports of the unusual [Dog Bites Man is not a news story, Man Bites Dog **is**], and it's often (but not always) unusual in a bad way. A news organization these days is organized in a top-down manner. The desk editor assigns stories to reporters, the reporters try to cover it but may not care too much if they get it right when the story doesn't interest them [They're only human, if they have a boring story and an interesting story on their plate, they'll give most of their attention to the interesting one and perform minimally on the boring one], then the editor decides what is actually printed, which may have little to do with what the reporter brought back.

Thus, there's a multiple-layer filter that any science story has to pass through in order to make it to the reader (who have their own filters). The editor has to think it's worth even checking on, the reporter has to be interested enough to do a good job, and then the editor has to decide that what the reporter turned in is even printable. Hence, science rarely makes it to the front page or the lead story on the nightly news, unless it's tied to something sexy, like a disaster.

Science is instead usually reported in focused media (magazines, blogs, BDIS, NOVA, etc). And each of these sources has its own requirements, such as "say it in 90 seconds or don't bother" for BDIS.

Regardless of the source, though, most editors want things kept simple. If it's too complicated, it becomes unsellable. And national outlets want things CHEAP, too. If they have to send someone more than a short drive from one of their existing outlets, it's a no go most of the time.

To sell your story, know who you're selling it to. Not just the audience of the outlet, but the person at the outlet who will be personally handling your story. Find them and pitch directly to them, rather than to the general editor. See what their prejudices and preferences are, and try to shape your story to fit that, within the limits of your ethical standards, of course. For instance, "balanced" coverage (aka polarized screaming matches) are popular now, if you hint that they could get someone from the "other side" to disagree vehemently, you might have a better time selling your story.

Of course, all of these things may result in your story no longer being **your** story. But there are a few ways to get your point across more or less intact.

1. Make it a paid advertisement. This is the brute force approach. It's expensive, but you have total message control.
2. Find a good target audience that you can craft your story for without losing its essence, and sell a package to media outlets that value that target audience.
3. Message management, the anatomy of a soundbyte. Come up with compelling short and uneditable statements, so they either present your message or no message at all. Talking points **work**, make them work for the cause of good.

Los Alamos is trying to create for themselves a public image as a "place that does cool science" rather than getting out specific information. This seems to be working for them.

It's important to have realistic expectations, though. There will be inaccuracies in any story that gets through the meat-grinder that is the press, find an acceptable level of inaccuracy and learn to live with it (but kick up a fuss if it's exceeded). **Something is better than nothing.**

The reality: it's their story to tell, not yours.

Tuesday, August 9, 2005

CF – Problem Solving

CF01: Student Choices in Beginning or Intermediate-Step Multiple Choice Problems – Ed Adelson, the Ohio State University - adelson@mps.ohio-state.edu

A test bank at OSU, containing multiple choice items for several courses, has recently been revamped and expanded. The new items in the bank were designed to look at the intermediate steps of more complex multi-part problems. Several examples were shown, and the importance of careful proofreading emphasized.

CF02: Tracking Steps in Multistep Problems – Bruce Sherwood, NCSU – bruce_sherwood@ncsu.edu

The multiple steps referred to in this talk are logical steps, rather than physical events.

Tested questions: two pucks start on a frictionless surface, one has four times the mass of the other. #1) Given the same force over the same time, which has the higher kinetic energy? #2) Given the same force over the same distance, which has the higher kinetic energy?

Analytical steps were coded in the student solutions. The research question was, does student difficulty arise from a failure of the logic chain, or merely from starting at the wrong point? Versions of the problems were administered as an unscored part of the final exam. There was good inter-rater reliability on the coding.

There were three versions of the instrument. Some students were prompted to start from fundamental principles in general, some were told to start from a specific principle, and the rest not given any advice on a starting point.

On #1, prompting seemed to help a little bit, but the percent of correct answers was the same for all groups. Only 60% of the unprompted group started from a basic principle.

On #2, only 40% of the unprompted group started from a basic principle. However, in this case, the prompted groups performed significantly better.

In general, honors students in the study did outperform non-honors students [which doesn't always happen].

It seems that both the use of basic principles and the correct working of logic chains are necessary to problem solving.

CF03: Developing a Coding Scheme to Analyze Collaborative Problem Solving – Adam Feil, University of Illinois at Urbana-Champaign – adamfeil@uiuc.edu

The goal of this work was to develop a coding scheme for analyzing hundreds of hours of videos of problem solving sessions, and have it be usable without a huge commitment of time. The sample pool of data was about 800 hours of video taken in a remedial physics course (mostly online except for weekly discussion sessions, which were all taped). Tapes are encoded as movie files, so that codes can be directly attached.

The point of coding, at least in this case, is to let people quickly find areas of possible interest. Early, more detailed coding was just unfeasibly complicated.

The code settled on used three colored flags that get placed on a timeline below the movie window. Each statement gets a flag.

Red – No reasoning shown, a simple assertion is being made.
Green – Students are reasoning in some way.
Brown – Off-topic chatter.

For instance, for students S1, S2, S3 –

S1: GG G R BBB
S2: BB R R G B
S3 RR G B R

There was good inter-rater reliability (about 90% among trained raters, 75% when given "cold" to outside raters). The issue of "what is a statement?" did come up (for instance, was a particular utterance a single statement, or two independent statements? Or was it not a statement at all?), but inter-rater agreement on this was comparable to the flagging reliability.

Some data analysis has been done on the tagged interviews. One question that was asked was, "Is a 'reasoning' statement more likely to follow another reasoning statement than otherwise?" In other words, does green clump? The answer was that green-tagged statements are slightly more likely to follow other green tags.

CF04: The Effect of Representation Use on Student Problem Solving – Charles de Leone, CSU San Marcos (Elizabeth Gire presented) – cdeleone@csusm.edu

This study looked at diagrammatic representations, referring to them as NMRs (Non-Mathematical Representations). NMRs include both highly abstract diagrams like force diagrams and more concrete representations such as drawings.

Experts tend to use NMRs more often than novices do, so the question was asked, "Does use of NMRs correlate with success among novices?" The courses in this study used IE, emphasizing modeling and NMRs. The problems examined were more complex, but did not have the items broken down into sub-problems. They did not require NMRs (i.e. no explicit "draw a force diagram" sort of items), but could benefit from NMRs.

Results on the 5 items were scatterplotted against the number of times NMRs appeared in the students' solutions, which maxed out at 8 times. Most data was in the lower right corner of "many NMRs, low score", with fringes into the upper right and lower left. There were no students in the upper left "few NMRs, high score" corner. There was no strong correlation in this N=39 study, but a suggestion that while use of NMRs is not sufficient, it may be necessary.

CF05: Student Representational Competence in Traditional and Transformed Classroom Environments – Patrick Kohl, University of Colorado at Boulder – kohlp@ucsu.colorado.edu

Study was performed in large lecture-style algebra-based physics courses, and was originally designed to look for the effect of representation type (verbal, mathematical, graphical or pictorial) on student performance. There were multiple versions of each quiz item under study, each focused on a different representation. The control group was randomly assigned problems from these four types, while the experimental group was allowed to choose which representation they wanted for each ite,

The results were significant, but odd and somewhat contradictory, leading to the development of a second study. This second study found no real differences, nor did a third study.

Then the instructional environment was examined. In reformed sections, there was no real difference, but odd differences showed up in the traditional courses.

Hypothesis: reform-style courses broaden student skill sets, making the choice of representation less of an issue, while traditional courses emphasize a limited set of representations and therefore a student would benefit from being able to choose from that set.

Lecture sections were taped, exams were copied and the results analyzed, and it was found that the traditional sections concentrated on the mathematical representation. Reform classes, in contrast, covered a much wider range of representations. This would seem to be in keeping with the data [and with other research]. Teaching more representations is better.

CF06: Students' Use of Multiple Representations in Introductory Physics – David Rosengrant, Rutgers University – rosengra@eden.rutgers.edu

[Note: Rosengrant moved **very** quickly through his slides, and I missed a lot of the content. Apologies if this is disjointed. I was also a bit distracted by a pet peeve (overuse of "utilize" when "use" is just as appropriate...it's a bit manager-ese).]

