

The Tutorial Teaching Method

Wells Wulsin
Stanford Physics SPICE Teaching Committee
14 August 2008



Motivation to adopt tutorials

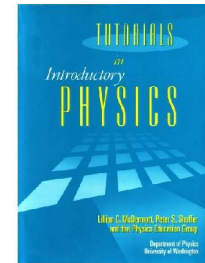
- Attendance at traditional discussions for Stanford physics courses is $\sim 50\%$, suggesting the opportunity to improve their effectiveness.
- Physics Education Research (PER) has shown that students learn most when they actively engage in the subject matter.
- Tutorials are used at many research universities, and often get very positive reviews.

Traditional discussions vs. tutorials

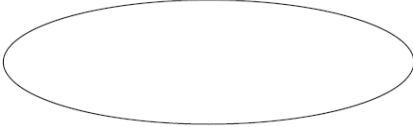
- **Traditional discussion:** teaching assistant works through problems on the board, pausing occasionally to ask or answer questions
- **Tutorial discussion:**
 - Students form teams of 2-4 (3 is ideal) to work through a set of problems that address the important concepts and problem-solving strategies from that week
 - “above and beyond” problems available if a group finishes the basic problems
 - Teaching assistant(s) roves from group to group, providing guidance when groups get stuck, and signing off when they successfully reach the solution.
 - Solutions may be written on marker boards or on individual worksheets
 - Marker boards focus the team’s attention on one place.
 - Worksheets require no extra hardware; each student gets a written record.
 - Students take turns as group leader.
 - Usually students receive a grade for participation, but are not penalized for incorrect solutions.
 - Requires reconfiguration of seats/tables from traditional classroom setup.

Research-based tutorial questions

Example of a Tutorial problem from *Tutorials in Introductory Physics*, L. McDermott and P. Shaffer, 1998.



Acceleration vectors for constant speed



Suppose that the object in part I is moving around the track at **uniform speed**.

- Draw vectors to represent the velocity at two points on the track that are relatively close together. (Draw your vectors LARGE.)
- Label the two points C and D.
- On a *separate* part of your paper, copy the velocity vectors v_C and v_D .
- From these vectors, determine the *change in velocity vector*, Δv .

i. How does the angle formed by the head of v_C and the tail of Δv compare to 90° ? (“Compare” in this case means “is it less than, greater than, or equal to 90° ?”)

As point D is chosen to lie closer and closer to point C, what happens to the above angle? Explain how you can tell.

What happens to the magnitude of Δv as point D is chosen to lie closer and closer to point C?

ii. How would you find the acceleration at point C?

- Designed to address common misconceptions, build conceptual understanding, and strengthen problem-solving skills.
- TIP problems have been tested and revised over many years, and improvements continue to be made by McDermott and Shaffer at U. Washington.

Most problems can be used in tutorials

Practice tutorial: Exercise 1.31, *The Art of Electronics 2nd Ed.*, P. Horowitz and W. Hill, 1989.

Figure 1.101 shows a classic switch circuit used to turn a ceiling lamp on or off from a switch at either of two entrances to a room.

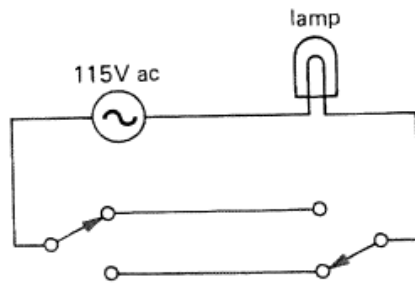


Figure 1.101. Electrician's "three-way" switch wiring.

EXERCISE 1.31

Although few electronic circuit designers know how, every *electrician* can wire up a light fixture so that any of N switches can turn it on or off. See if you can figure out this generalization of Figure 1.101. It requires two SPDT switches and $N - 2$ DPDT switches. (Hint: First figure out how to use a DPDT switch to crisscross a pair of wires.)

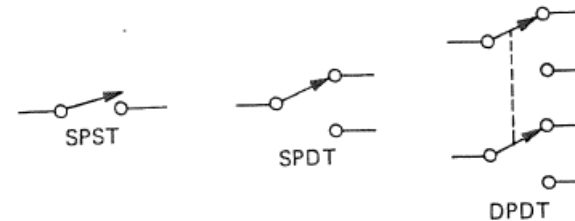


Figure 1.98. Fundamental switch types.

Directions:

- 1) Work in group of no more than 3.
- 2) Appoint one scribe.
- 3) Show work and solution on easel paper.
- 4) Sign Tutorial Progress sheet, and get TA signature when finished.

