AAPT Winter National Meeting 2003

Austin, TX – Renaissance Hotel

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This document is a transcription of the notes I took at the Winter 2003 AAPT meeting in Austin, TX. A few caveats before I start with the notes, however.

1) This only covers sessions I personally attended.
2) I did a fair amount of analysis and interpretation "on the fly" as I wrote these, so they do not always represent what was said in the talks, rather what I understood from the talks. I may be misrepresenting a few talks here and there.
3) I didn't always note something that I already knew. I'll try to fill those logical gaps in with this document, but I guarantee nothing.
4) I did not take notes at any of the talks by members of the KSU PERG, on the grounds I can get my hands on their Powerpoint files if need be. If we put the files on the web, let me know the URLs so I can add them to this document.
5) Not everyone gave talks that lent themselves to note-taking (too fast, too disorganized, organization too nonlinear, etc). So a few of these entries may be a bit scattered.

Monday, January 13, 2003

AB: Ceremonial

AB04: Richtmeyer Lecture: "Can We Make Atoms Sing and Molecules Dance?" – Margaret Murnane

The general point of this talk was to discuss recent work with ultrashort laser pulses in the femtosecond range (with possibilities of getting down into the attosecond range eventually). These pulses are shaped like thin discs, since they're about a millimeter wide and only a few microns thick.

These pulses are used both as strobe lights to watch very fast atomic and molecular processes, and as tools to control such processes. By using a pulse of just the right shape, an initial population can be guided mostly into a desired final state. Such manipulations could allow for: controlling energy populations, making designer wave packets, manipulating molecular motion/vibration, controlling chemical reactions, etc. Unfortunately, most of these final states break down in picosecond times, so it's vital to have pulses shorter than that.

The main breakthrough that has made this sort of thing practical has been to use the system itself as an Analog Computer (AC). Rather than having to try every possible combination of wave shapes, an iterative process is employed to narrow things down to the optimal wave shape, a sort of artificial selection evolution.

The evolution starts with a number of random wave packets and reads the results. Then the best subset of waveforms is picked and "mutated" slightly. This new set is sent through, and the best subset picked, etc. Iterate until results are fairly stable, this generates ideal waveforms for the task at hand in a quite reasonable time.

An example of the evolutionary process involved generating soft X-ray lasers by adding together many IR laser photons (much like standard frequency doublers can take two IR photons and make a green one). The goal was to be able to select a specific Extreme Ultraviolet (EUV) frequency while suppressing the others: i.e. pick a 27 photon sum over the other possibilities. By evolving the system with femtosecond pulses to regulate it, they were able to generate true laser beams of pretty monochromatic EUV photons. The pulses would essentially rip electrons off their atoms and then slam them back down to generate the desired EUV photons. And it only took 105 iterations to get the pulse just right.

An important note here is that while the pulses were on the femtosecond (10^{-15}) scale, they produced results on the attosecond (10^{-18}) scale by tuning things just right. Well, tens of attoseconds.

A secondary tool they developed to help keep the EUV beams in coherence was the "smart fiber", an optical fiber with wavy borders that selected out certain frequencies. The evolutionary process also helped them find the right shape for these fibers.

Another use of femtosecond pulses is to force a resonance on just one "bond of interest" or one vibrational mode in a molecule, rather than "ringing" the entire thing. For instance, you could get a transverse vibration (flapping) with little or no longitudinal vibration (squishing) in a CO_2 molecule, or even suppress an existing vibration. Given that some reactions are favored or suppressed depending on the vibrational modes, femtosecond pulses can be used to control reaction rates (i.e. make just one side of the molecule vibrate, making it react with something while leaving the other side intact).

AB05: Oersted Lecture: Schrödinger's Alarming Phenomenon – Edward "Rocky" Kolb

Opened the talk with a picture of a street sign in Rome, the intersection of "Astronomy" and "Physics." The unity of these two is the main thrust of the talk, connecting inner space (nanometer scale) to outer space (megaparsec scale), atoms to galaxies.

(Biography of Schrödinger omitted from notes. As with Kepler in the days of the Thirty Years War, he found times of trouble to be good times to do science.)

Schrödinger determined in one of his papers that the very fact of universal expansion would result in the creation of particle/antiparticle pairs that would not immediately annihilate each other. Okay, not a lot…one very low energy particle per trillion cubic parsecs per ten billion years. But even this was alarming to him, as something was coming out of nothing! **The vacuum froth** came out of this idea.

Later on, Stephen Hawking followed up by showing that at the event horizon of a black hole, the mangling of spacetime would allow pairs to pop out of the froth. Sometimes one of the two virtual particles would fall into the event horizon, leaving the other to not annihilate. Since something had just been created out of nothing, the something had to come from somewhere, and that somewhere was the black hole itself. The black hole would evaporate. Something from nothing was moving up in the world.

Then came the theory of Inflation at 10^{-34} s, and it all broke loose. The rapid expansion of the inflationary epoch would result in HUGE numbers of particles being permanently created out of the vacuum froth, as pairs would be hurled apart so quickly they'd never get a chance to recombine. The froth of particles so created resulted in the anisotropy of space, δ, that led to all large-scale structure of the universe.

All anisotropy (i.e. **us**) arises from quantum-level effects that happened during Inflation. "Almost everything comes from almost nothing." Much ado about nothing, indeed.

The energy density of nothing is λ, the cosmological constant that seems to be driving the expansion of the universe. Dark energy. It's value is only about 10^{-30} g/cc, but there's an awful lot of cubic centimeters out there.

AI: PER: Cognitive I – Mental Models and Meta-Thinking

AI01: Salomon Itza-Ortiz's talk
AI02: Sanjay Rebello's talk

AI03: Mental Models in Some Topics of E&M – Rasil Warnakulasooriya, Ohio State

Due to the higher level of abstraction involved in E&M, it's hard to get students to exhibit consistent mental models. But by forcing them to explain themselves, it does make them pick/generate/etc a model.

The research in this case looked at how the "field lines" representation of electric fields affected students. Questions such as, "Do students think the lines are concrete representations of the field?" "How does placement of the test charge in the field affect results?" "Does removing the picture entirely help or hurt students?"

The instrument was a web survey, with electrons in a field (electrons used to see if the direction of the arrows still determined which way students thought the particle would move). If the electron was touching the actual line, this tended to encourage an answer of motion in the direction of the arrow (wrong direction). If the electron was not touching a line, it tended to encourage responses of "no motion". And so forth.