This is a study in its second year, focusing mainly on free body diagrams (FBDs). There were three basic questions:

1) Do students use FBDs if not specifically required to?
2) Do those who use FBDs perform better than those who do not?
3) How do students use the FBDs?

The ISLE cycle labs were used, and ISLE is big on multiple representations. The students were taught to use FBDs before covering any mathematical representations on the topic. A case study using representative students from both the reform and traditional courses was conducted.

Students more often than not did use FBDs, even in cases where an FBD was no help at all. Their FBDs weren't always good, however, and badly done FBDs were actively harmful. Student FBDs also tended to get sloppier as time passed. Students in the traditional course generally avoided FBDs, but did fine without them.

So, to answer the three questions above:

1) Usually, at least in the ISLE-based class.
2) Yes, but only with correct FBDs. Incorrect FBDs hurt them.
3) To formulate Newton's Second Law, or to evaluate the problems.

CF07: Large Group Lecture Creative Problem Solving Experiences – Richard Hills, Weber State University (Utah) – rhills@weber.edu

This was pretty much entirely presentation (without introduction) of a videotaped lecture, focusing on filling in worksheets on the topic of centripetal acceleration. There was no provision made for a sound system, however, and the laptop's speakers weren't loud enough to hear past the first row.

CF08: The Role and Place of Imagination in Contemporary Science Education: An Introductory Case Study – Marina Milner-Bolotin, University of British Columbia – milnerm@phas.ubc.ca

Imagination is the key to science, not just a collection of facts. Science is not just what you know, but also how you found it and how you use it. So why just teach the collection of facts?

Imagination does not require formal operational ability! Imaginative Education (ImEd) should cover non-hierarchical types of imagination, such as somatic, mythic, romantic, philosophic and ironic [the tale of the Cosmological Constant is an example of ironic].

The ISLE cycle system was used for ImEd. Each element of ISLE covers several types of imagination. Examples were shown from summer science camps, and from advanced introductory students engaged in robot-building exercises.

Projects in the ImEd class were heavy on writing analytically and creatively, with the goal being to get students involved in creative activities related to science instead of merely working through "cookbook" exercises.

Physics 100 type courses are often called "Physics for Poets", but we need to consider how that's not necessarily a contradictory phrase, when there's so much potential poetry in physics.

CO – Millikan Award Lecture

CO01: The Mystique of Physics: Relumine the Enlightenment – John Rigden, Washington University (St. Louis) – jrigden@aip.org

The 19th Century was a good time for physics, and very fortunate for methodology and public perception of science. It was showed that it was possible to understand and control natural phenomena, rather than simply being victim to nature's whims.

The Enlightenment of the 18th Century and the Scientific Revolution of the 17th Century paved the way for the rise of physics in the 19th Century.

As Kant put it, the Enlightenment was all about "thinking for oneself". Nature was seen as being governed by natural laws and subject to rational examination, rather than the province of inscrutable spirits. Unfortunately, the 21st Century seems to be heralding a "De-enlightenment" as spiritualism and pseudoscientific thinking creep back into public thought.

Belief in a Designer, according to Rigden, is not a danger in and of itself. However, the position that the Designer is not beholden to natural laws is a danger. [In other words, Deism is no danger to science, but Theism is. A Demiurge who creates the universe and sets it in motion but then lets it work on its own is an acceptable God for scientists. A miracle-slinging interventionist God, however, makes rational scientific endeavors pointless, since the rules could be changed at any time.]

Debates between science and not-science are not helpful...they heat emotions but freeze minds. Debunking the opposition is counter-productive, it's best simply to show how science works and let it sell itself. Don't even mention the theistic side of the story. Emphasize the two main points of the Enlightenment: nature is run by natural laws, and reason can be used to determine what those laws are.

Physics does still retain some mystique, in part because it can claim universality for its laws. Physics demonstrates and validates the power of reason. We can correct, predict, and fill in gaps (i.e. the discovery of Neptune after predictions made based on Uranus's orbit showed there should be something there, or how the verification of gravitational lensing in 1919 made the front page, boosting Einstein's reputation and that of physics in general).

Proposal for change in the long term (i.e. forever):

- Relight the Enlightenment
- Provide students with course content on what makes physics physics, and that engenders confidence (most intro courses today break down confidence).
- Bring **words** into the course, qualitative stuff that goes beyond the mathematical representation.
- Cover fewer topics in more depth, make each topic self-contained.
- Cover more modern topics, as well as discussing how science is done these days.

The laws of physics demand that the universe exists as a necessary consequence of those laws.

DC – Mathematical Modeling of Quantitative Data (Invited)

DC01: Modeling Students' Conceptual Understanding of Scientific Phenomena – Rebecca Lindell, Southern Illinois University at Edwardsville – rlindel@siue.edu

[Another very rapid talk, apologies if I missed or misinterpreted anything important.]

Students enter the classroom with very firmly established mental models, which may be very firmly established and wrong. The models can also be very ad hoc, however, made up on the fly and quite unstable. So it's important to be able to tell which sort of model is in use.

There are two basic types of quantitative instruments:

- Efficacy instruments – these measure whether instruction was effective, and often contain many concepts.
- Diagnostic instruments – these focus on a smaller number of concepts and try to get a deeper reading of understanding. They are sometimes used as efficacy instruments anyway (i.e. the FCI, FCME, etc). A diagnostic may also be used to determine if concepts must be introduced in a particular order.

Example – The LPCI (Lunar Phases Concept Inventory) has 20 items over 8 dimensions, and has been analyzed using Lei Bao's Model Analysis (MA) method.

Understanding lunar phases requires a mental model of the interaction of sun, earth and moon over time, as well as a model for how lighting works.

The efficacy-style use of the LPCI shows that instruction improves student understanding, but provides no detailed diagnosis, merely generalities like "IE classes seem to do better."

Model Analysis theory was used in an attempt to get diagnostic information and determine the likelihoods of various models being in use. In the simple MA practice, the correct model is compared against only the dominant (most popular) incorrect model. Percentage of correct model use is plotted against percentage of incorrect model use, and the graph divided into three rough chunks. The upper left third represents students or classes that generally "get it". The lower right third represents robust adherence to the dominant incorrect model [You know, "DIM" as an acronym for that seems apt, but more than a little unfair/cruel], those who will be hardest to teach. The middle chunk are those in a mixed state, with no strong attachment either way (although those who are really close to the origin may cling strongly to a non-dominant incorrect model).

Post-testing will show a movement to the upper left if instruction has been successful. Looking at the triangular plot of pretest data can tell you which areas not only need work (low scores) but where your efforts will have the most effect (mixed state).

With this tool in hand, it's time to ask the question, "Is there a proper order for introducing topics?" In other words, does learning X make learning Y afterward easier? Or does Y remain equally hard to teach no matter when it comes up?

DC02: The Physics of Education in the Education of Physics – Lei Bao, the Ohio State University – lbao@mps.ohio-state.edu

[This was a very mathematical talk that did not lend itself to meaningful note-taking, as it was presented too rapidly for me to transcribe, much less digest. You should email Bao for a copy of the PowerPoint file if you're interested.]

Given the normalized change:

$g(x,y) = (y-x)/(1-x)$ for $y \geq x$; $(y-x)/x$ for $y<x$

Then $g(\langle x\rangle,\langle y\rangle) \neq \langle g(x,y)\rangle$ (where $\langle x\rangle$ means the mean value of x). The gain of the averages is not necessarily equal to the average of the gains.

Score-based measurement hides data on incorrect responses. This results in hidden processes...right vs. wrong alone doesn't give us much info.

A great deal of math regarding two-state systems follows.

DC03: Assessing Knowledge Transfer from Individual Instructional Items – David Pritchard, MIT – dpritch@mit.edu (presented by David Palazzo, http://masteringphysics.com)

The Mastering Physics (MP) materials were used as online tutorial homework.

If we are to be teachers, we need to assess the learning from item N by examining the performance on item N+1.

MP tries to emulate a Socratic dialogue with the student, and the logs of this help inform the instructor in depth about how the student did. This dialogue includes the now-standard online hinting system.

