How can the Internet be used to enhance the teaching of physics?

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Abstract
Selection is the key to learning from the huge amount of information on the Internet. This article describes how teachers can use a school Intranet or website to organize resources and direct students to the best interactive and educationally appropriate pages.

Keywords: M, H, A; TLA

Introduction

The search engine Google lists over 1 870 000 pages relevant to the word 'physics'. Many of these pages will be of almost no use to the physics educator or student.

The aim of this article is to show you some of the ways in which the Internet can be used to enhance the teaching of physics. The article will give examples of top-class sites relevant to different ways of using the Internet in the classroom. We will also provide some basic guidelines on creating your own Intranet/Internet pages. Finally we will provide a few tips on searching the Internet for further similar pages.

When is it appropriate to use the Internet?

Most physics teachers that we have spoken to have no intention of using computers in their lessons purely for the sake of it. The following criteria can be used to indicate when you should be using the Internet:

- You feel your current mode of delivery of a particular topic or could be made more interesting.
- Students find a particular concept difficult to grasp. Computer graphics are particularly useful for illustrating things that cannot be observed directly, e.g. the motion of particles in a gas.
- Simulations of experiments are best left to situations where the practical is inaccessible to the students for reasons of safety or equipment availability (in the UK students under 16 are not allowed to handle radioactive sources—an ideal opportunity for a simulation).
- Where students need to gather information/carry out research.

The rationale for running your own Intranet or Internet site

The emergence of the World Wide Web has significantly changed the way in which we access information and think about computers. Online learning is convenient for students, as they can proceed at their own pace and can work independently out of lessons wherever they have access to the Internet. However, undirected and unfocused 'surfing' of the Internet does not yield much lasting and meaningful learning. While it may be true that learning often occurs fortuitously, without a clear focus students may spend too much time in recreational web surfing.

Most teachers would agree that for learning to take place the learner must actively process and

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make sense of available information. Generally speaking, a more active learner will learn more quickly than a passive learner. Unfortunately, active learning is seldom required when students access the web. It's true that students have to make decisions as to which links to pursue, but too often they merely browse information before jumping to another site.

The main purposes of a physics learning web are to:

- Make the learning experience more interactive.
- Provide a greater variety of learning experiences within the classroom.
- Permit 'virtual physics' experiments to be carried out in interactive Internet sessions using downloaded Java applets.
- Allow to teachers to create an 'interactive whiteboard' with the use of applets and data projector.
- Allow physics teachers everywhere to freely share resources with colleagues and students at other establishments.
- Create wider opportunities for students to learn independently either from home or in school.
- Make all course documentation freely available to students and their parents.
- Direct students to web pages closely related to their course requirements.
- Make teaching resources (e.g. teacher notes and PowerPoint presentations) available to students outside lessons to facilitate independent catch-up and/or review.
- Provide opportunities for students and ex-students to contribute directly (by producing web pages) and therefore to feel some sense of ownership and involvement.

In short, a physics web is an additional resource, an enhancement of existing provision, and is not intended to replace the normal workings and relationships within the classroom. The fully fledged online course for physics students under the age of 18 is a long way off. The scenario of students enrolling in a well developed, essentially teacher-free online course does not appear realistic, and efforts to do so will probably result in wasted time, effort and expense. But we do envisage webs that provide additional teaching and learning resources closely related to syllabus requirements.

The exception to this is of course courses that are specifically intended for distance learning, for example home-study degrees. This specialized area of physics education is beyond the scope of this article. However, the potential to enhance this type of course is huge.

Why using the Internet/Intranet can be easier than buying in CDs

Many schools now have an extensive network of computers and it seems that the number of networked computers in schools will continue to rise for some time. This presents problems and advantages. Work can be accessed from any networked computer. Once the school has a connection to the Internet it can be shared across the network (although there are issues about how many computers can be successfully wired to any particular Internet connection before it will run so slowly that it is unusable).