In all contexts, the rate of correct responses was about 50%. However, the choices of incorrect answers (distracters) were influenced by the context. The following three choices defined each context:

1) On the line or off the line
2) In the middle of the field area or at an edge
3) Diagrams included or text only (text only made the previous two choices irrelevant)

As far as I could tell, the main result here is that drawing in the field arrows tends to confuse students who are most susceptible to confusion in the first place. The arrows are seen as concrete things, and the defined field area is seen as a rigid box. Removing these potentially unhelpful visual cues may be in order.

AI04: Meta Thinking Behavior of Some Sophomore Physics Students – Keith Oliver, Ohio State

The behavior of students working problems was split into physics and math work, then further subdivided into three categories each.

Physics (P) – Just doing the equations and digging up the concepts.

Sense-Making Physics (SP) – Stop the flow of work and ask questions like "How do I do it?" "Why am I doing it?" and "What does this MEAN?"

Sense-Making Physics Plus (SP+) – SP+ behavior involves having a preferred set of metaprocesses to help in sense-making. These metaprocesses are generalizable to other contexts, reliable and involve appropriate social relationships (inappropriate being things like copying solutions).

Similar divisions were made for working the math, M, SM and SM+. A seventh category was added for times when the student was not working, but was listening to the interviewer.

These categories were used to graph student behavior over time in a problem-solving task during an interview. These graphs allow researchers to compare the metacognition of successful and unsuccessful students more easily.

AI05: Cancelled

AI06: Variability in Student Learning Associated with Diverse Modes of Representation – David Meltzer, Iowa State University

The goal of this work was to compare and contrast student responses to different representations (i.e. verbal, mathematical, graphical, diagrammatic, etc). It was vital to make sure that students were familiar with every representation so used, making it impossible to do true pretests.

Meltzer has used multiple representation quizzes across several years of his courses. Several representations would be used on each quiz, and often there would be similar questions posed in different representations on the same quiz. For instance, the question might be posed as text only on page 1 of the test, then in diagram form on page 2.

As with AI03, Meltzer found that while the proportion of correct answers was relatively insensitive to representation, the representation used strongly affected how the wrong answers came out. This disparity was consistent from year to year, and within the Verbal, Diagrammatic and Math Symbolic representations.

A measure of confidence (a point-wagering scheme on the tests) indicated that students were generally more confident in their answers on the Verbal representation than on Diagrammatic or Math Symbolic.

There was no trend of any one representation being more troublesome than the others for students, with the exception of Graphical representations, maybe. Women had more difficulty with Graphical than men did, but the statistical significance is very weak ($P = .05$).

A closing note was that it might be possible to use multiple representation exams to help diagnose representation-related learning disabilities.

AI07: Probing Students Learning Physics With A Flexible Test – Gyoungho Lee, Ohio State

A "Flexible Test" is one that is optional, essentially. In the course of a quarter, students had two regular tests and two flexible tests, all of which had to be taken. However, after finishing a Flexible Test, students had the option of not having it count for their final grade. Many students used them as practice tests, and it seemed to reduce stress.

Unfortunately, the data presented in this talk was rather hard to figure out. Talk BC06 clarified some things.

BC: PER: Cognitive II – Epistemology and Attitudes (reordered due to cancellations and technical difficulties)

BC02: Teasing Apart Confidence from Epistemology – Andy Elby, UMD

Both epistemology and lack of confidence can lead to a student view that something can or cannot be done.

Epistemology: I can't do it because that's just the way things work. It's an impossible task.

Confidence: I can't do it because I lack the ability, but it's possible for others.

Ergo, it is possible for a test looking for epistemology to actually get confidence results, and vice versa.

The MPEX2, despite revisions, remains somewhat susceptible to this conflation. One thing done to try to combat this problem has been to depersonalize the items (i.e. "I can do this" replaced with "A good student can do this.")

If you plan to use the instrument for an intervention of some sort, you MUST decouple epistemology and confidence. Unfortunately, sometimes they're so deeply entangled that they cannot be fully teased apart.

The "J" case study that UMD uses a lot showed evidence of this entanglement. J's confidence in her own abilities kept her from changing her beliefs (epistemology) even when she was wrong.

BC03: What Contributes to Shifts in Elementary Teacher Practice? – Laura Lising, UMD

The group under study in this case were in-service teachers taking a combination of summer workshops and weekly meetings during the school year, covering the past three years.

This program has resulted in some excellent inquiry-based teaching/learning. The shift in teaching style has been dramatic, and takes place during the first year of the program. This suggests that very little of the shift was due to changes in content knowledge, since very little actual content could be covered in the initial workshops. Content knowledge did seem to play a role, just not a very large one.

Teacher epistemologies shifted more than their content knowledge increased. A sample of such a shift would be a teacher who started off believing that only actual experiments could possibly yield anything (very inductive) and later on found that thought experiments and logic were very useful (deductive).

Some of these epistemological shifts also caused boosts in confidence. As the world started to make more sense, the subjects felt better about their ability to explain it.

BC01: Qualitative Investigation of Epistemology in a Female-Centered Learning Environment – Beth Hufnagel, Anne Arundel CC

Based on work done at Bryn Mawr, inspired by holes in the MPEX data collection (no data from primarily female or minority schools in the MPEX study). Bryn Mawr has both an academic honor code (fairly standard, plus a prohibition on discussing grades with each other) and a social honor code (essentially the Golden Rule).

Bryn Mawr's results on the MPEX were very favorable, at the high end of all data taken. Further work suggests that women's colleges are attracting and retaining students with good attitudes.

The sample at Bryn Mawr was fairly broad, as all students taking Physics are in the same course together (small college). And the honor codes reduced competitiveness and helped foster cooperative work.

BC05: The MPEX2: Modification of a Survey Instrument – Tim McCaskey, UMD (talked rather fast, so I missed some parts)

As mentioned above, revisions tried to separate epistemology from expectations. The MPEX2 incorporated items from the Epistemological Beliefs Assessment for the Physical Sciences (EBAPS) to pump up the epistemological content.

Items were reworded in hopes of minimizing misinterpretation.

An attempt was made to provide better context for the items, including eliciting "gut reactions" to problems and adding dialogue problems where subjects would read a dialogue on some topic and then state which side they agreed with more.

Also, items were dropped if it seemed like they covered content that would not be touched on in the "Physics for Life Sciences Majors" course at UMD.

The "Effort" cluster was dropped, as self-predictions in pretest tended to be unrealistically high compared to the actual performance (the "New Year's Resolution Effect").

New clusters (aka factors, but without factor analysis to back them up) were created: Coherence, Concepts and Independence. The coherence cluster was further subdivided into "reality", "math" and "other" batches. Independence was split into "epistemological" and "personal" batches.

As with the MPEX1, the MPEX2 is not designed to evaluate individual students, rather entire classes.

