# Disseminating Innovative Curricula: A Modified Role for Dissemination Sites*

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# Dissemination project

- *A New Model Course in Applied Quantum Physics*
  - E.F. “Joe” Redish, Richard N. Steinberg, Michael C. Wittmann, and the University of Maryland Physics Education Research Group
  - A junior level quantum physics course for scientists and engineers
- Department of Education FIPSE grant
  (Fund for Improvement of Post-Secondary Education)
- Test sites:
  - phase 1: five schools:
    from liberal arts colleges to research universities
  - phase 2:
    original test sites help reach out to other schools

# Dissemination programs: what, how?

Three elements:

- What are participants “buying into”?
- How should they work with the materials?
- How can dissemination leaders provide help?

The role of **P**hysics **E**ducation **R**esearch:

- Student-centered curriculum development
- Site-centered revision and evaluation
- Instructor-centered faculty development

# What are they buying into?

A modular device-based approach
to conceptual learning of physics

# New Model Course in Applied Quantum Physics

## Motivation

Scientists and engineers need to understand the physics behind quantum tools:

- Transistors
- SQUIDs
- Lasers
- MRI
- STM
- . . .

## Implementation

Real examples used to teach basic QM:

- photoelectric effect
  $\rightarrow$ photomultiplier tubes
- conductivity model
  $\rightarrow$ LEDs and diodes
- Quantum tunneling
  $\rightarrow$ STM

# New Model Course: Modular approach

- Tutorials

  Modeled after UW-style tutorials[1]
- Just-in-Time-Teaching[2] web essay assignments
- Applied HW

  Based on our experience with alternative homework assignments (AHA) in the Activity Based Physics Project[3]
- Software

  *Visual Quantum Mechanics*, *Photoelectric Tutor*, physlets, MBL, spreadsheet physics, *CUPS*, *MUPPET*…

[1] L.C. McDermott, P.S. Shaffer, and the Physics Education Group at the University of Washington, T*utorials in Introductory Physics*, Prentice Hall, Upper Saddle River, NJ, 1998.
[2] G.M. Novak, E.T. Patterson, A.D. Gavrin, and W. Christian, *Just-in-Time-Teaching: Blending Active Learning with Web Technology*, Prentice Hall, Upper Saddle River, NJ, 1999.
[3] E.F. Redish and the Physics Education Research Group, University of Maryland. Materials available on the web at http://www.physics.umd.edu/rgroups/ripe/perg/abp/aha/.

# UMD variations on a theme

Implementations at UMD have consisted of:

| *Tutorials** | *Essays* | *Software* | *Applied HW* |
|---|---|---|---|
| 6 | 0 | limited | none |
| 13 | weekly | extended | limited |
| 13 | daily | extended | moderate |

low

↓

high

* drop one lecture per week

Focus has been on:

- conceptual learning
- revisiting and revising classical prerequisites
- connections to the “real world”

# Conceptual learning in modified setting

Measured improvement in student learning of:

- photoelectric effect
- understanding of potential energy diagrams
- wave-particle duality
- interpretation of the wave function
- tunneling
- conductivity
- …

(Compared to traditionally taught courses for scientists and engineers)

Results reported at previous AAPT meetings (1997-present).

# Improved attitudes and retention rates

QM is notoriously unpopular with students;
Modified course shows improvements are possible:

| | modified | traditional |
|---|---|---|
| recommend to classmates | 91% | 43% |
| Enrollment rate (# students) | 23 | 22 |
| Retention (total / female / underrepresented) | 18 / 3 / 2 | 8 / 0 / 0 |

Additional results on expectations and attitudes reported at this AAPT meeting.

# Is the QM course disseminable?

- Is the product worth handing out?

  *Yes!*
  - Improved conceptual learning
  - Improved student attitudes
  - Improved retention rates

- Is the product complete, finished, and done?

  *Of course not!*
  - Site specific
  - Population specific
  - Limited in scope of content

## How can test sites implement the modified course materials?

Site-based modification
with peer review
within dissemination group

# UMD assumptions

- A course for scientists and engineers…
  … means a course for junior/senior
  electrical engineers
- Students have taken required math classes (including diff.eq.) but understanding is neither synthesized nor easily applied.
- Software tools and computers exist in an available studio classroom.
- Students have easy access to web outside of class

# Test site realities

- Population ≠ electrical engineers
- Math qualifications may be much lower / higher
- Lack of computing facilities for group instruction
- Lack of easily accessible computing facilities outside of class.

# Consequences for test sites

Modify the materials to match test site needs

- drop some: essays / applied hw / software / tutorial
- redesign tutorials to match student skill-level
- write new applied HW to better fit student population
- develop new essay questions to better match lecture
- use additional software as needed
- re-write software for new activities (e.g. physlets)

# A scientific approach to teaching

Evaluate curriculum modifications

- examination questions
- student surveys
- in-class ungraded quizzes
- on-line questionnaires

Communicate results:

Treat like a scientific process!