They looked at ordering issues, problem pairs, and times to completion. They decided to group the students into three blocks by the time to completion:

- Quick Responders (QR) – These spend less time logged into the system than most people require just to read the problems..
- Realtime Solvers (RS) – These spent about as much time logged in as one would expect they'd need to work through the problems while logged in. This was the only group closely examined for the main protocol.
- Delayed Solvers (DS) – These would often start the problem, then leave for an extended period before finishing it (i.e. going to ask for help, taking a study break, getting called away by friends, etc). These were removed from the main study because of the messiness they create...you don't know what they're doing when they're not doing the problems.

QRs often waited for the last minute to start, and there is some suspicion that they are cheating. They never ask the system for hints, nor do they ever enter incorrect answers. Students who are frequent QRs do poorly on exams compared to students who aren't frequent QRs, which bolsters the hypothesis that they cheat.

Data from RSs was fit to a graph where the independent variable was the natural log of the time [I didn't note what the dependent variable was, or whether the fits gave any useful information...I was feeling somewhat woozy at this point.]

For those in the RS group, their solution times were on average 15% faster on the second item of a paired group, regardless of the ordering (some students got A-B, some got B-A). They needed fewer hints on the second item and made fewer errors. This suggests a robust problem-solving transfer.

DO – Labs Crackerbarrel

[Being a crackerbarrel, this is more a collection of things that caught my fancy. The format was to go around the room and have everyone mention either one bit of apparatus they had made (or were planning to make), or something they needed apparatus for in the hopes that someone else had one. My contribution was for a lab in which students spin a spring to get $F_{centripetal} = k(r-r_0)$. I suggested a "sticky hand on stretchy cord" toy of the sort available in K-Mart vending machines or from places like orientaltrading.com or kippbrothers.com, which has the advantages of cheapness, low spring constant, and softness in the event someone gets whacked in the face.]

Tom Greenslade is the master of old apparatus.

Suggestion: make wave tanks for demos, and look at the relationship between amplitude and velocity at different water depths (they're only independent in fairly deep water, depth >> wavelength).

Magnetic coil coin shrinker. Two coils lined up end to end with a coin between them. Turn up the field strength rapidly, and one of the ways the change in flux is countered is by radial forces that compress the coin to reduce the area. This can shrink a quarter, but also destroys the coil in the process.

A PASCO interferometer can project white light fringes if you modify it a bit, including installing shims to keep the mirrors from wobbling. You have to avoid tightening the screws too much, though, or you'll bend the mirrors.

Northerntool.com has 24" long vernier calipers for $13.

MFJ (mfjenterprises.com) makes a power supply for ham radio operators, it has low voltage and high amps. Modify it with a ballast resistor so that it doesn't blow the breaker, and you have a good low-V/high-A power supply for labs.

TeachSpin makes good demo equipment, but it's expensive.

Tenma is another power supply manufacturer to look at if MFJ doesn't meet your needs.

One instructor had devised a "scale" lab, where students made measurements at various size scales, from a microscope reticule to GPS.

An automobile alternator can be used to provide a three-phase current.

Starcryo.com makes a $2000 SQUiD apparatus for advanced labs.

Biomechanically oriented courses can use a Tinkertoy physical pendulum to simulate the swinging of a bent arm.

Another physical pendulum of interest is a swingset, possibly driven by an off-center flywheel in resonance.

Dip a lead bell in liquid nitrogen and it will ring sweetly. Rather than simply folding lead into a cowbell [not everything needs more cowbell, after all], it's not too hard to make a mold for casting nice lead bells. Make the mold out of RTV rubber, which can handle the temperature of molten lead.

One person made a rotational brake (satellite de-rotator) with a bicycle wheel.

Another designed special clamps to let him use PASCO cart tracks as optics benches, but it turns out PASCO now sells just such an item.

Wednesday, August 10, 2005

EH – History and Philosophy of Physics in Physics Teaching

EH01: Einstein and Russia – Genrikh Golin, Franklin Delano Roosevelt High School (Brooklyn, NY) – physgen@netzero.net

Russian physicist A.A. Friedmann published his first paper in 1905, the year he graduated high school. Due to the turmoil around WWI and the Russian Revolution, Einstein's first papers on General Relativity didn't reach Friedmann until 1920.

In 1922, Friedmann wrote a paper showing that the radius of curvature of the universe need not be static, that it could increase or even oscillate. This went counter to the then-current position (that even Einstein held), and resulted in some public discussions via published letters. After a few back and forths, Einstein admitted that it was possible that the universe was expanding (although he didn't agree that it **did** expand until Hubble's 1929 work). Friedmann died in 1925.

EH02: Cancelled due to family illness.

EH03: Teaching Professionalism/Ethics to Undergraduates – William DeGraffenreid, CSU Sacramento – degraff@csus.edu

In recent years, there have been some highly publicized cases of fraud (such as Schön and Ninov), but is it really a big problem in the sciences, or just the press blowing things out of proportion?

According to a poll in the June 2005 Nature, 1/3 of respondents admitted to having engaged in sanctionable activity at least once, and ½ to some sort of iffy ethical behavior. So, yes...it **is** a problem.

Organizations like the APS are cracking down, both in enforcement and in education (such as the "Ask The Ethicist" column in APS News). AIP did a special on ethics in a recent issue of Physics Today, and the SPS is developing policy and guidelines. But we need to do better on the front lines of undergraduate study!

To improve things at the undergraduate level, we need to hold high standards as an exemplar (set a clear departmental policy) and expose students to examples of questionable behavior, so they know something's fishy when they see it. Students like knowing where they stand.

Review case studies with students in a controlled environment before you end up having a "live" case study in which a student is being tried for violations. SPS meetings now involve review of case studies, at both local and national meetings.

It's also a good idea to offer special courses and seminars on professional ethics, which CSUS is doing. It's too early to say if this is working at CSUS, but people like it, and it can't hurt!

http://www.nas.edu has a free PDF book on the topic, On Being a Responsible Scientist..."

EH04: Majorana: His Life And Work – Walter Jaronski, Radford University – wjaronsk@radford.edu

Another early 20th Century physics theorist who died young (possibly by suicide in this case). One of Fermi's students, he was on the fringe of the Italian physics community. A polymath and recluse, he came out of his shell briefly in 1937 to publish a major work that so impressed the community that the university at Naples created a chair in theoretical physics for him.

He vanished from a ferry off Palermo after having written a suicide note but then recanted it, so it's possible that he died accidentally in a fit of irony. He left behind a great deal of unpublished work, including a paper on the statistics of physics and social sciences that was published posthumously.

Amaldi's 1966 Strong and Weak Interactions has a good biography, and The Moro Affair has a lot about him.

[A combination of tiny print on his overhead slides and too-rapid progress through them kept me from getting anything beyond this point.]

EH05: Lessons Learned from the Past Aid in Research – Karen Williams, East Central University – kwillims@mac.com

Two biographical sketches were presented to illustrate important points in research: go the extra mile, and report all results.

Henry Moseley's 1913-4 experiments initially got good results, with only a few data points off the regression line (r = 0.99919). This wasn't good enough for him, though, and he tried a different fit using atomic number instead of atomic mass as his independent variable. The new fit had r = 0.99992. He went the extra mile.

Michaelson had measured some indices of refraction using group velocities for the waves, and got okay but not great results. He still published it, though, and others were able to use his data to prove that there were important differences between group velocity and wave velocity.

EH06: Learning the "Game" of Science – Dave Malony, Indiana University – Purdue University – Maloney@ipfw.edu

He created a course using puzzles to teach the nature of science, the rules of the game. Given the pieces, boards, the list of moves from several sample games and who won, students were to figure out the rules. Most games were of the "pieces move about on a grid of squares" variety.

Competing groups were given time to work out the rules, which they then reported at a "research conference". The process would iterate until workable rules were agreed upon by all students.

Students got experience in developing and integrating hypotheses. The exercises bridged from the familiar (games) to the unfamiliar (scientific process).

This course did require a **lot** of preparation on the instructor's part, and it's hard to judge appropriate difficulty ahead of time. Not all games are appropriate or easily represented.

Email him for copies of the games developed to date.