BC06: Action-Based Measurement of Student Attitudes and Learning Styles – Gordon Baugh, Ohio State

The following were listed as concerns related to giving surveys: misinterpretation of the instrument, a disconnect between student beliefs and student actions/statements, "vandalism" of the test (or sandbagging) by students, test-retest variation, the short time allotted to collect data, and any limitations of the formats used.

The treatment applied at OSU included: more time (cover the entire period), integrate a wider variety of formats into regular instruction, depersonalize the instrument, hide the instrument in some other task so it's not obvious as a survey, and use a flexible environment.

The Flexible Test has already been covered, and this talk introduced the Flexible Homework. Students were given 20-30 problems split into two batches (one of which had the answers provided in advance, the other did not) and had to submit (online) five problems from each batch.

Looking at results from both the Flexible Homework and Flexible exams over time, Bao et al split the students into four groups, each of which followed a particular curve on the "Achievement vs. Time" and "Effort vs. Time" graphs, much like following a Herzsprung-Russell chart of stellar lifecycles. The four paths were HH (high initially, high at end), MH (middle, then high), LH (low, then high) and LL (low all the way through).

I'm still not really sure how the benefits of Flexible stuff connected with these diagrams. I know it was covered, but pretty quickly and amidst a pile of other stuff.

CF: Student Preparation and Motivation

CF01: Using Supplemental Instruction to Improve Minority Success in Gatekeeper Science Courses – Dan MacIsaac, SUNY Buffalo (formerly Northern Arizona)

Supplemental Instruction (SI) is a course developed at University of Missouri at Kansas City. It is tutorial-oriented, with extra undergrad instructors hired to help out and extensive use of peer tutoring. The use of it being discussed in this talk was at University of Northern Arizona, where a large number of Native Americans (NAs) attended class.

SI had a significant positive effect on Minority Student Development, particularly among NA students, despite the fact that this was a post-hoc analysis with sub-optimal conditions.

SI groups had higher retention than non-SI groups for NA students, and the grade gap between NA students and white students dropped just below the threshold for statistical significance in SI groups. It is thought that the peer instruction aspects helped NA students cope with culture clash between home and school (i.e. things like eye contact and pointing being frowned upon in NA cultures), and the cooperative learning structures fit well with their social pattern.

Upshot? SI is a watered-down, badly implemented form of cooperative learning…**and it still works.**

CF02: Relationships Between Sports Experience, Sex and FCI Performance – Jennifer Blue, Miami University (Ohio)

Research question: Do gender-based differences on the FCI arise from differences in sports experience? Are there any sports-based differences in the first place?

Answer: As far as she could tell, no and no. Gender differences do exist, but sports-based ones don't seem to, nor does sports participation seem to impact FCI scores.

There do seem to be sports-based differences in other areas, though: female athletes generally have much higher graduation rates than male athletes do.

It's possible that the sports scale used was the problem, that it was simply too coarse to find the differences, or focused in the wrong places.

CF03: Factors that Affect Student Motivations: Quantifying the Context Map – Gordon Baugh, Ohio State

A context map is, in this case, a diagram that divides influences into internal and external, then maps them according to how far out from the center they are. Internal factors include interests, fears and beliefs. External factors include teaching methods, course content and expectations of the student.

Research question: How many context factors are involved in student learning, and how do they interact?

Since interaction is of interest, contexts at the border between internal and external will be most closely examined. Especially paired contexts that link across that border (such as Fear (I) and Stress (E)). After all, things are more interesting at the boundary.

A web survey was created that listed a variety of factors, both internal and external, and asked students to rate its effect on learning from –2 (strong negative effect) to +2 (strong positive effect). Items rated with high absolute values were placed on the boundary of the context map, on the grounds that they were interacting most strongly. A few items suffered from the "New Year's Resolution Effect" and had to be dropped or refined.

Once these influential context have been identified, the intent is to use that information to improve teaching.

CF04: Investigating Sample Exams (Part 1) – Carol Koleci, Worcester Polytechnic Institute

WPI's class schedule runs on 7 week quarters (presumably not counting summer, since OSU has 10 week quarters), inspiring the questions "How many exams is too many?" and "How do students study for exams on such a tight schedule?"

Most of the students had already been intimidated by Massachusetts's mandatory high school exit exams, shaping how they would respond to the first question.

Students were given surveys and sample exams during recitation, with extra credit given for completion (right answers not necessary). 70% of students participated.

The sample exams had items with the same deep structure as the real exams, but different surface features (students often did not therefore recognize the problems as being the same, although they were able to see that the difficulties of the real and practice items were about the same). There was no real improvement between scores on the sample exams and scores on the real exams, but students who took the sample exams did better overall than those who didn't.

Not really sure if this answered either question, although I suppose it could indicate that the students who take the practice exams are not waiting until the last minute to study.

CF05: Making Web-Based Homework a More Effective Teaching and Evaluation Tool – Major Frank Saffen, US Military Academy at West Point

All cadets are required to take an introductory calculus-based physics course, resulting in class sizes around 900 (split into small classrooms of about 16). WebAssign was used for some of their homework assignments, the number randomizing of problems fitting well with the needs of their honor code.

At first, cadets put more effort into the homework and liked the system, getting feedback quickly and giving it to instructors as well. However, it seemed to eventually help foster a "points = effort" mentality, and while instructors saw the feedback as helpful and uplifting ("forklift"), the students saw it as negative, pounding away at them ("jackhammer").

To try to fix this, a few changes were made. More complicated problems were moved to post-lecture group sessions, there were less homework problems overall, and they brought back instructor-assessed homework (not scored, just commented on). This "worked" in the sense that scores shot up and cadets liked it, but there were concerns that this was solely due to lightening of the load.

So other things were studied. Correlations between homework and exam scores shot up by 30% after the changes, participation improved, and WebAssign-measured time-on-task did not fall off as abruptly over the course of the semester as previously. So it seems to have worked.

Conclusion: there exists a threshold of complexity and length above which your results get worse, not better. Even a convenient tool like WebAssign doesn't let you ignore that.

CF06: Improving Interactive Examples (IEs) Using Student Interaction Data – Tim Stelzer, University of Illinois (Urbana-Champaign)

IEs are a web-based homework system developed at UI, structured like a worked textbook example but asking the students to do some of the work. It is designed to ask many layers of leading questions and side problems along the way, starting with conceptual help and then working towards "strategic" help and finally quantitative help. Once the problem has been completed, all of the help files are made available to the student, even those not used in solving the problem. There are currently about a hundred IEs.

