Information Technology for Teaching Physics & Astronomy

Michael Allen

Physics Department, Mahidol University
Outline

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• Uses of IT in teaching
• Impact of IT on the syllabus
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Impact of IT on Research & Teaching

Computers have greatly changed how research is done. This change occurred very quickly.

So far, IT has had relatively little impact on teaching physics.

Research is controlled by individuals. Little resistance to change. The rewards for successful change are obvious.

Teaching (methods and syllabus) are controlled by other people. Large resistance to change. Rewards are not so obvious (in the short term).

The crisis in physics teaching: all over the world, students hate physics. IT can help solve this problem.
Benefits of IT for students

• Help emphasize fundamental physics
• include more contemporary (= interesting) physics
• train student intuition
• provide more experience with complicated (real world) systems
• give research experience
Benefits of IT for instructors

- Large (and growing) resource of teaching materials
- Web-based multiple choice exams
- Lecture note/homework/exam preparation
Uses of IT

- Practice questions
- Exams/testing
- Course management and preparation
- Tutorials, dialogue, AI
- Instructional games ("edutainment")
- Lab simulations
- Lab data acquisition
- Modelling physical phenomena
Replacing textbooks and teachers

Hypertext (clicking on links) has the advantage of quick cross reference to other subject areas.

Animation and user interaction in figures.

Tutorials disguised as games.

AI instructor (expert system): asks student questions, anticipates mistakes, gives clues on how to get correct answer based on those mistakes. This is not yet well-developed.
The trouble with labs...

- Students are not prepared — they do not read the material before.
- Labs are considered boring.
- Too much work in too little time.
- Objectives are not well understood.
- Students can’t make equipment work properly
- The partner does the work, and the student leaves the lab with little understanding.
...and the traditional and technological solutions

Traditional solution: lab instructors give extra pre-lab instructions. But this makes the time problem worse, and doesn’t help with student understanding.

Some successful IT solutions: (1) ask the students to run a computer simulation of the experiment before they do the real one. (2) get the data using a computer interface (but beware of turning whole lab into a black box that gives out the answer in some mysterious way.)

Less successful IT solutions: put video of lab on the web for students to look at beforehand. Danger of becoming a cookery lesson – students just imitate without understanding what they are doing.
The need for a change in the syllabus

The order in which physics is taught is based on a mathematical hierarchy of physics from 100 years ago: algebra, geometry, trigonometry, calculus, differential equations, linear algebra, probability and statistics, partial differential equations.

We have decided which areas of physics to teach based on how easily exact answers can be obtained mathematically.

The maths of real world problems is difficult.

If we remove friction and nonlinearity to make the problem easy to solve exactly, it becomes too far from everyday experience.

Students often separate the real world from the mysterious ‘physics world’ where objects continue to move without you pushing them.
Numerical methods and complex problems

Research physicists now use numerical methods as much as analytical methods.

The simplest numerical methods are not so difficult (Feynman mentions them in his second lecture (1963)), but they can be used to solve mathematically difficult real world problems.

It has been suggested that, like the research physicist today, the student first sees the numerical solution to the problem with all its real world complexity, and then sees how to reduce it to the traditional simple model.
An example: Nonlinear Systems

The world is mostly nonlinear — if you plot one quantity against another quantity, it is usually not a straight line. But almost all physics taught up to graduate level is linear, because linear is easy mathematically.

But nonlinear systems e.g. logistic map \( x \rightarrow rx(1 - x) \) are easy to study with a computer.

Even teachers/lecturers do not fully understand them — students like that.

Appropriate: show real world behaviour.
Astronomy

Astronomy is usually not taught has a separate subject at school or university.
However, astronomy draws many people to science and eventually to physics.
Young children will show an interest in astronomy before they have even heard of physics.
Some interesting physics and astronomy websites

First, don’t be discouraged by dead links. Just keep searching!

- [http://physicsweb.org/resources/home](http://physicsweb.org/resources/home) (and then click on General Physics).
- [http://www.nottingham.ac.uk/~ppzrfp/TeachAstro.html](http://www.nottingham.ac.uk/~ppzrfp/TeachAstro.html)
IT for teaching at Physics Dept, Mahidol

Physics Education Network in Thailand (PENThai): various projects including mpegs of lectures on web for students to review.

gl4c: graphics library for C. C functions for creating windows, buttons, menus, mouse control, and graphics easily on Linux based systems. See http://einstein.sc.mahidol.ac.th/~scmal/gl4c/

\LaTeX\ style files for easy preparation of homework, exams, student reports, etc.
Conclusions

Using computers in teaching physics can help students learn if it is done well.

However, it is not easy. Applications must be selected carefully.

The problem of the unpopularity of physics in schools/universities could be solved by a change in the syllabus to make it more apparent how the real world relates to physics. This can be done with computer simulations and teaching simple programming and numerical methods at an earlier stage. This should make physics more fun.