From our own experience of networks, particularly the secure networks required by schools, they reduce the power of individual users to install and run software. This means that when, say, the Science or Physics department wishes to have a new CD installed on the network they are dependent on the IT technical staff to provide the service for them. The more software the network runs the more likely it is that there will be conflicts or incompatibilities between programmes. For this reason we have waited up to a year for software to be installed on the school network. Colleagues at other institutions have had similar problems.

Getting your school network to the point where you have Internet access and the software to run and edit an Intranet site may seem a far-off goal for many people. To our minds it is a very worthwhile goal because once this has been achieved you have a resource of limitless potential, which can be expanded indefinitely at no additional cost and with no help from people outside your particular department.

For people working in institutions with Internet access, but with no facilities to create or manage an Internet or Intranet site, quite sophisticated development is still possible. Most Internet service providers (ISPs) provide free web space with their service. So it is possible to create and run a website fairly easily from any home with a PC and standard Internet connection. It is obviously beyond the scope of this article to

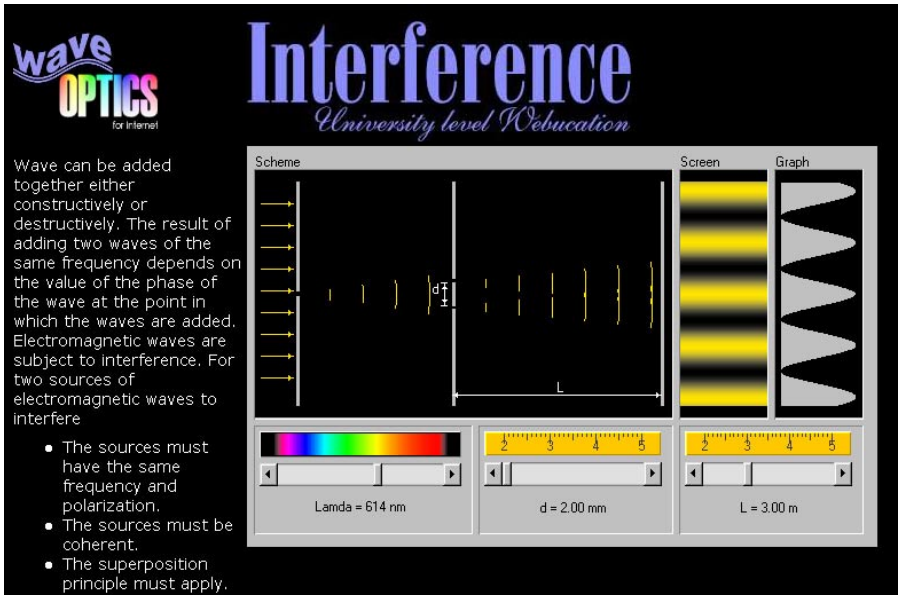

Figure 1. Young's slits simulation at http://members.tripod.com/~vsg/interf.htm

describe exactly how to do this, but a good starting point is the help area of your ISP's website.

Once you're in a position to start building an Intranet or Internet site, what should it contain? As a starting point, you are creating a custom interface to the Internet for your students. The contents should be organized in such a way that it will be familiar to the students, for example using the titles of the modules that your students are taught. It can also be used as a filing cabinet, holding copies of all the documents used by the department. If staff or students require further copies of the documents they are easy to find and reproduce. Files on the Internet or Intranet do not need to be in a universal format such as HTML if they are only to be used by a particular institution where the software required to read these files is available.

A simple example of using a school's own site to provide a custom interface to the Internet is to be found on the Northallerton College's website in the science area. The science and physics content of this site is largely the work of the authors. Visit

- http://www.northallertoncoll.org.uk

If the student (or you) clicks on the revision button then you see a list of the modules that the students study at Northallerton College. If you click on any these units (for example 'Food for Thought') you are taken to the relevant part of the BBC bite-size revision site. This has proved popular with students revising from home because it is surprisingly hard for them to work out which part of the BBC site is relevant to 'Food for Thought'.