Students seem to like the IEs, but that alone is insufficient. Exam and quiz performance is discussed at another talk, which I did not attend.

Looking at just the reams and reams of data collected within IE allows investigators to ask the following questions of a particular item and student:

What was the last action taken before success? (i.e. What was the key help item?)

What sent them away for a while (in frustration)?

Which students use what help items?

Who got the problem right on the first try?

CK: Young PER Faculty Crackerbarrel

The topic of this crackerbarrel was collaborations in research, and trying to work out substantive, fundable, publication-oriented projects. Fairly free-floating, resulted in some helpful hints:

Collaboration needs one grant writer, with the others providing feedback. Don't write the grant by committee, that way lies madness.

Acquire a means of easily exchanging data and drafts, such as an FTP site or web board of some sort.

If hierarchies are needed, establish them clearly. Don't leave anyone wondering where they fit in. Beware of the pitfalls of working with a senior partner (they may not have much time for you, etc), but keep in mind the benefits as well.

Communication is VITAL.

Avoid ego overpopulation. Try not to have more than one primadonna in the group.

Take responsibility for your part! Don't just let it drift and hope someone else does the work.

Collaborators should either have similar needs (i.e. "Gotta get X publications done in Y years for tenure!") or at least be aware of differing needs and accommodate them.

Make sure everyone can work on the same timetable (corollary to previous point).

Keep that momentum going, or you're in trouble.

Try to find collaborators with complementary skills and backgrounds.

PER Committee Meeting

The main issue of this meeting was a push to find a way around the current system of scheduling invited sessions, which requires a one-year lead time and makes it hard to deal with hot topics. A few suggestions were made, such as putting in just a "Hot Topics" session like other groups did, or shotgunning the application to get as many approved as possible, then canceling the overage. The question of "how many sessions constitutes too many?" was also raised.

It was agreed to try the "Hot Topics" approach, and (I think) to limit the submission for next winter to only about 6-7 invited sessions.

Tuesday, January 14, 2003

DC: PER Research on Labs

DC01: Cancelled

DC02: Physics as Community: Social Construction in the Introductory Physics Laboratory – Juan Burciaga, Bryn Mawr

This was essentially an overview of the course design at Bryn Mawr, implementing the UMinn cooperative learning system. The hook they used was to set up the classroom as a model of the scientific community and attempt to represent how real science progressed. The students would variously challenge and support each other while being fully engaged in the scientific process. Students liked it.

DC03: Concepts for Building an Understanding of Uncertainty – Rebecca Lippmann, UMaryland

Clarification: this talk is about measurement uncertainty (error), not Heisenberg Uncertainty.

Biology students tend to be too literal in interpreting the numbers their calculators spit out, treating them as completely accurate and precise. This is, of course, a Bad Thing.

Two basic mindsets were identified. "Point" thinkers who treat a single measure or single average as the True Value, and "Set" thinkers who consider ranges of values to be the truth and recognize that overlap happens. We want students to be Set thinkers.

Two basic causes of measurement range were also established. External variations involve unreliable measurement apparatus or errors in procedure. These variations are always bad, and to be eliminated where possible. Internal variations are real, and due to properties of the thing under examination (i.e. height variation within a class of students).

Point thinkers tend to treat variation as all External, mistakes that need to be cleared up. And when they do see Internal variation, they tend to treat the sample as the population (i.e. if the tallest person in the room is 2m tall, then the tallest person anywhere is 2m tall), and later deviation is purely the result of errors. Point thinkers are descriptive, the data is the reality.

Set thinkers are more likely to recognize internal variation, and also less likely to incorrectly generalize the sample to the entire population. Set thinkers are predictive, the data can tell you things about what reality might be.

http://www.phyics.umd.edu/perg/projects.htm will contain the final thesis based on this work, likely by June 2003.

DC04: A New Way for Students To Plan and Understand Laboratory Experiments – Paul Gresser, UMaryland

This talk is about the Experimental Design Chart, which is designed to give students a common format for planning experiments, carrying them out, and communicating the results to their peers. The labs used in this study were focused on measurement (as in DC03).

In the course of the normal lab course, students reached a point where they suddenly couldn't plan their way out of a one-sided box. So it was decided to give them an aid in planning.

What I Will Directly Measure	Equations, Assumptions	What I Need To Solve

The planning starts in the right column, then the left, then center. Working through the experiment goes from left to right. For each measurement in the left column and for each needed quantity in the right column, the students write out in words what the quantity is, draw a box around it, and then attach sub-boxes at the bottom that list the variable name and the unit involved. This helps them keep from using the same variable twice. Arrows would be drawn from quantity boxes to equation boxes, flowcharting the experiment.

Many students found the format helpful even in cases where they used it incorrectly. Their plans were more coherent, and they didn't need as much TA guidance in planning. The less active students didn't get lost as often, since they could refer to the plan. And TAs could tell at a glance how the students were progressing.

However, the better students tended to see it as a big waste of time, and once it was no longer mandatory, no one used it.

DC05: Physics Lab Reports and Student Learning – Are There Any Relationships? – Paul Knutson, UMinnesota

This is a report on the very beginning of a new study at UMN.

Data from students is split into three groups: Quantitative (Qt), Qualitative (Ql) and Expository (Ex). Apparently splitting what most think of as Qualitative into conceptual Qualitative and verbal Expository.

Lab reports are the Expository data in the study. The FCI is the Qualitative instrument and the Mechanics Baseline Test is the Quantitative.

The question is, how well (if at all) do Qt, Ql and Ex correlate?

It is known that when the instruments are well-designed, Qt and Ql do correlate pretty well. Ex does not seem to correlate well with either of the others, however (correlation of about 0.25), but this may be due to inter-grader variance.

Reducing the noise in the data by comparing topic to topic (i.e. grades on a Newton's Second lab to performance on N2 problems on the FCI and MBT) does seem to result in a more respectable correlation coefficient. Improved grading rubrics are also seen as a way to reduce noise.

DC06: The Development of Students' Scientific Investigation Skills: Cognitive Dimensions and Indicators – Xueli Zou, CalState Chico

This work involved the ISLE (Investigative Science Learning Environment) curriculum developed by Eugenia Etkina at Rutgers. In ISLE, lab is the core of the course, with lecture supporting it. Students work through learning cycles and an attempt is made to get them to use "real scientist" strategies. Talk FF02 concerns more on ISLE.

The "Dimensions and Indicators" of the title are those things that testing instruments can measure, and which relate to abilities (in this case, processing skills and higher order thinking). The indicators are the labels placed on the dimensions, and the dimensions are the measurable magnitudes.