- presentation of ideas / modifications / evaluation
- open discussion with other dissemination group members

# Additional peer-review responsibilities

Sharing within a community of teaching:

- Outreach to area schools interested in using the quantum physics materials
- Presentations on curriculum implementation and evaluation at regional or national meetings
- On-going participation in a growing group of interested faculty

PER-based application of academic research and development and open source software approach*

* See Eric S. Raymond, "Homesteading the Noosphere," URL http://www.tuxedo.org/~esr/writings/cathedral-bazaar/homesteading/

# Analogies to the open source movement

Open source software development:

- Publicly available source code, modifiable
- Duty to notify others of code changes
- Distributed approach to development:
  No medieval monasteries of knowledge,
  free-form bazaars of knowledge instead*

Examples of open source software:

Linux, Apache, Emacs, Mozilla (Netscape),
StarOffice (Sun), Darwin (Mac OS X core)

* For those interested in my opinions on the value of the medieval cathedral state, ask later…

## What benefits can dissemination leaders provide for test sites?

Faculty development aimed at promoting and developing PER skills

# Assumptions of the open source movement

Observations about open source development:

- Participants have the coding skills
- Effective communication methods for sharing ideas and code already exist
- Definition of "good code" determined partially by the "benevolent fascist" leader group

With huge numbers of programmers willing to donate their time, Linus's Law[1] may hold:[2]

*Given enough eyes, every bug is shallow.*

[1] Eric Raymond, "The Cathedral and the Bazaar"
URL: http://www.tuxedo.org/~esr/writings/cathedral-bazaar/

[2] See commentary in A Second Look at the Cathedral and Bazaar by Nikolai Bezroukov,
URL http://firstmonday.org/issues/issue4_12/bezroukov/index.html

# Realities of PER-based dissemination

Observations of the physics classroom:

- Adopters often not experienced in PER
- It's difficult to communicate modifications or evaluation of materials without additional tools (classroom video, more-than-e-mail…)
- Definition of "good curriculum" determined by the realities of each test site and are not universal

There are few participants,
and most are unwilling to donate their time,
so there is no equivalent to Linus's Law.

Instead: *Most problems are local,*
*their solution, site specific*.

# Consequences for dissemination leaders

- Implementation aid:
  - Helping choose appropriate curriculum materials to best match student population at each site
  - Helping develop appropriate modifications
- Evaluation aid:
  - Helping design appropriate evaluation tools
  - Helping analyze student responses from a student-centered and PER-based view
- Communication aid:
  - Designing effective communication venues
  - Promoting communication between sites
  - Sharing of information

# Hidden strength of QM course dissemination

Active PER researchers at each university

- (Often not the ones teaching the courses)
- Available as resource in each case
- Provide both implementation and evaluation aid

So our dissemination plan should work…

… or should it?

Implementation of the
*New Model Course*
*in Applied Quantum Physics*

Limited implementation,
but building to full scale

# Preliminary implementation at test sites

| School | Implementation | Evaluation |
|---|---|---|
| A | limited modified | limited |
| B | limited modified | limited |
| C | traditional / baseline | baseline |
| D | coming Spring 2000 | none |
| E | coming Spring 2000 | none |

Comments:

- At many schools, QM is taught only once a year, or sometimes once every two years.
- Sites B and C teach QM every semester, the rest teach it once a year.

# Implementation scale and limitations

Scale of implementation at schools A and B:

- Limited use of tutorials
- No use of essays
- Limited use of software

Reasons for smaller scale implementation:

- Limited planning time prior to start of semester
- Essay system is most difficult to implement quickly
- Computing needs and power differ at each site
- Materials not given to easy overview

# Incorporation of evaluation results

- Evaluation at modified sites
  - Both schools A and B have evaluated student learning in their classes
  - Results are mixed

- Effect of evaluation at sites
  - Instructors indicate they are changing their instructional methods based on results
  - Instructors plan to present results at coming AAPT summer meeting

# What is still needed?

Modified curriculum materials

- To provide more choices for test site
- To promote development at the test sites
- To provide additional opportunities for student learning

Communication tools

- To promote an active community among the dissemination group
- To promote easier feedback between test sites and dissemination leaders

## Conclusions:
## Can this dissemination model work?

We don’t know yet...

# Multi-pronged PER approach

Instructor-centered dissemination
of student-centered curriculum:

- Research-based curriculum
- Implementation and site-based modification
  require evaluation and research-based improvements
- Faculty development relies on “buying in”
  to both the curriculum and the the research process

# Reciprocal demands

- Building an improved curriculum requires
  - recognition that the product is not complete
  - aid in developing more complete implementation
  - a community of equals…
- Building a community of equals requires
  - developing a common language of instruction, based on evaluation of materials and communication of results
  - developing dissemination leaders' skills in consulting
  - developing a proper communication system

# Where we go from here

- Phase 1 test sites (with detailed coordination)
  - First year implementation at all test sites (hopefully including more detailed use of materials)
  - Second year implementation will include more detailed understanding of student learning

- Phase 2 test sites (with more open collaboration)
  - Includes volunteers from workshops / presentations
  - Will join community built up in first year of project

# Goals of dissemination project

- Improved student learning
- Increased faculty awareness of PER and evaluation-based curriculum refinement
- A community of teachers using PER methods
- Effective materials to help teach quantum physics to a broad population.