Examples of how we can use the Internet/ Intranet in lessons to enhance learning

Sites for showing to a whole group to promote discussion and aid visualization

At a parents' evening one of us overheard a colleague being asked what students did in lessons if they opted to study science post-16. The colleague replied, accurately, that a surprisingly large amount of time was taken up in discussion. A good interactive applet, preferably projected onto a large screen, is an excellent stimulus for discussion. The animation clearly aids the students' ability to visualize events that it is not normally possible for them to see. Interactive applets where parameters can be changed will have students spontaneously asking: 'what happens if you change that?' Students are easily encouraged to predict what will happen, qualitatively or in some cases even quantitatively. If required, the discussion can be backed up by questions on worksheets to be completed later in the lesson or independently. If the physics of the applet is good then your existing question bank can be used and the students use the applet to check their answers.

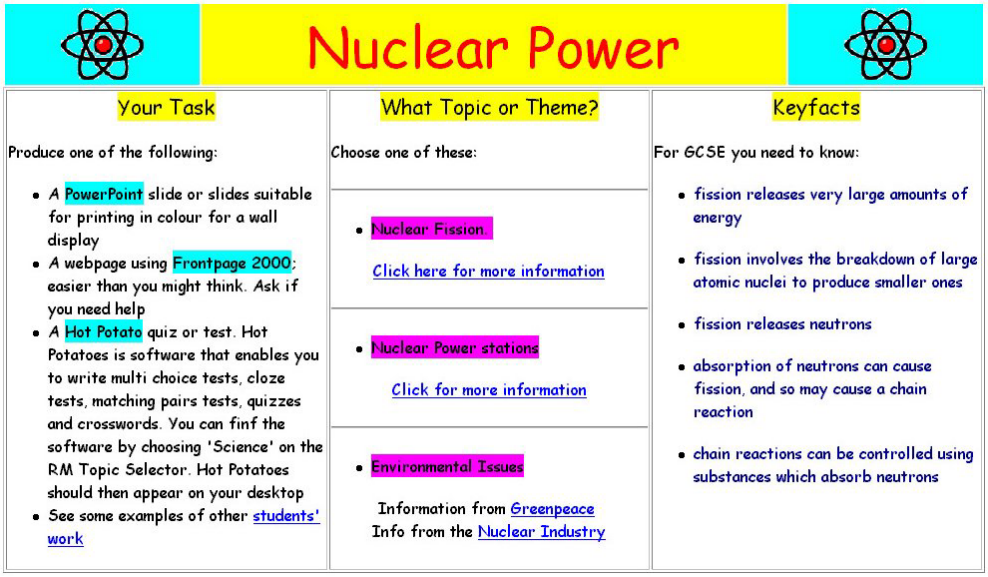

Figure 2. GCSE Science Nuclear Power research at http://www.northallertoncoll.org.uk/Science/GCSE%20Science%20Topics/Y11%20Topics/ETT/Nuclear%20Power.htm

- Simulation of an ideal gas
  http://www.phy.ntnu.edu.tw/~hwang/idealGas/idealGas.html
- Electric field due to point charges
  http://www.colorado.edu/physics/2000/waves_particles/wavpart3.html
- Young's slits simulation (variable wavelength)
  http://members.tripod.com/~vsg/interf.htm
- Nuclear chain reaction
  http://library.thinkquest.org/17940/texts/java/Reaction.html?tqskip=1

Sites that provide complete activities

These are the sites that are probably closest to what we imagined 'online learning' would be. However, the number of really worthwhile activities that we found is quite small. They are clearly difficult to write and have to be very specific in terms of contents. For example, on one site three out of 20 questions on statics and dynamics require students them to know about the coefficient of friction. If your students don't need to know this (as in our case), a whole set of questions becomes virtually useless. The virtual earthquake activity is excellent because it requires students to make measurements from graphs on the screen. The computer then converts these measurements into the location of an earthquake. The more careful they are the more accurately they locate the earthquake.