EL – Ceremonial (videotaped)

EL01: Excellence in Pre-College Teaching Award: Things I've Learned Along the Road – Patrick Callahan, Delaware Valley Regional High School (New Jersey) – ptcallahan@epix.net

[Somewhat disjointed notes, this was mainly an autobiographical talk that I cherry-picked for bits that interested me.]

Callahan is considered an expert in "make and take" experiments.

He decided he wanted to be a teacher while a freshman in high school, settled on physics as a subject when a junior. Of course, his first job was almost entirely 9th grade Physical Science (with one section of Physics in there as well). This was definitely not what he had trained for, but it was certainly interesting.

In fact, it's hard **to** train for Physical Science. It's a deliberately vague name, because school administration needs to have flexibility in assigning faculty to it. So, if the only person available is a chemistry teacher, Physical Science becomes more of an intro to chemistry. That sort of thing.

Never plan to have all 180 scheduled class days. The "interruptions" such as field trips are what the students live for.

Over time, he shifted from a traditional "lecture, confirmatory lab, exam" style of course to a more student-centered "discussion mode" course that started with investigatory discovery labs.

If you really want to get students to discuss something, ask them after the discussion to tell them what **someone else** said, forcing them to listen during the discussion, not just talk at each other.

"All I really need to teach physics is **students**. Everything else is just gravy."

EL02: Excellence in Undergraduate Physics Teaching Award: Reforming Introductory Physics Courses at Research Universities – Gary Gladding, University of Illinois at Urbana-Champaign – geg@uiuc.edu

Reform is necessarily the work of many people, especially at a research university. "Lone Rangers" will always fail in the end, due to the greater institutional inertia of large research universities and their focus on research. At best, the reforms will only last as long as the reformer does, and will die once the reformer leaves.

Organizational changes are necessary to make reform work, but they're "unnatural".

About half of all students taking introductory physics courses (conceptual, algebra, calculus) do so at a large research university. A significant chunk of these students are in engineering majors, however, and recent pressures from accreditation concerns have in turn gotten the engineering programs interested in reforming physics courses.

Urbana-Champaign's mission statement: Integrate all aspects of a course using IE methods based on PER, in a team-teaching environment. [This is similar to the Gateway project carried out in the late 90s at the Ohio State University.]

The specific elements involved in carrying out this mission statement include:

- "All-in-one" courses.
- Emphasize concepts.
- Use IE methods that have been proved out in PER.
- Do not try to build on a few "heroes" who are willing to reform. The new system must be something that even the most reactionary faculty can handle without requiring them to put a great deal of effort into it (compared to the effort they expend doing things the old way).
- A large amount of infrastructure is necessary, in order to lower barriers to participation.

16-17 faculty were assigned to a 2500 student intro course. There was a clear division of labor to spread the effort around evenly. The team meets weekly, and they write exams as a group.

The goal is to find things "out there" to adapt before taking the time to make things from scratch. The Just in Time Teaching system was heavily borrowed from, including online "preflights" to do before class. Thornton & Sokoloff's "Predict-Observe-Explain" labs were used.

Post-reform, student ratings of TAs improved dramatically.

The exams shifted to a multiple choice format (both quantitative and qualitative items) in order to make grading fairer and more reliable. They used a partial credit multiple choice method (i.e. option A is right and worth 10 points, option C is kinda right and worth 5 points). It has worked well for them, proving to be reliable and valid.

Homework is done online, and rather than use an existing package, this is one time where they built their own from scratch, a system called TYCHO. TYCHO includes web-based Socratic dialogues called Interactive Examples [abbreviated IE in the talk, but to avoid confusion I will use the abbreviation IX].

Reformers are rarely the sort who like "making the trains run on time," and would rather move on to a new project than stick around and keep working on the same thing. This makes establishment of an infrastructure vital, so that when the reformer moves on to a new reform, the old project keeps working. There have to be people and positions dedicated to the needs of the new program, full computer support, and a change in culture (which is made easier by the team approach). It's also a good idea to create a PER group so that there is a reliable source of new ideas and practices.

Students see "concepts" and "calculations" as orthogonal. They use one or the other, but rarely use both at the same time. IX's were developed in part in an attempt to bring quantitative and qualitative into the same room for students. They involve concept analysis, strategic analysis, quantitative analysis and meta analysis. For samples, see http://www.physics.uiuc.edu/Research/PER/ie.html

Students can answer IX's at any time, and ask for more help as long as they need it. Students love 'em, and prefer getting the online guidance to simply being told the final answer. The consider working a problem with help from the computer to be "solving it on my own," as opposed to when they get help from a live instructor. The students are in control of when they get help, and how much they get.

IX's are goal-driven, so the reasoning behind the Socratic questions makes sense.

Do students learn more? In comparing groups with and without IX's, there's a z-score greater than 3, a significant difference.

Overall, the reform worked. Organizational change has happened. The "guru guide" of the reform mostly validates what happened. "People don't resist their own ideas."

Large scale complex change may be easier, because systems resist small, simple changes pretty robustly. You have to break everything down and rebuild to get anything to work in the first place, and rebuilding from scratch is better anyway. [Replace KISS principle with KICK – Keep It Complex, Kid.]

The main obstacle to change in Physics Departments is the faculty [We have met the enemy, and they is us.]. Research physicists tend to be (perhaps justifiably) arrogant, and faculty in general get possessive of their courses.

This obstacle can be overcome, if you accept an open attitude towards student learning and can derive satisfaction from the collective reform efforts.

FD – Pedagogical Theories and Related Topics

FD01/02: (Team Talk) Constructing a Responsive Methodology: Grounded Theory, Phenomenology and Action Research – Peter Fletcher, Kansas State University – fletcher@phys.ksu.edu AND Administrative and Methodological Professional Development: Case Study - Every Day Electrical Devices – Sanjay Rebello, Kansas State University – srebello@phys.ksu.edu

Motivation: Provide a common framework for research.

Overview: Grounded Approach casts a wide net, Phenomenological Approach investigates student ideas, Action Research is used in a "regular" educational setting.

Grounded Theory:

- Everything is Data
- Constantly compare what you have to what you get
- Collect data until you saturate (i.e. all new data looks like existing data)
- Chase anything interesting.

Phenomenological Approach:

- There are no prior assumptions.
- Look beneath the surface.
- [There was a third point, but Peter went through his first half dozen slides so quickly that I missed a lot of material.]

Action Research: Real environment (field test), collaboration.

Several frameworks are needed: Administrative (Teacher/Researcher/Student), a Grounded Theory backbone, and a Methodological framework.

[At this point I totally fell behind and gave up as my hand cramped up. Email Peter for a copy of the slides.]

On to the case study. Everyday Electrical Devices (EED) was devised as a test run for using the method outlined by Peter.

How do we effectively prepare our graduate students for PER careers?

What we want for them:

- to integrate research and education.
- to collaborate all over the curriculum.
- to help them learn how to obtain external funding.
- for them to mentor other students.
- an attitude of lifelong diversification and growth.

Incoming grad students typically have:

- strong physics background.
- weak pedagogical background.
- diverse cultural backgrounds.
- diverse career paths (Physics PhDs, Science Education MA, PhD, etc).

Thus, we need a flexible program. The one at KSU includes:

- Physics 620 Seminar Course in PER (survey course).
- Coursework from the Education Department.
- Weekly PER seminar during terms Phys620 is not offered (covering the students' own research, as well as outside work being examined).

Despite the efforts of the existing program, the graduate students still have trouble applying what they learn about PER. So more needed to be done. In the terms of the earlier frameworks:

Administrative framework:
- Communication between teachers and students.
- Integration of research and education.
- Scalability for larger projects.

Methodological framework:
- Multiple methodologies were presented.
- Segmented phases of the study made scaffolded training easier.

Implementation:
- Fall 2004 through Spring 2005 saw an overview of methodologies and training in interview techniques.
- Positives: connected with previous courses, students did learn the techniques and how to code interview data.
- Negatives: There was a recipe-like use of the methodologies, and too much focus on the physics content rather than on the techniques. There was more of a surface gloss than a deep understanding.