The scale for the dimensions in this study runs from Naïve at one end to Expert at the other. Naïve student indicators are generally bad (i.e. a Point mindset towards uncertainty), while Expert student indicators are good (i.e. a Set view).

Sixteen indicators were chosen, each with a statement that typified a purely Naïve view and one that represented an Expert or Expert-like view. Each item asked if the student agreed with one statement, the other, or moved from one to the other over the course of the semester (given as a posttest).

The instrument is still under development.

EC: Understanding Understanding: A Celebratory Session (Joe Redish's birthday)

EC01: Questioning the Questions: Playing With Constraints in Physics Education Research – Rachel Scherr, UMaryland

Art education research is finding similar problems to those faced by PER, and has been suggesting similar (Piaget-inspired) responses. This leads to two questions: "Can we mine AER for PER?" and "Is Joe Art?" (This talk, as with the rest of the session, is a mix of "serious" invited talk and a roast for Dr. Redish.) A certain amount of examination of art pieces and discussion similar to a Socratic dialogue followed.

"Frames" are, in the context of Redish's work, structures of expectations that define and constrain activity types. Examples include the lecture frame (seriousness expected, audience is treated as a collective, etc), joking frame (seriousness NOT expected, audience treated as many individuals focused on in turn, etc).

How do we detect frames?

- The contrast between frames. We tend to notice changes (in tone, volume, pitch, body attitude, etc) more than we notice absolute quantities.

- Negative descriptors. In other words, if an otherwise normal activity is forbidden, it's a sign we're in a particular frame.

- Notable features. The opposite…if it's not a normal activity but you note it is happening, it's probably part of the frame.

What do we do with frames? We should mess with them to increase our freedom in teaching and expand our range…no matter how useful one frame might be, it has its limitations, and you can get around those limitations by moving to a different frame.

A deliberate change of frames can serve a pedagogical purpose, forcing students to make sense of what's going on, allowing us to make sense of student behavior, etc. We need to pay attention to frames when performing PER.

Reframing can help to mix and match the properties of both misconceptions (stable, enduring incorrect ideas) and resources/primitives (basic ideas that are applied on the spot when a concept is needed, very fluid). This allows for a model that combines aspects of stability and fluidity.

Changing frames can turn a barrier into a boundary…and it's always interesting at the boundary.

Above all, get meta, think about your thinking.

EC02: Making Meaning: Emergent Cognition in Physics and Physics Education Research – Michael Wittmann, UMaine

Claim: Joe Redish is a non-ergodic memetic system. (Terms to be defined later)

Opened with a brief history of Redish's time as Wittmann's "Doktorvater" (literally "Doctor-father"), or thesis advisor, and Wittmann's "childhood development" in PER. Redish had four main pieces of advice in this:

1) Do it because you enjoy it!
2) Do YOUR thing.
3) Follow your curiosity.
4) Seek relevance, value what's valuable.

There was also something about there always being a pony, a running joke that wasn't really explained, but seemed to mean "Don't compromise too soon, there's worthwhile results in store for those who will forge ahead." I think. Wittmann talked VERY fast and employed a number of "in" references.

Ergodic: a system is ergodic if it either exists in very large numbers or has a very short relaxation time allowing rapid retesting. Either way, your can perform a great many identical tests on it. Redish is neither extremely common nor likely to relax, so he's non-ergodic.

A meme is a currently fashionable (if starting to fall out of fashion) label for something that is to ideas what a gene is to organic life. Memes don't do anything on their own, and they function somewhat differently depending on where they are expressed, but they have a similar effect wherever they go. Warning: there are a lot of psychoceramicists (crackpots) out there with radical meme theories, and you have to be careful when invoking memes not to cause someone to think of such unpleasant examples (my warning, not Wittmann's).

A memetic organism is an entity composed of memes (and the product of those memes) in the same way we are composed of genes (and the products of the genes).

Richard Dawkins The Blind Watchmaker has something to say about memetic organisms, as does Jared Diamond's Guns, Germs and Steel. (Quick explanations of the titles. The blind watchmaker refers to the forces of natural selection, shaping complexity without being able to "see" what's going on. Guns, germs and steel are Diamond's Big Three for explaining why European culture steamrollered everything else…aside from the technological advances of guns and steel, Europeans were from a stewpot of disease and were carriers for loads of stuff.) Dr. Redish is made of ideas as much as he is made of flesh and bone, so he is a memetic organism.

Conceptual elements in PER can be expressed as memes, knowledge in pieces. These memes can be called p-prims, forms, facets, etc…all sorts of resources. So, rather than continuing to hack at the problem from the ground up, we should look to memetic research to see if they've already solved any of our problems, or at least better defined those problems. Models of reasoning are themselves memes that we can adopt.

Reference was made to Redish's 1999 Millikan lecture, but 1999 was Van Heuvelen. It might have been at the 2000 meeting, but I never did type up my notes for Guelph, since I moved to Michigan a week after getting back.

Moving on. S. Johnson's Emergence: the connected lives of ants, brains, cities and software was recommended for further reading. In an emergent system, low-level properties combine and interact in relatively "dumb" ways to produce high-level properties. Very simple and unthinking rules result in complex behavior.

There may be no thought involved in thinking.

As a result, it's important to consider how low-level memes may be producing observable student behaviors.

Meme-based conceptual change can take four basic forms:

1) Incremental. Add a few memes here and there in the corners.

2) Dual construction. Swap bits back and forth.

3) Cascade. One thing leads to another, and another, and another….

4) Wholesale. Chuck it all and start fresh.

Looking at this sort of thing, Wittmann breaks the misconceptions and resources mentioned in the previous talk down into several dimensions. Misconceptions all take one value for these dimensions, while resources take the other. A new model could be created in which some dimensions have misconception-like values and others have resource-like values, without being either a misconceptions model or a resources model.

The dimensions/memes are:

1) Existence. Do the ideas exist separately (misconceptions), or are they generated on the spot (resources)?

2) Correctness. Do the ideas have to be correct/incorrect (misconceptions), or are there no correct or incorrect ideas, just correct or incorrect applications (resources)?

3) Coherence. Does the idea hold together well (misconception) or is it a bit of a mess (resources)?

4) Context Dependence. Misconceptions are context-independent, resources aren't.

5) Stability. Will the idea remain after repeated probing? Misconceptions are very stable, resource application is unstable.

6) (Effect of/on) Instruction.

To close, Wittmann followed a memetic evolution of Redish's last 10 years in PER. He started as a curriculum developer, more concerned with the tools and presentation than the content. Then he moved on to actual education research, asking about frames and resources and such. Now he's moved into the realm of cognitive scientist ("Let's get a student under a PET scanner so we can see what areas of his brain lock up when we give him Rachel's Relativity problem!").

