Web-based Pedagogical Assistance for Under-prepared Teachers of Physics

Dean Zollman
Kansas State University

Supported by the National Science Foundation under Grants 0455772 & 0455813

Scott Stevens
Michael Christel
Carnegie Mellon University

Sytil Murphy
Brian Adrian
Kansas State University
Physics Teaching Web Advisory Pathway
www.physicspathway.org

Goal
Provide just in time assistance on the pedagogy of physics

- The need
- Our approach to a solution
  - Introduction
  - The real thing
  - Simulated
- Feedback so far
The problem

"Yet in high schools, more than 20 percent of students in math and more than 60 percent of students in chemistry and physics are taught by teachers without expertise in these fields."

- President Obama
Speech to the National Academies, 2009

~1.1 million secondary students were taking physics in 2005

Source: American Institute of Physics
Why are they learning physics

- At present medical colleges & biological sciences degrees require physics at University
- Engineering also requires University physics
- Students believe
  - Completing secondary level physics gives them an advantage in University physics
- Very few wish to study physics at University

Positives & Uncertainties

- Side effect: ~50% students in secondary level physics are girls
  - But they do not become physics students at University
- Physics requirement may change, but not soon
  - Medical Colleges Admission Test (MCAT) will be revised in the next few years
  - New report from Association of American Medical Colleges recommends “competencies not courses”
    - Competencies in physics (even quantum) included.
**Who teaches secondary level physics**

- **Percentage of physics teachers**
  - 0 courses: 5%
  - 1 or 2 courses: 15%
  - 3 to 5 courses: 30%
  - 6 to 9 courses: 20%
  - 10 or more courses: 35%

Source: American Institute of Physics

**Retention of teachers**

5-year change for teachers who began teaching in 1995-1996 in 4 states

- **Physics**: Movers - 13, Leavers - 40
- **Math**: Movers - 21, Leavers - 31
- **Chemistry**: Movers - 18, Leavers - 32
- **General Science**: Movers - 17, Leavers - 32
- **Biology**: Movers - 19, Leavers - 19
- **Secondary**: Movers - 21, Leavers - 29
- **Elementary**: Movers - 18, Leavers - 26
- **All Teachers**: Movers - 23, Leavers - 28

Source: North Central Regional Educational Laboratory
Who teaches physics (Kansas)

- Physics student with teaching certificate
  - Same preparation as other physics students with additional study in education
- Science education student with physics specialty
  - About equal study in physics and education
- Science or math education student with ~3 courses in physics
  - Primary study in other science & education
- Emergency Certification

Tories: Dumber days are over

Ofqual, the exam regulator has admitted that the current level of rigour in GCSE science is not good enough.

Sir Peter Williams

Quoted in Leicester Mercury, today
Who is Pathway’s target audience?

<table>
<thead>
<tr>
<th>Number of University physics courses</th>
<th>Percentage of physics teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1 or 2</td>
<td>5</td>
</tr>
<tr>
<td>3 to 5</td>
<td>30</td>
</tr>
<tr>
<td>6 to 9</td>
<td>20</td>
</tr>
<tr>
<td>10 or more</td>
<td>10</td>
</tr>
</tbody>
</table>

Source: American Institute of Physics

Teachers’ needs
Particularly the under-prepared teachers

- Immediate relevance
- Need it tomorrow
- Completeness
  - Little time for searching out additional information
  - Background in physics is limited
- Proof that they are teaching the “right thing”
  - Consistent with their State Science Standards
Some advice is on the web

But not very useful
Our approach

- Web-based access to thoughts of experienced physics teachers
- ~6,500 pre-recorded answers to questions about physics teaching
- Conversation mode interface
- Frequent improvements based on input & feedback

Ask an Experienced Physics Teacher the night before the lesson

Paul Hewitt

What topic should I teach first?
Questions suggested by teachers, students & physics education research

Capture responses on video

Extract information from responses; create indices & alternative questions

Teachers & Students

The experienced teachers

Paul Hewitt
Author of highly popular physics and physical science textbooks for both high school and college

Charles Lang
High school physics teacher in rural Nebraska & Omaha; Presidential Award recipient
The experienced teachers

Roberta Lang
High school physics teacher in Orlando; trained as a chemistry teacher

Leroy Salary
Physics & teacher educator at Norfolk State University

A teacher selects one of four experts to ask a question about the pedagogy of teaching physics.
The teacher asks a question about the teaching of physics.

The question is matched by the Pathway search engine to one of 6,500 responses in our multimedia data base.
An experienced teacher provides a pre-recorded response.

Auxiliary information can be popped up as needed.
Quick questions for the teacher who does not know where to start.

Similar questions which are have been asked by other teachers can be selected, or the user can send the question to comPADRE, the digital resource for physics and astronomy education.
Feed back on the appropriateness and value of the response can be given.

http://www.physicspathway.org
Some questions

• What topic is best to begin teaching physics?
• What is a good way to introduce sound?
• How do you teach vectors
• What concepts should I use to teach acceleration?
• What senses help student feel the difference between constant velocity and acceleration?
• How you use mathematics to teach physics?