The EED Project had all students participate as researchers over the Summer 2005 term..
- Week 1: Generate themes, topics and interview questions individually.
- Week 2: Narrow the focus, share ideas, eliminated redundancy. The larger number of workers generated more divergence in ideas overall.
- Weeks 3-5: Work in pairs to design and conduct interviews. Critique each other's work, both in public and in private.
- Weeks 4-6: Transcribe and code the previous week's interviews.
- Week 7: Apply the work of the previous weeks to the student's own thesis research. Present this to the group for critique.

Evaluation consisted of a one page self-reflection paper. The positive outcomes were the greater focus on methodologies, applications and on sharing ideas. On the negative side, many students just wanted more recipes to follow.

The plan is to continue this project, focusing on methodologies and their applications to ongoing student research.

FD03: Student Reactions to Vygotskian Social Constructivist Reforms in a Physics Class – Eric Brewe, Hawaii Pacific University – ebrewe@hpu.edu

Context: a small, isolated island school, with heavy teaching loads. Social constructivism was chosen as the common ground across disciplines for this university. The Physics angle on this was that social constructivism influences modeling.

Communications faculty helped to evaluate the effectiveness of modeling from a student perspective. The research question was, "Do students notice what's being done, and what impact it has?"

The changes were made to a non-majors course, with a survey delivered at the end of the semester to 34 students. Hammersly & Atkinson's 1995 Qualitative data analysis framework was used to find "sensitivity groups" and exemplary interview bits.

The groups included:	(percent citing)
• Ownership of knowledge	71%
• Enjoyment (liked the new pedagogy)	68%
• Salience (not too abstract for them)	58%
• Germaneness (relevance to their lives)	29%
• Listening to others	29%
• Expressing to others	29%

Did they get it? It's good that they felt they had ownership of their knowledge, and the last two categories were at least hopeful in showing that they were active. Those who enjoyed the course identified peer interaction as a major reason why...the class wasn't boring. All data was self-reported, so take with a grain of salt.

FD04: Pedagogy from Textbook Ideality to Classroom Reality in Physics – Michael Gabriel, University of the District of Columbia.

[This was a combination of an "I had this great professor who made everything work perfectly" talk and sales pitch for that professor's book. The "miracle" professor only ever taught small classes (no more than 30 or so). Some decent points in the talk, but nothing not already common knowledge. I took notes, but don't find them worth transcribing.]

FD05: Inventories of Basic Conceptions – Luanna Ortiz, Arizona State University – luanna.ortiz@asu.edu

[Will refer to title phrase as IBC. Note: talk somewhat messed up by practice timer advancing slides seemingly at random...this happens at least once at every conference I've attended since PowerPoint came into fashion.]

IBCs were developed as part of a five year grant involving Arizona State and area community colleges and high schools. The grant mainly covered personnel.

Goal: improve evaluation of student learning in science and math courses (or STEM in general, where relevant). Create a comprehensive assessment framework that targets a basic threshold of understanding.

The IBC-Mechanics supercedes the FCI (Halloun, noted for work on the FCI, is involved in the IBC-M). The IBC-M tests student learning on two models of mechanical behavior: the free particle (net force = 0), and the uniformly accelerated particle (net force is constant nonzero).

The items were broken into taxonomies, such as facility with 2D vectors. Some FCI-based items are included in the IBC-M.

A sample ICB-M item was presented, and data presented to show that it agreed with the more open-ended lab quiz in showing that students had not really learned from a particular mechanics lab.

FD06: Circles & Bubbles: A Learning Cycle – Stephen Maier, Northwest Oklahoma State University – sjmaier@nwosu.edu

[This was another sales pitch talk. A paper about the associated book is in press for The Physics Teacher. They essentially reinvented the Karplusian wheel for instruction on fitting data to curves. Examples included deriving pi from circumference vs. radius data for physical circles, motion of bubbles in viscous liquids, and the motion of flywheel cars.]

FD07: The Constructivist Metaphor and Physics Education Research: An Alternative – Paul Wendel, Kent State – pwendel@kent.edu

The main concern of this talk is that the ways we talk about thinking may be locking us into certain areas and out of others. Notably, that the constructivist metaphor has numerous patently false aspects, although he agrees with some of the basics (such as the Lego-like view of fitting new things into old structures, or having to break the old stuff apart to make the new bits fit).

However, treating abstract models as if they were concrete things is objectionable. It treats the mind as some sort of separate thing, rather than a process.

Assertion: models are external, only a metaphor for what happens mentally. They are a metaphor that locks us into a limited set of possibilities, which can be bad.

Out metaphors determine our ways of thinking about thinking.

Memory is a performance, not a static text. An example cited was that of people from an oral tradition who would sing a song differently every time, but insist it was always the same song. No static model can be correct, our minds do not work like our texts and computers.

Performance tendencies are corrected by coaching and practice [note: strongly resisted any implication that he was therefore advocating Thorndyke's drilling method.].

Mental models are non-falsifiable and therefore bad science.

PERC Keynote Address

PERC01: How Can PER Contribute to K-12 Teacher Preparation? – Lillian McDermott, University of Washington.

The talk opened with some background on teacher preparation curriculum at U.Wash (pre-service, in-service, faculty development). The university helps local school districts obtain and administer grants.

Science Education is once again "enjoying" a period of crisis, much as it did in 1991, when McDermott gave her Millikan Award lecture. There are both obstacles and opportunities, and one of the opportunities is to learn from the past.

From the 1991 lecture, here's the standard cycle of reform: curriculum reform leads to enthusiastic adoption which leads to disillusionment, degeneration, and finally a new set of reforms. We want to short-circuit the cycle and go from adoption back to new reforms without passing through the disillusionment and degeneration (the "bottom half" of the cycle).

Belief that materials are teacher-proof helps drive the full cycle. Once you hit the "forget" part of "fire and forget", things fall apart. We don't want to spend time in the bottom half of the reform cycle.

K12 teachers are poorly matched with both the things they learn during teacher prep courses, and with the material they actually teach. While there are many things important to the professional development of K12 teachers, we should focus on the content mismatch, since content is our area. Let the education departments handle the rest of the stuff.

Most courses available to K12 teachers are too formalistic, with insufficient hands-on and numerical aspects. These courses are poor role models, as K12 students learn poorly by the ways we teach college [and one could argue that college students don't do so well either, but that's a topic for a different talk].

There are several questions we need to ask ourselves before we throw ourselves into yet another cycle. Is there evidence of a mismatch between how we teach physics and how K12 teachers need to learn it? What steps can we take to deal with the mismatch if it exists? What assessment if most meaningful? Will simply modifying standard curricula work, or will it require a ground-up rebuilding effort?

Some examples of bad matches between how we teach and how they need to learn are kinematics, dynamics, and buoyancy. Matches that have improved in recent years include circuits and electric lights (although more testing is needed to see if the latter has really improved).

Questions requiring qualitative reasoning and verbal explanations are essential, and effective. On some examples of these types of problems, standard instruction has been shown to have no effect on student performance.

We assume that teachers must be able to perform at above the level they expect their students to reach by the end of the course. How can we help teach them up to such an expert level? We know that standard instruction isn't doing the job. For example, a "rank the brightness of these bulbs" task had about the same success rate (about 15%) for students, new teachers **and** experienced teachers who had only gone through standard instruction. That last group is notable: just teaching a topic doesn't necessarily mean that you eventually come to understand it.

Teachers need to have a correct, coherent conceptual framework, and traditional instruction doesn't lead to them getting one. Teaching by Telling is ineffective for most people, including most teachers. And the existing "Teacher Guides" are often too compressed and generally useless.

We need guided inquiry instruction. Guided inquiry is not totally open-ended discovery learning, rather it nudges students in the right direction every so often. Physics by Inquiry (PBI) is a classic example of such a course, as are the Tutorials from UW.

PBI tries to keep equipment simple and cheap, so that teachers will be more likely to successfully replicate it for their own classrooms on limited budgets. It has shown itself to be successful in generating understanding on the topics it covers, and has been used for teacher instruction for over a decade now. Due to its embedded epistemology and pedagogy, PBI has been significantly more successful than the Tutorials (better student scores, better retention).

A constructivist pedagogy on its own is not enough.