EC03: Theoretical Frames and Overlapping Communities: A Linguist and a Physicist Evolving Together – Janice "Ginny" Redish (Proto-IndoEuropean specialist)

Opened with biographical background on how she met, fell in love with and married Joe Redish. It took a while before their research interests started to dovetail.

Ginny worked on a government project intended to help government offices generate more comprehensible documents. And while it doesn't seem to have made things too much better (no doubt due to the Dilbert Principle: no matter how good the idea is, the person in charge of implementing it will do so horribly), it has allowed her to gain a lot of practical experience in how people communicate and understand. <u>A Practical Guide to Usability Testing</u> (Dumas & J. Redish) was one product of this work.

Once computers came into the classroom, the professional lives of the Redishes started to come together. Ginny's work in trying to make comprehensible computer manuals and Joe's need to get his students to use computers led them to see many of the same problems in need of the same solutions.

"What can Linguistics contribute to Physics Education and PER?" Linguists have learned a lot about thinking and knowing, involving: Constructivism, Community Maps, Code Switching (changing frames), Location of Knowledge and Meaning, and Setting the Context First.

Constructivism: Language changes from one generation to the next. Everyone speaks their own language, constructed from what they hear and experience. We can still communicate because of the similarities between these individual languages.

Community Maps: Language is a community map. The common elements of all the unique languages form the community in question.

Code Switching: Talking to others requires changing frames! Each person's language is like a frame of its own, and we depend on context to let us decide which frame to use. We simultaneously hold onto many different languages at a time, even within the label of "English" or "Russian." So it's no wonder that students are able to hold onto multiple, conflicting mental models…it's just like being able to speak "me" and "parents" at the same time.

Location of Knowledge and Meaning: As with PER, linguistics used to have a "funnel model" of knowledge transmission, and as with PER, it has been abandoned. The funnel has been replaced with a series of implications:

- You are not your user/student!
- You must understand the user/student.
- You and the user/student do not speak the same language.
- Each of you has their own filters.

Setting Context First: They need to know what you're talking about before you give them new information. People do not buffer information and wait for the context to become clear, they jump the gun and start to try to interpret things immediately, often before they have enough information. RTFM (Read The, um, Full Manual) does not come naturally to people. Providing context before new information is called the "given-new" model. GIVEN known context, then NEW information can be assimilated.

FF: PER: Research on Curricula

FF01: Teaching Introductory Physics in the Investigative Science Learning Environment (ISLE) – Marina Milner-Bolotin, Rutgers

ISLE uses an iterative flowchart to help students generate and accept or reject models. The goal is for students to see how physics is really done, and maybe even enjoy it, while giving instructors a way to stave off or reverse burnout. Traditional lectures are done in support of ISLE labs.

The standard format of any given ISLE exercise is as follows: Observations, Modeling, Testing of Model, Applications, Exit Interviews and Formative Assessment.

The exit interviews involve a question about the topic that each student must be able to answer before being allowed to leave the lab. The formative assessment includes both conceptual questions and experimental design questions.

Lab practicals were used for summative assessment. They were open book tasks using old exit interview questions and requiring students to design a new experiment. Due to the new format, the first time this was done was a bit tough on all involved, but the second practical went better. The time demands of studying for a lab practical are greater than for a regular test, and the deisgn aspect was very challenging, so students were encouraged to prepare in groups.

TA training is vital in an ISLE setting, as there is a lot more front-end work.

It is possible that ISLE labs will result in a long term attitude change, but it's too early to say for sure.

FF02: Modified Exam Structure in a Large-Enrollment ISLE Course – Eugenia Etkina, Rutgers

"How do we know ISLE works?" Assessment! Formative assessment with immediate feedback works best.

The course used in this particular study of ISLE was intended for "at risk" Engineering majors, those who were deemed less likely to graduate as Engineering majors (or graduate at all). Each week was one complete learning cycle, using lecture, workshop labs, recitations and work on the web (WebAssign used for homework, plus periodic web surveys).

Four one-hour exams are held during the semester. Each exam has ISLE-cycle problems, multiple-part multiple-choice problems and one "essay" problem with complex calculation. All problems are designed with a focus on higher cognitive levels than simple Knowledge. The more traditional problems are also tied to ISLE in some way.

After the exams are graded in a traditional way, they are fed through a set of coarse rubrics to code them. 0-3 points each for "Describe the experiment," "Describe the data and analysis," and the correctness of the physics used. Over the course of the semester, the number of zeroes went down and the number of threes went up, and the rough code scores correlated strongly with exam grades.

When looking at the grading on parts of the exams, the ISLE problems correlated only so-so with traditional problems or with overall exam scores. This leads to two possible conclusions:

1) ISLE measures something different from traditional problems.

2) ISLE measures nothing in particular.

They kinda hope it's 1.

FF03: Changes in Physics By Inquiry Teaching at the Ohio State University (Marion Campus) – Gordon Aubrecht, OSU

Physics By Inquiry (PBI) is taught as Phys106-108 at OSU. The Marion campus typically has smaller class sizes, under ten.

The pretests in PBI were starting to look pretty useless (having stacked my share of the never-to-be-analyzed sheets, I have to agree with that assessment), so a decision was made to do something new with them. Rather than a simple test-retest, the format of each pretest was changed so that pretest answers were entered on the left half of the page. Then, after instruction, students were required to rework the problem on the right half of the page, and then fill out a "What Have I Learned?" section at the bottom. This way, students see the change in their answers, and have to think about it.

Additionally, attendance points (and points off for lateness) were replaced by a Question Of The Day mini-quiz given at the start of the class. If you were late, you lost the points for the QOTD, simple as that.

The use of journaling and surveys was continued, and used to ask students to define what they thought inquiry-based learning was.

Student response was generally positive.

FF04: Alternative Routes to Teacher Certification for Math and Science Professionals: Research as a Guide to Preparing Prospective Teachers – Donna Messina, UWash

Discussed a partnership between UWash and the Seattle Public School system to prepare science teachers, getting the UWPERG more involved. The main result was to demonstrate that the content knowledge of the teachers was much weaker than the public school administration had been assuming, and therefore the current system of teacher preparation (assume they know the subject, just teach them to teach) is insufficient. Alternative routes are needed, you cannot assume the participants have **any** skills near the needed level.

FF05: Development of Physlet-Based, Tutorial-Style Curricular Materials – Melissa Dancey, Davidson College

Physlets are physics Java applets, first developed by Wolfgang Christian at Davidson.