Pros and cons of tutorials

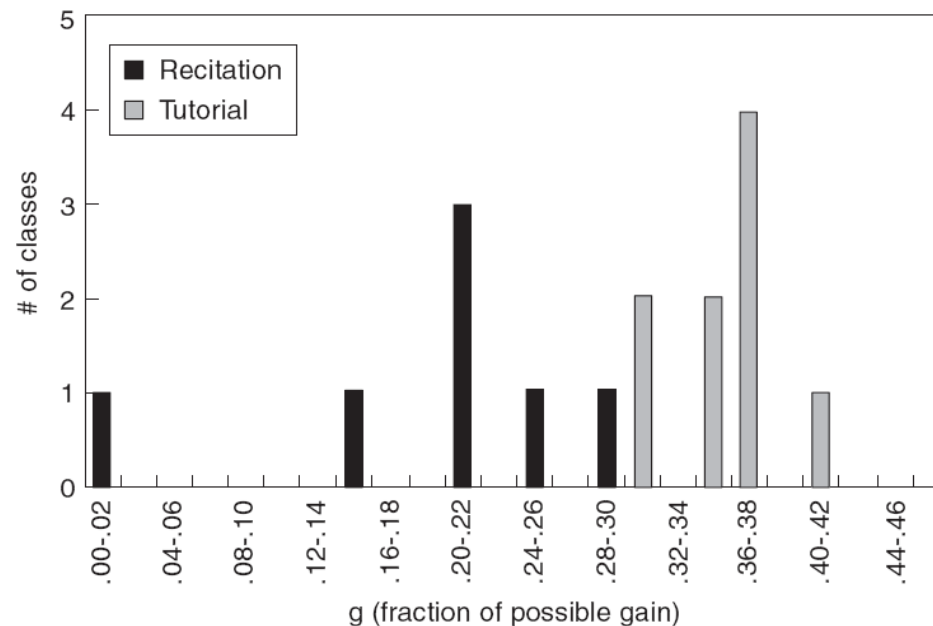
Advantages

- Students are more actively engaged during the recitation: they are doing physics rather than watching physics.
- TA's serve as guides rather than lecturers, while students teach each other.
- Group interaction creates a more social environment, improving student attitudes toward physics.

Disadvantages

- Likely misconceptions must be targeted in problems since they are not broadcast in traditional discussion mini-lectures.
- Takes more time to cover same amount of material (increased recitation time is one solution).
- Requires more guidance of teaching assistants from the course instructor (writing problems, at a minimum).

Effectiveness of tutorials



Source: TPPS p. 151

Figure 8.3 Fraction of the possible gain attained by engineering physics students at the University of Maryland in classes taught with traditional recitations (dark) and tutorials (light).

- Who uses them: U. Washington, U. Maryland, U. Illinois, U. Colorado

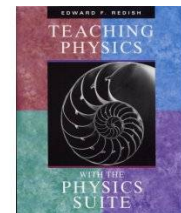
TA tutorial training draft agenda

- 10am-noon, Friday, Sept. 26 (first week of classes)
- Full group welcome and introduction (~5 minutes)
- description of the tutorial method, with sample videos of tutorial classrooms (~15 minutes)
- Joe Redish: motivation for tutorials, with statistical evidence from other universities of its effectiveness (~25 minutes)
- Breakout groups of no more than 15 TA's each; demonstration of the tutorials (~55 minutes)
- Closeout: questions, discussion, and refreshments (~20 minutes)
- Lunch with Joe Redish following training

Backup slides

Physics Education Research

- PER addresses the problems of physics education by studying how students learn physics and what teaching techniques are most effective
- Many PER folks have physics Ph.D.'s and came from traditional physics research backgrounds before migrating later in their career
 - Closer in culture and organization to physics departments than education dep'ts
- At least 36 U.S. universities have websites for PER groups (<http://www.physics.umd.edu/perg/homepages.htm>)
- Wide body of PER literature
 - American Journal of Physics (AAPT)
 - Physics Education (IOP)
 - Physical Review Special Topics - Physics Education Research (APS)
 - The Physics Teacher (AAPT)
- The “Jackson” of PER, and the source for much of this talk, is *Teaching Physics with the Physics Suite*, E. F. Redish, 2003, available free at <http://www2.physics.umd.edu/~redish/Book/>



Redish's Cognitive Principles

- **What matters most in a course is what students actually do**
 - Implication: Get students to actively engage in physics as much as possible. Physics is not a spectator sport!
 - But students can actively work with equipment without learning much physics
- **Five principles:**
 - Constructivism: People build knowledge by connecting to existing knowledge.
 - Context: People think differently depending on context.
 - Change: It's hard to learn something we don't almost already know.
 - Individuality: Individuals show significant variation in how they learn.
 - Social learning: For most individuals, learning is most effectively carried out through social interactions.

Learn More

- The Bible of PER techniques: *Teaching Physics with the Physics Suite*, E. F. Redish, 2003.
- An uber-bibliography: <http://www.physics.umd.edu/perg/tools/rl.htm>
- Sample ILD's: *Interactive Lecture Demonstrations*, D. R. Sokoloff and R. K. Thornton, 2001.
- Guide to interactive techniques in lecture: *Peer Instruction: A User's Manual*, E. Mazur, 1997.
- Research-based tutorial problems, developed at U. Washington: *Tutorials in Introductory Physics*, L. C. McDermott and P.S. Shaffer, 1998.
- Computer-based labs: *Real Time Physics*, D. R. Sokoloff, R. K. Thornton, and P. Laws, 1995.
- Take a free (NSF-funded) Chautauqua summer course (~3 days)
http://physics.dickinson.edu/~wp_web/wp_resources/wp_workshops.html or <http://uoregon.edu/~sokoloff/chaut1.htm>
- How one university adopted widespread reform in its intro courses:
http://research.physics.uiuc.edu/PER/Course_Revisions.html

Tutorials

Practice tutorial solution.