Student-oriented instruments like the FCI or FMCE are inadequate for testing teachers, who must be off the top of the scale and then some. Objective tests in general are inadequate for evaluating teachers, you must ask for explanations.

Tutorials are good at getting students to the answers, but not at getting explanations from them. PBI, on the other hand, does get at explanations.

An experienced teacher adapted PBI to a high school classroom with noticeable success. Preservice teachers in the same area were helped in performing their own adaptations of the material. While all students did well, those in the class of the experienced teacher significantly outperformed those in the classes of neophyte teachers. While preparation helps, experience helps a lot too...in this case. It's a synergy, with neither being much use on its own, but the two creating great results together.

Teachers have the same conceptual problems as most students. Merely giving them more experience in being confused doesn't help, but a good pedagogical background isn't enough on its own either. They need to have the good pedagogy **and** experience in using it. Preparation helps everyone.

Standard courses cannot be "tweaked" enough to do the job, as found in the experience with Tutorials. And broad assessment is not enough to tell if the teachers have learned the material.

Some standard short-term treatments such as research experiences or sending in "stunt teachers" can help with motivation, but they otherwise don't really help. Short-term solutions do not help with understanding or the ability to deal with the unexpected.

Intensive preparation is needed, so that they can learn the material as they're expected to teach it. Special courses are required, but these should be **in addition to, not instead of** the course requirements of the students' majors/minors. These should also be made open to non-teachers [although if half the football team decides to take it, you may run out of room for the education majors, so be ready to expand enrollment].

These new courses should teach concept/content and process concurrently. They need to cover the basic concepts, scientific reasoning skills (so students understand the nature of science), and multiple representations. Teach by questioning, not by telling. Provide ongoing support and mentoring beyond the confines of the course itself.

Scientific thinking, critical thinking and reflective thinking are all vital.

A quick note on the evening poster session. Scott Bonham did some extensive work with WebAssign to determine if giving extra credit for earlier completion of work had any real effect on things, and it didn't seem to.

Thursday, August 11, 2005 - PER Conference

TP-B: Research on Improving Content and Pedagogical Knowledge of Science Teachers (targeted poster session)

[The numbering of the posters is totally arbitrary on my part. There may be some official numbering, but I probably am not following it.]

TP-B01: The PATHWAY Project – Brian Adrian, Kansas State University

[I didn't actually take notes on this, since I've seen it many times at home. But for completeness, here's a rough outline of the project.]

PATHWAY is composed of two main parts. One is a library of video clips that can be searched by content and used by instructors. The other is a series of "synthetic interviews", in which experts were videotaped answering a number of common questions. Typing in your own question results in the system picking the interview segment that seems to best fit your question.

The synthetic interviews currently only cover mechanics, and involve three subjects, although two more are in the process of being sorted into the system, having been taped over the summer. The search function is being refined away from an earlier brute force "include a quarter-million possible questions for direct matching" approach.

Both parts of PATHWAY are intended for the use of teachers, not students.

http://www.physicspathway.org is the webpage. It is currently only enabled for Internet Explorer (and actually crashes the PalmOS browser), but this should improve with time.

TP-B02: Increasing Awareness about Teaching Issues amongst Science Undergraduates – Chandrasekar Singh, University of Pittsburgh

According to a NSTA survey, there is a serious shortage of science teachers. There have been various schemes implemented in an attempt to address this, such as emergency or out-of-field certifications, drawing from non-traditional talent pools [such as in New York City's move to let just about anyone in a profession teach a subject related to that profession, and get certified as they go...something that has found its way into comicbooks, by the way. Peter Parker, aka Spider-Man, now teaches Biology at his old high school].

The best solution in the long run, though, is to get more undergrads ready and interested. UPitt has developed a new course to help with this.

The new course increases awareness, improves pedagogy, familiarizes students with cognitive research, and discusses PER literature (with a focus on applications). Students must have a B average or better in calculus-based physics, plus a cumulative GPA of at least 2.5 to be allowed to enroll in this 3 credit, 1 semester course.

Those who signed up for the first semester tended to have some prior teaching experience, such as tutoring while in high school. Curiosity about teaching methods was the main draw.

In the course, existing PBI modules and Tutorials were used and discussed. Students read papers on the topics covered by these modules.

Students worked in pairs, picking specific units (from the broad categories of DC Circuits and EM Induction) to study and then teach to the rest of the class. The normalized gain on the topics that were covered was about 0.8. Students developed their own evaluations for this purpose.

There was no significant change in student attitudes, but they did start out pretty high. Most students reported a positive impact, about 10% were neutral, and none negative.

The self-evaluations were highly unreliable (all students self-rated very positively), but peer evaluations were reliable.

Critiquing did not seem to change behavior, it may have been too small of an intervention in this case, however.

At the end of the course, with the instructor absent, the students held a focus group discussion about the course and audiotaped it. In general, despite the efforts to change viewpoints, the class still believed that "teaching = lecturing".

TP-B03: Seeing Gender – Jacqueline Spears and Cecelia Hernandez, Kansas State University (presented by Brian Adrian).

GROW – Girls Representing Our World. A summer workshop for middle school girls at KSU.

GROW is meant to address gender issues in science, something not really addressed at most schools because of the perception that gender issues automatically mean radical feminism. Gender issues are also frequently treated as having been solved already, so the school can move on to other diversity issues.

However, researching gender issues helps both genders, and helps both students and teachers.

Upcoming CDROM titled "SeeING GENDER" will cover in more detail. [Yes, it's a tortured acronym.]

TP-B04: Out-Of-Field High School Teachers – Larry Escalada, University of Northern Iowa

NCLB's "highly qualified" clause exacerbates the shortage of science teachers. Fortunately, exceptions have been made in the clause for multi-subject instructors (i.e. the physics teacher who also gets roped into teaching calculus or physical science).

To teach outside one's degree field in Iowa, you need an "endorsement". In the case of physics, a science teacher who isn't specifically a physics teacher needs 15 credits of physics to get an endorsement in physics. A non-science teacher needs 24 credits (the science teacher is presumed to at least have some relevant math and science in their background, if not actual physics).

About 20% of physics teachers in Iowa are "emergency endorsed", which seems to be consistent with national trends (allowing for different state nomenclature and procedure, of course). At least one introductory physics course must be on the teacher's transcript for them to get emergency endorsement, however.

About 80% of physics teachers in Iowa are the only one at their school teaching the subject, and about 54% are not members of any professional science teaching association (AAPT, NSTA, etc). They are **isolated**.

At UNI, teaching majors are all add-ons. Students pick a base major, such as physics, then add on teaching courses.

For in-service teachers, UNI offers a Physics Institute in the summer to help teachers get their 15 credits. It uses a learning cycle to tie elements together. Curriculum draws from modeling, Real-Time Physics, PRISMS (a home-grown system) and other established material. Teachers who attend get not only the college credits, but also a stipend for the time they're in attendance, and a small grant to cover purchase of equipment for their classrooms. This program is essentially funded by porkbarrel, getting slipped into budget bills here and there. This does result in a slow funding cycle, however.

The average Physics Institute participant had taught for three years already. However, there was no real correlation between teaching experience and topic expertise, mirroring McDermott's findings [see PERC Keynote].

The summer course resulted in some good improvement, but the mastery level was not yet attained after only one year. No better after two years. Journaling on the part of the participants revealed that teachers had many unmet needs, such as equipment resources (i.e. they couldn't practice what they had learned between institutes, because they lacked the equipment to practice it with).

It was determined that treating the two years as regular semesters (with different topics each summer) didn’t allow for debriefing. Mixing the topics up in later years did seem to help those who had some physics background, but had no effect on those coming in blank.

Invited Talks

PERC01: Repositioning Ourselves from "Knowers" to "Learners": Formative Assessment, Vygotski and Teacher Preparation – Valerie Otero, University of Colorado

"After I gave the students their prior knowledge, I continued their lesson." – an in-service teacher, 2002

In a Vygotskian scheme, there are two kinds of concept. Scientific (academic) concepts are formalized and abstract, while spontaneous (experience-based) concepts are context-dependent and concrete. Learning is the process of bringing the two together, to concretize the abstraction and abstract the concrete.