Physlets increase visualization and allow for easy exploration and instant feedback. They have a "game mode" that helps develop physical intuition, but are NOT meant to be a total replacement for hands-on activities. They provide alternative problems and multiple solutions, encouraging creativity and discouraging plug'n'chug solutions. They can also be used to introduce some measurement error, due to pixel-coarse measuring methods.

Ready To Run Curricular Material is a new book providing more packages for using physlets, so you don't have to learn a scripting language to put things together. It comes with a webpage-on-CD for this.

FF06: Combining ILDs and a Modeling Curriculum in University Physics – Michael Politano, Marquette U.

An attempt was made to reform one of four lecture sections at Marquette using ILDs (Interactive Lecture Demonstrations). Only the kinematics ILDs were used, as there was concern that the lecture would even touch on dynamics in the time frame allotted. Hestenes-style Modeling was also brought into the classroom, which was an overly large lecture classroom that let the medium-sized class all sit near an aisle.

The class was tested using the FCI, MPEX, FMCE and MBT. Students did very well on the Mechanics Baseline Test, but showed pretty traditional gains on the FCI. Nor was there any real difference between the experimental section and control sections on the MPEX and FMCE. It is considered odd to do well on the MBT but not the FCI, and it was speculated that a lack of "discourse management" (modeling terminology) caused this disconnect.

GG: PER: Problem Solving and Math

GG01: What Does It Mean To Solve A Physics Problem? Instructors? Beliefs? - Charles Henderson, Western Michigan University

Faculty conceptions influence quite a bit, so it only makes sense to examine them. In this case, faculty conceptions of problem solving are of interest. Both curriculum developers and professional development providers have a vested interest in how faculty think of solving problems.

Goal: build a model of faculty conceptions of problem-solving processes.

The initial model created at University of Minnesota is a big flowchart, and subjects were asked to create their own flowcharts where possible. The pilot study was performed using 6 UMinn faculty as subjects.

The subjects fell into three categories:

Type 1: Linear decision-making process, zip through from beginning to end. (3 subjects)

Type 2: Trial and error, wander about through the problem. (2 subjects)

Type 3: "There is no general method, each problem has its own." (1 subject)

There was also a Type 0 presented, which was the cognitive psychology model of problem-solving. Type 0 has four basic steps:

A. Qualitative analysis

B. Quantitative analysis, subproblems. Splits into several possible solution paths here.

C. An answer

D. Evaluate the answer, loop back into the process if necessary, otherwise solved.

Type 1 proceeded in the order of B, A, C, D, done. No loopback. The core question of this method is "How do I select the principles used in quantitative analysis?"

Type 2 was similar to Type 0, but with a much larger spread of possible paths at B, and doesn't assume any prior knowledge that might allow for a more direct path. This method asks "How do I limit the number of divergences?"

Type 3 isn't really chartable yet, although GG02 has more on it. To use a South Park reference, it's kinda like the Underwear Gnomes at this point.

Types 0, 1 and 2 lie on a spectrum of choices. 1 offers no choices, railroading the solution down a single path. 2 offers infinite choices, requiring a strong force of selection to narrow things down to a solution (i.e. you can get a finite number of monkeys on typewriters to get Shakespeare if you go a letter at a time and always choose the correct letter in each step). Type 0 is a balance between the two, more strategic. It assume you will be able to use prior knowledge to eliminate most choices, but still explores what is left.

Type 1: Personal experience is everything, it takes a well-drilled expert to solve problems. Curricula are best focused on a single concept, and Thorndykian drill is useful.

Type 2: Choices are almost magic, because you have to make them without knowing in advance which ones are good. Curricula should be multi-concept, so that the student has a better idea of when he's scored a hit.

Type 0: It's best to give students problem-solving strategies with useful frameworks, to help them narrow down the choices to a productive few.

GG02: Solving a Physics Problem – An Expansion of Instructors' Beliefs – Vince Kuo, University of Minnesota

This paper continues the subject of GG01, but with data taken from a larger sample size with broader backgrounds (instructors from various teaching universities). All interviews concerned the same set of problems, for consistency.

The overall pattern did seem to persist, although with more subjects in each bin it was easier to look for similarities and differences. There were generally more details all around in this implementation.

The Type 1 flowcharts got more complex and fleshed out, with some slight differences, but were otherwise still linear processes.

The Type 2 flowcharts had a few different loopback patterns, but were otherwise pretty similar.

Type 3 got flowcharts. Most fell into the pattern of A, B, C, D, with explosive radiating growth between B and C, and most of the looping concerning B and C. Radiate then organize.

It would be good if a way could be found to reduce the variability in teacher conceptions of problem-solving, as it would make it easier to work with (or around) the instructors. A fair amount of complexity cropped up in this study, but it is not yet certain if that's good or bad. Work is ongoing.

GG03: Interactive Recitations: Incorporating Conceptual Learning Into Problem-Solving - Homeyra Sadaghiani, Ohio State

A number of problems have been identified with regards to student learning and the recitation classroom:

1) Student reading skills are poor, and this is exacerbated by the fact that textbooks read differently than novels do.

2) Imprecise use of the language (i.e. the common interchangeability of energy and power) gets in the way.

3) Traditional recitations are just scribing sessions, where students copy down homework solutions from the board with varying levels of success.

To address these problems, the recitations were modified and a new homework system was used. Quizzes were given in recitation that covered material that was in the textbook but not in the lecture (addressing 1 by making them read the book), and the grading of the short-answer quizzes emphasized use of language (point 2). Additionally, students were given group work assignments in recitation that focused on improving language skills (point 2 and 3). This was the same experimental group as in the Flexible Test talks, a calculus-based introductory physics sequence, and they were surveyed during and after the quarter.

Surveys suggest that the quizzes worked in terms of getting students to read the textbook for comprehension. 85% of students said they had been encouraged to read for comprehension and said that doing so had helped them.

GG04: Alicia Allbaugh's talk.

GG05: A Framework for Understanding the Role of Mathematics in Physics – Jonathan Tuminaro, UMaryland

It turned out that the actual framework was too unwieldy to actually present in the talk, but as this was not stated up front it made it very hard to figure out where things were going. The gist is that the framework is a way of connecting facets of understanding to symbolic forms in math.

GG06: Cancelled.

(Omitting my notes on the Faster-Than-Light tutorial.)

Wednesday, January 15, 2003

HD: PER: Identifying Student Difficulties

(note: the presider for the session was not present. Paula Heron started off replacing him, but had to leave partway through, so I took over presiding. My notes may be a little thinner as a result.)

HD01: Korean Science Teachers' Alternative Ideas About the Simple Pendulum
- Youngmin Kim, Pusan National University

Premise: Teacher misconceptions lead to student misconceptions, so it's a good idea to figure out what misconceptions teachers have.