More questions

• How should I introduce pendulum motion?
• What is gravity?
• Should magnetism be taught as vectors?
• What misconceptions do students have about forces?
• Should I use activities to teach electrostatics?
  – Conservation of charge
Simulated Examples

- Bobbie Lang – What is a good way to introduce sound?
- Chuck Lang – How can I help students understand the difference between constant velocity and acceleration?
- Bobbie Lang – What topic should I teach first?
- Leroy Salary – What topic should I teach first?
- Chuck Lang – What topic should I teach first?
- Chuck Lang – How should I introduce waves?
Underlying Principles of Teaching

- Actively engage the students in their learning
- Pedagogy is related to physics education research
- Emphasize simple experiments and demonstrations
- Connect with but not focus on National science teaching standards

Feedback & Evaluation

- Primarily formative so far
  - Significant changes in the interface
  - Provide help without calling it help
    - E.g. Related questions
- Added many questions & topics
- Connections to comPADRE
  - Cannot keep up with research within Pathway
  - Provides additional print resources
- Technical changes
  - Improved searching
  - Flash video
Lesson Enhancement Case Study

Sound

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is sound?</td>
<td>How does sound move?</td>
<td>Sound waves and SLAM!</td>
<td>Sound waves and SLAM!</td>
</tr>
<tr>
<td>Describe the wave and discuss its properties</td>
<td>Explain the wave and discuss its properties</td>
<td>Explain the wave and discuss its properties</td>
<td>Explain the wave and discuss its properties</td>
</tr>
<tr>
<td>Sound wave (like a sine wave)</td>
<td>Sound wave (like a sine wave)</td>
<td>Sound wave (like a sine wave)</td>
<td>Sound wave (like a sine wave)</td>
</tr>
<tr>
<td>Describe the wave and discuss its properties</td>
<td>Describe the wave and discuss its properties</td>
<td>Describe the wave and discuss its properties</td>
<td>Describe the wave and discuss its properties</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Digital video library

- Clips from videodiscs by me and others from the last century
- AAPT Film Repository – even older
- Teacher contributed videos
- The big question:
  - How do we make this relevant in the days of YouTube
Next step

- Search engine searches both our video databases & YouTube
  - Maybe also TeacherTube, and others
  - Collect relevance information from our users
- Display all info on 1 or 2 screens
- Programming problems not yet solved
  - But, I am told they are soluable
www.physicspathway.org

- Available now
- Covers most topics in high school physics
- Focuses on concepts not math
- Seeking field testers who will provide feedback
  - Preservice teachers
  - Workshop participants
  - Inservice teachers

http://www.physicspathway.org

Dean Zollman
dzollman@phys.ksu.edu
Paul G. Hewitt

Paul G. Hewitt, former boxer, uranium prospector, sign painter, and cartoonist began college at the age of 28 and fell in love with physics. His name is synonymous with Conceptual Physics to physics educators everywhere. Before the advent of Professor Hewitt’s textbook of the same name, physics was traditionally taught primarily as applied mathematics - geared to students with high math and science aptitudes. As such, any serious study of physics was out of the educational mainstream for most students. Hewitt’s conceptual approach changed all this. By translating the central concepts of physics from mathematical language to common English and by extensive use of analogies as a teaching tool, Hewitt brought physics into the educational mainstream. His textbook, the leading physics textbook for nonscientists since 1971, has changed the way physics is taught to both non-science and science majors as well.

Hewitt’s teaching career began in 1964 at City College of San Francisco, his home base. He has taught an evening course for the general public at the Exploratorium in San Francisco. He has taken leaves to teach physics at the University of California, both at the Berkeley and Santa Cruz campuses, and more recently at the University of Hawaii at both the Hilo and Manoa campuses.

In 1987 he wrote a high-school version of Conceptual Physics. The high school text is now in its third edition. The college text is now in its ninth edition. Translations of both texts find Conceptual Physics popular worldwide.

Hewitt’s other textbooks include the 2nd Edition of Conceptual Physical Science, co-authored with his daughter Leslie, a geologist, and his nephew John Suchocki, a chemistry instructor formerly at Leeward Community College in Oahu, HI.

Very recently, Paul, Leslie, and John have written a version of the physical science book aimed at 9th graders in high school. It is Conceptual Physical Science-Explorations.

Hewitt’s only trade book (non textbook) is Touch This-Conceptual Physics for Everyone. Its former title was simply Conceptual Physics for Everyone.

In recognition of Hewitt’s achievements, the American Association of Physics Teachers honored him in 1982 with their Millikan Award - the once-per-year prestigious prize for outstanding contributions to physics teaching. At present, Hewitt is a column editor for The Physics Teacher, the monthly magazine of the American Association of Physics Teachers.

Hewitt now resides in both St. Petersburg, Florida and Hilo, Hawaii.