Beginning learners tend to have the two types of concept separated, with connections that are tentative at best. There can be some bizarre hybrid mixtures. We need to give them useful concrete experiences, plus opportunities to apply their abstractions.

So, what are teacher views of student knowledge?

Study part 1: at University of Colorado, 10 STEM college faculty were interviewed about teaching goals, practices, etc. 6 of them (population IA) were involved in current reform efforts, while the other 4 (population IB) were not involved in the reforms, but were aware of them. The reforms in question seek to integrate content with pedagogy and practices. Undergraduate TAs, aka Learning Assistants, were involved in the reform, and they were also interviewed (population II).

Statements about students were coded into three general bins.

- Property of Students – an immutable, intrinsic "good student/bad student" description.
- Condition of Students – transitory states, where the student is or is not "getting it", generally a transitory state.
- Learning Process – what the students need to do in order to learn.

[Note: those familiar with Spanish could consider Property to be "ser" and Condition to be "estar".]

Faculty statements were fairly evenly spread across the three categories, but the LAs mostly coded things under Process. It's possible that the LA coding was so different because they were peers of the students being talked about (and therefore knew more about what was going on in their heads), or because they were taking Otero's course (which strongly emphasized Process) at the time.

We want instructors to have a Process view.

Study part 2: Elementary pre-service teachers (population III) were studied. Data was taken from a long-term portfolio project. The first half was a pre-measure, while the second repeated the same items as a retrospective reflection.

Most of the entries were coded as Condition. Instructors had a "definitions" view of science, you either could successfully memorize everything or you couldn't. Instructors also took a view that students came into their class as blank slates, and that the only relevant prior knowledge was material covered earlier in the semester. They assumed that if and only if something had been taught, it had been learned, ignoring the effects of prior experience.

There were some Process views and some acknowledgement of prior experience, but this was mostly seen in the retrospection side. Taking a course on teaching moved people farther away from the Property view.

Measuring just the Condition view, there was an increase in 2002 and 2003, but a decrease in 2004. This may indicate that they left Property at the beginning, but were now migrating into Process.

Otero's own awareness improved over time, thus improving her ability to elicit responses and aid in the development of her subjects. The teacher-trainer developed in parallel with the teacher trainees. The teacher is also a learner, and should not be positioned as a content-expert but instead as a learning-expert.

When a teacher stops learning from her students how to teach, she stops teaching her students how to learn.

PERC02: The Physics Teacher Education Coalition (PhysTEC): Results, Directions, Initiatives – Ted Hodapp, Director of Education and Outreach, APS

http://www.cur.org – Council on Undergraduate Research (plug)

Teacher prep is not generally being taken seriously by physics departments around the country, only a few isolated schools here and there were taking it seriously. PhysTEC was devised to help fight this problem. It was funded in 2001, expanded in 2003-4, and in 2004 Hodapp became a new PI on it.

The mission of PhysTEC is to improve and promote education of future physics and physical science teachers. The new model is being employed at 8 core PhysTEC sites, and numerous coalition sites draw in the core sites for help and resources.

The components of PhysTEC are:

- Collaboration between Physics departments, Education departments and local school districts.
- The TIR, or Teacher-in-Residence. A TIR is pulled out of their normal faculty slot for a year to work on the project intensively.
- Reform courses, drawn from PER and Science Education.
- Early field experiences.
- Mentoring, to help with the retention of teachers.

TIRs are taken out of high school faculty roles to work in a university physics department and help with changing teacher training. They mentor pre-service teachers going through that training. Careful work is done to make sure that TIRs still have high school jobs to return to.

PhysTEC is trying to build a network of schools to solve the problems facing high school physics teaching. Truly collaborative relationships are desired, to help us disseminate the things we know work.

The program seems to be working pretty well so far, but there's a long road ahead.

Unsurprisingly, schools with PER groups are the most successful in teacher training.

PhysTEC has helped to ease the antagonism experienced between Physics and Education departments in Arkansas.

The program seeks to build an infrastructure that will outlast their grant funding, and is working with ComPADRE on a digital library as part of that infrastructure.

Their national conference will be March 23-24, 2006 in Fayetteville AK. Individuals wishing to join should go to http://www.PTEC.org, while departments interested in participating should see http://www.aps.org/educ/joint.cfm

PERC03: Evaluating Activity-Based Teacher Workshops – Ron Thornton, Tufts University

Evaluation depends on:

- Demographics
- Self-reported evaluation by participants (content and expectations)
- Testing participants (for content)
- Observations of teaching
- Testing students (for content)

[I think "participants" in this case means faculty.]

Three case studies were presented.

#1: A short, activity-based workshop for in-service high school teachers.

They were trying to change teacher practices to more of an IE approach, using SOS (Student-Oriented Science) workshops. These were 2-day main meetings, with one or two single-day followup meetings, using MBL.

Teachers were taught the content using the sort of effective pedagogy we would like them to use in their own classes, to learn as they would teach. It required reflection and meta-learning.

Short workshops usually don't help, but SOS did, and has evidence of efficacy. Over 90% of participants changed their teaching in some way.

54 participants from the mid 90s were surveyed in 1997. Their self-reported implementation of what they had learned came in varying degrees, from just tossing computers into the mix, to a fairly full use of the course as they had learned. Financial support was shown to be essential to successful change, however, since you need money for equipment. 83% of the participants tried to get colleagues to try the new pedagogy as well, and there was no prompting from SOS. Most praised the program.

#2: Two-week summer seminar for professors, starting in 1990, to expose them to IE.

Activity-based collaborative learning environments with lots of computer tools were used. The positive views of the exercises learned in the seminar faded with time. Funding, time and effort requirements and the inflexibility of colleagues were major problems. About half thought students learned more the new way, but 5% thought students learned less.

#3: One-week activity-based summer workshop for professors in 2005.

All participants found it useful or helpful (but keep in mind there hasn't been time for possibly fading of these views). The progress of this program will be followed for the next five years. Participants wrote multiple-year plans as part of the workshop.

Overall moral of the story: meaningful evaluation is a lot of work.

PERC04: Panel Discussion.

[Comments will be coded as follows: V – Valerie Otero, T – Ted Hodapp, R – Ron Thornton, P – Person in audience.]

How does our experience as students reinforce the Condition view?

V – As we are not rewarded for "kinda knowing" in most cases, evaluation doesn't really reinforce the Process view.

Self-selection issue: are those who participate already primed to change?

R – This isn't a problem as long as the workshops are full. It's numbers that matter at this stage in the game.

V – Even the self-selectors don't always change much.

T – Self-selectors tend to have a demonstrated track record, and are a safer investment in time and effort to train.

P – Sometimes colleagues force-select those who really need the training.

T – We need to pressure NSF on teacher-training funding [comment unrelated to a question.].

Disenchantment issue (poor retention, lack of implementation).

R – It's not really that bad, actually. He had expected far worse. Just be sure to get more than one participant from any given school, so that they can back each other up. In-service teachers are more receptive than pre-service teachers.

V – We need to help support teachers during the period when the new methods haven't started showing results yet. We also need to instill a need to know what students think, to help carry teachers across this period.

T – Tools aren't enough, you need to build in a positive attitude.

Redirect – There's a mismatch with various standards and testing requirements (such as in NCLB), which discourages the use of new tools.

V – If you prepare teachers to be learners, rather than holders of content, they can cope.

T – We need to establish good support structures to help overcome these problems.

R – Covering less material in a superior way gives better results on high-stakes tests anyway. If students truly know 1/N, they do better than those who have seen N/N but learned none of it.

Two day workshops aren't short...there's three hour workshops that are expected to show results. And "Get It" seems to equal "listen – cram – forget".

R – Even those three hour tours seem to have some effect, although eight hours is a more effective schedule.

Preservice workshops are mostly conceptual, rather than covering math skills and representations.

V – Math Education is big on multiple representations for K12 training.

R – Teachers tend to add in concepts without cutting down on the math required. Algorithmic solution strategies are retained.

K-8 assessment and the perception of "getting it". Major publishers get involved, and their textbooks drive so much of curriculum.