The test item was a simple pendulum. Teachers were told that the string was cut at one of two points: P (at bottom of arc) and Q (at maximum height).

For P, many teachers confused acceleration with force, drawing in opposing acceleration vectors and then adding them. Many also said acceleration was zero (possibly confusing with other cases of simple harmonic motion). The rate of correct answers was about half.

At Q, the total number of correct answers was a little larger. Many thought the acceleration was only the tangential component, or that it was zero. A popular answer (around 20-30% of responses) was that the ball would continue to rise a bit after the string was cut, arcing out in a ballistic path.

Overall, anywhere from 40-80% of teachers got the various questions wrong. Most science teachers in the sample had some serious misconceptions.

HD02: Preservice Teachers' Use of Technology to Explore Momentum Conservation
- Jill Marshall, UT Austin

(Title not quite correct, original talk was intended for a technology session, but was modified once the speaker found she'd been put in a concepts session.)

Students were given interactive software with several examples of situations exhibiting some behavior, and were asked to find a "general truth".

p=mv was never used in the early modeling phase of the class.

Velocity conservation was sometimes "found" by the students. This idea and its permutations proved to be very robust, even when students were shown cases where it did not work.

One problem with the computer software is that some constants had hidden parameters, such as mass being affected by resetting the coefficient of restitution. This is something they have asked the software designers to fix.

In the second trial, contamination of the virtual and real experiments by previous experience (students with high school physics, basically) led to all groups getting momentum conservation. However, most of them couldn't state what it really meant. Much of the time, conservation of momentum really meant (to the student) that the objects swapped momenta.

In post-tests, "The biggest one wins" was the most common view expressed.

Simulation work did seem to help the least-experienced students. Students picked up some more physical intuition.

HD03: Addressing Student Difficulties in Applying the Principle of Conservation of Momentum – Hunter Close, UWashington

This was an example of a UWash iterative cycle tutorial course, focusing on conservation of momentum.

The tutorials seem to help overcome student difficulties with the momentum of system elements and treating momentum as a vector, but other issues resisted treatment. Interviews probed these issues.

Students tended to drop the directional (vector) aspect of momentum when it became inconvenient, such as the case of bouncing off a very large object and not giving it any momentum (object keeps the same momentum, it just changes direction because there's an immovable thing in the way). This could result in students initially ("accidentally") having a correct response, then throwing it away later because it contradicted with a vectorless momentum.

HD04: Identifying and Addressing Student Learning Difficulties in Calorimetry and Thermodynamics – Ngoc-Loan "Lon" Ngyuen, Iowa State

Students were subjected to treatment after they had completed standard instruction in calorimetry (i.e. $mc\Delta T$ stuff). About ¾ got the answer to pretest #1 correct, half with correct explanations. Interviews taken with some of these students were consistent with the pretest data. A common problem in the wrong answers or explanations was that rather than using heat transfer, students used temperature transfer. Heat and temperature were conflated in general.

A worksheet was created in an attempt to address this problem, using energy and temperature bar charts. The intervention sample had only 6 subjects, and no statistically significant results were found. Qualitatively, however, it did seem to have a positive effect.

HD05: Exploring Student Conceptions About Optical Fibers and Total Internal Reflection – D.J. Wagner, Rennselaer Polytechnic

Science of Information Technology (ScIT) is a course developed at RPI, see http://www.rpi.edu/dept/phys/ScIT for more. After a few false starts (Wagner talked in general for a couple of minutes on the pitfalls of hasty assessment), an interview protocol was developed to probe student ideas about how optical fibers work, focusing on Total Internal Reflection (TIR).

Students seemed to respond better when the term "fiber optics" was used, as it is more familiar thanks to telecom advertisements.

Students also tended to view TIR as a refraction effect, that the refracted light was bent through more than 90 degrees, rather than it being reflection.

Wagner used WebCT's chatroom function to perform interviews, including some interviews done the night before the talk. She found some technical issues, but the students seemed to like it better than coming in for face to face interviews. It is possible to carry on multiple interviews at the same time (if a little messy), but each interview takes longer due to the fact we tend to type more slowly than we speak. It was also sometimes difficult to tell if the student had finished saying something, or had just paused to write the next line. On the other hand, no need to transcribe, just do a little reformatting. And it's a lot easier to schedule.

HD06: Coherent or Incoherent? Student Understanding of Quantum Mechanical Wave Functions – Robert DuFresne, UMass

Looked at how classical understanding interfered with Quantum Mechanical understanding, by drawing out student understanding of the **information content** of wave functions.

N=6 for interviews, N=34 for test items. All subjects had covered QM in class.

Student views included:

- The "curvature" of the wave function was important to a third of them, rather than wavelength or frequency. A more curved line meant more energy.
- Wave amplitude was almost always seen as being related to energy, despite being merely a probability measure in QM.
- Whether a wave is bounded or unbounded had an inconsistent effect on student views of the energy of the wave. Some thought the bounded wave had more energy, some thought it had less.
- Potential well depth (finite versus infinite) also affected what energy the students thought the wave had.

HK: Plenary Session III

HK01: Space Flight: The Human Perspective – Kathryn Thornton, astronaut 1985-95

(Note: this is just a grab bag of things I found interesting during the talk, which was a lot more coherent than the notes would lead one to believe.)

The shuttle is limited to 3G's on takeoff because more would rip the wings off.

Once you adjust to freefall, you lose about 2 quarts of fluids, since there's no longer that much pooling in your legs. You get puffy for a while until this fluid is passed.

Freefall adaptation includes inner ear adjustments. The lack of balance leads to both nausea and a shutdown of digestive functions. This is particularly unpleasant.

The Space Lab module normally carried on the shuttle was recently replaced by a much nicer Space Hab module.

Astronauts are subject to some experiments that PETA wouldn't let you perform on a dog. Ah, the joys of informed consent.

Astronauts may perform a lot of experiments, but they rarely get to find out the final results of their work.

The transfer tunnel between the main shuttle and Space Hab is relatively featureless, so if you get to turning while in it, you come out disoriented. When I asked why they didn't just paint features on the walls, the reply was "We actually kinda like it the way it is."

On re-entry, there is a sort of St. Elmo's Fire-like "shuttle glow" due to incandescence of the rarified atmosphere. It looks very pretty.

Astronauts in the shuttle can NOT see the Great Wall of China. It bends and twists with the landscape, becoming effectively invisible. However, they can see many freeways and airports thanks to the nice straight lines. And land use differences between nations does make some national borders stand out.

And that's a wrap…only had half a dozen sheets left in the notebook when it was over.