V – Yes, this is why the "get it" view is so common. There's too much summative assessment, students aren't even aware that formative assessment exists. They don't know that partial knowledge is still important. We should teach learning gain analysis. The textbooks are slowly starting to change, though.

Why do reforms fail when training is handed off to a new instructor?

T – A training course is no more instructor-proof than any other kind of course. You need to properly train the trainers, who have different needs than regular instructors.

R – Change the culture, and the new trainers will have support. If the new methods become the standard, then changing trainers is easier.

There is a tendency for schools to take existing programs off the shelf and use them without adapting the programs to their own particular needs. How to avoid that "instant gratification" situation?

V – Provide sample adaptations as part of the "shelf" version, and discuss how to make the changes.

R – Try to recommend which parts can be used raw, then iterate the adaptation by bringing in new parts each time. Don't try to cold-start the adaptation.

T – Make sure they know it's **okay** to adapt! Many think that they've picked up an unalterable modality, the graven word of God.

[There was some discussion after this point, but I left for lunch here.]

Lunch Speaker

LUNCH: Teacher Quality Issues in Science Education and Research Opportunities – Harold Himmelfarb, U.S. Department of Education (formerly instructor of Sociology of Education at the Ohio State University)

[These notes will be a little disjointed, as he covered a lot of topics and I didn't always take notes on the connecting bridges.]

Scores in math have been improving, and are better than ever for 4^{th} grade students. But they're still pretty low. There has been no improvement in recent years for 17 year olds, despite an increased enrollment in math courses by this age group.

We're doing well on TIMSS Science. 4^{th} and 8^{th} grade students rank in the top 1/5 of the countries surveyed, and the racial performance gaps are closing.

National science scores have been pretty flat for 1996-2000, the 2004 data is still being analyzed.

Few high school students take more than 2 science courses. Few college students get B.S. degrees in science. Asian schools are turning out a much higher proportion of science degrees, and about half of our PhD's in science go to foreign students who plan to go back home when they finish. There has been a dropoff in these numbers post 9/11, however.

This is a long term hazard. We have few homegrown scientists, and lose most of the ones that we import.

There is a lack of alignment between the standards and what is taught, but that's not necessarily a bad thing...the standards may need work. Especially since the standards are not testing inquiry-based education, which most agree is a good type of teaching.

We have a high percentage of Out Of Field physics teaching (about 50% in high school, 84% of middle school physical science teachers do not have physics degrees). As a result, teachers lack the deep conceptual understanding we'd like, and they're uncomfortable conducting inquiry-based lessons. They need to relearn the material the right way. [Canned lectures and cookbook labs stick around in large part because they're easy to do, even if you don't really understand the material.]

The Department of Education invites research projects to verify that this relearning will help, and be worth the effort.

The high rate of teacher attrition in public schools makes the school administration leery of committing resources to faculty development, but lack of faculty development undoubtedly drives a lot of the attrition. Catch-22. Also, since the existing standardized tests don't measure the sorts of things that would show the direct benefits of new teaching methods, why waste resources retraining when it won't keep the NCLB wolves at bay?

The existing research lacks enough rigor to convince people that change is needed and that change would be effective. [Editorial aside: "Rigor" seems to be the new buzzword at the DoE, be sure to include it prominently in all your future grant applications. Unfortunately, the vigor with which he promoted rigor suggests to me that it will be a "negative" buzzword, used to ignore the results of any research that is inconvenient to the current political climate.]

The IES (Institute of Education Sciences) has recently been reorganized again to encourage rigorous research. As part of the reorganization, Congress almost mandated that **all** supported research involve randomized blind trials. [But apparently someone finally convinced the relevant committee that some work can't be done blind, like, oh, pretty much all qualitative research and case studies.] They do now demand an "evidence based" field in applications.

The IES will support researcher training, support research that is rigorous and relevant, and disseminate findings (via mechanisms such as their "What Works Clearinghouse").

The remainder of the talk covered material that can be found at their webpage, http://www.ed.gov/ies, such as funding cycles and specific programs.

[Apologies for the somewhat high level of snarkiness in this section, but I actually got up and left before the talk was over, I was finding it that irritating. Yes, you have to expect a bureaucrat to talk like a bureaucrat, but I think I ran out of patience about the fiftieth time he said the word "rigor".]

Workshop W-A: Important Issues in Preparing GTAs

Organizer: Kathy Harper, the Ohio State University

[A lot of time was spent brainstorming up lists, then going over Ohio State's TA training program and discussing things. Just so you know what to expect in terms of format here.]

We need to look outside of physics departments to see if other disciplines have had, and solved, the same problems we have regarding TA preparation.

List of TA preparation complaints:

- TAs say they get it, when they don't.
- How can we train TAs to do modeling discussion?
- There **is** no training in some schools.
- Teachers don't find out when TAs make mistakes (no feedback).
- There aren't enough resources to do it right, even if we knew for sure what "right" was.

- Short deadlines (i.e. TAs arrive on campus Wednesday, have to be teaching on the next Monday).
- Lack of experienced mentors (TAs often go on research money after one year and are never seen again).
- Lack of continuing support aside from weekly training meetings (which mostly just focus on the details of the next lab).
- Lack of addressing international students' difficulties.
- Lack of content knowledge on the part of TAs (they may have a B.S., but that doesn't mean they ever really understood the introductory material!).
- No constructive intercommunication.
- You can't fire TAs that do poorly (either they have to be supported somehow, or you simply can't hire a replacement).
- TAs are overwhelmed by the rest of their graduate school experiences.
- TAs don't get useful feedback to let them know if they're doing a good job.
- The best of the crop are often stolen for recitations or other courses, so they can't provide an example to the beginning TAs (going back to the lack of mentoring).
- Pedagogy concerns in general.
- Just because you have a detailed plan doesn't mean it will work.

Elements critical to TA preparation and support:

- Diagnose basic knowledge (FCME, etc).
    - Give ongoing help with content as needed
    - Have them perform useful activities
    - Make them perform all the work in advance as if they were students, and hand it in for evaluation.
- Pedagogy instruction and practice (necessary, but not sufficient)
    - Models of good teaching
    - "No" ads [I don't remember what this means]
    - Practice with Socratic dialogue.
- Have TAs perform the opening lecture of the lab in front of peers, so they can critique each other. Similarly, critique each other's grading.
- Regularly schedule training meetings and enforce the times, but do allow them some autonomy in setting this schedule.
- Define lines of responsibility, give rules some teeth.
- Cultural awareness/sensitivity training.
- Make sure they know the University rules!
- Make sure there's **time** to train, both before the semester starts, and during it.
- Include student-type activities in training, so the TAs are taught as they are expected to teach.
- Provide rubrics for grading, especially in large classes where inter-rater consistency is important.
- Explain the motivation for what you do.
- Community-building and mentoring.
- A manual would help.

- Provide "helpful hints" on both professional duties and personal life (i.e. personal life should not destroy professional life, try to avoid things that will hurt your teaching, like staying up until 4 AM playing computer games).

[At this point, we looked at the OSU handouts, which provided examples of many of the above points. However, the view from the trenches is that the OSU system doesn't necessarily accomplish what it sets out to do.]

Baselines can be useful, but they should be flexible.

TAs should be treated like professionals, not like cogs. They need not just responsibilities, but also rights and respect.

Run training as a university-wide professional conference, with sessions and talks and so forth. Each TA picks the sessions appropriate to their own position, with help from departmental advisors.

TA's need to know that, "Your students aren't you, but they aren't necessarily worse than you, either. They are motivated in general, just not necessarily for your class."

Use peer discussion (professor leaves the room) to get TAs to buy in. Experienced TAs are a more credible source of information for new TAs than faculty are.

Find where the money is shuffled, shuffle some into training. For example, at University of Minnesota, a bookkeeping issue makes it so that TAs are paid for two weeks before the semester begins. The Physics department makes the TAs show up during those two weeks, and uses them for training.

Hold a weekly seminar to debrief after teaching, to process experiences. Mentor TAs should run this.

Some useful online resources:

- http://web.uvic.ca/terc/critical-incidents - Movie files of vignettes showing things that could happen to TAs on the job.
- http://www.podnetwork.org
- http://www.uea.ac.uk/ - University of East Anglia