- http://vcourseware3.calstatela.edu/VirtualEarthquake/VQuakeExecute.html

This site provides an excellent summary quiz of free space diagrams:

- http://www.glenbrook.k12.il.us/gbssci/phys/shwave/fbd.html

Research activities

The Internet provides an immense resource for research and it's important that our students become proficient at finding what they want. But even a skilled 'searcher' will spend a lot of time at the task and some students will become frustrated and lose interest. The way to avoid this is to set up pages on your web that both set the scene and provide a number of suitable sites to set the student off in the right direction straight away. Here are two good examples:

- AVCE Science Rope research
  http://www.northallertoncoll.org.uk/avcescience/Unit%206/unit_6.htm
- GCSE Science Nuclear Power research
  http://www.northallertoncoll.org.uk/Science/GCSE%20Science%20Topics/Y11%20Topics/ETT/Nuclear%20Power.htm

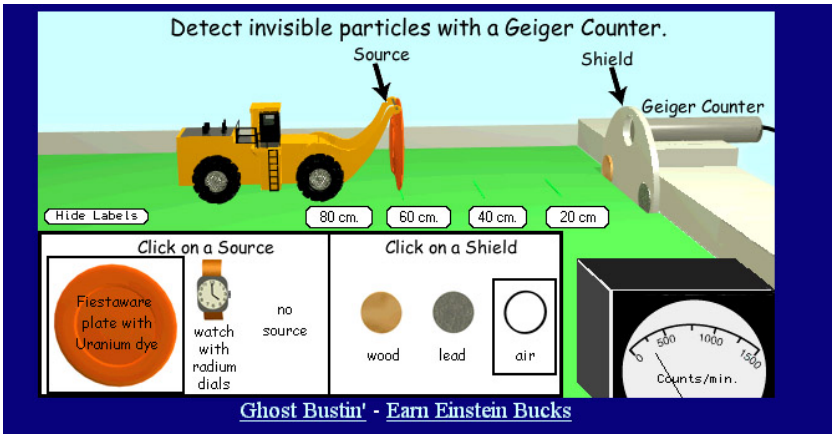

Figure 3. Geiger counter simulation at http://www-ed.fnal.gov/projects/labyrinth/games/ghostbustin/geiger_counter/geiger.html

Sites for fun

The Fermilab in America has a fantastic education website with an online exhibit called the Fermilabyrinth. It is a collection of games and simulations, all of which are very high in quality, not just in terms of graphics but also in terms of their approach to education. Genuinely engaging games allow users to find patterns in things like the quark composition of baryons. Not only does the site provide much that is useful to people wanting to learn about particle physics but also a model of what it is possible to achieve via the Internet.

- Home page
  http://www-ed.fnal.gov/projects/labyrinth/games/index1.html?name=
- Geiger counter simulation
  http://www-ed.fnal.gov/projects/labyrinth/games/ghostbustin/geiger_counter/geiger.html
- Four force game
  http://www-ed.fnal.gov/projects/labyrinth/games/lawnorder/four_forces/four_forces.html
- Baryon bonanaza
  http://www-ed.fnal.gov/projects/labyrinth/games/lawnorder/standard_model/baryon_table.html
- Particle Families
  http://www-ed.fnal.gov/projects/labyrinth/games/lawnorder/particle_families/activity.html

Creating your own quizzes and online tests

Any website tailored to the needs of your own students will require the writing of formative assessments and self-tests. Some teachers have gone to the trouble of learning Visual Basic or become advanced users of Microsoft Excel in order to do this, but there is another way. We have used some free software called Hot Potatoes to produce multiple-choice tests, short-answer quizzes, Cloze tests, crosswords and exercises in matching pairs. The software is straightforward to use and tests can be produced quickly and easily by busy teachers. Students find the tests enjoyable and are motivated by them but they enjoy producing the tests too, the reward being that good ones can be added to the web for their peers to enjoy. The great thing about this software is that it's free shareware and can be downloaded from: http://web.uvic.ca/hrd/halfbaked/

Tips on searching for sites

Most of the sites listed have been found searching with Google (www.google.com). If you search for a particular physics topic then in general the results are poorly suited to educational use. Adding the following terms to your search increases the likelihood that you will find something useful and interactive: Java applet, interactivity, education.

Conclusions

The essence of teaching is the relationship established between the teacher and students. The ongoing interaction between teacher and students,

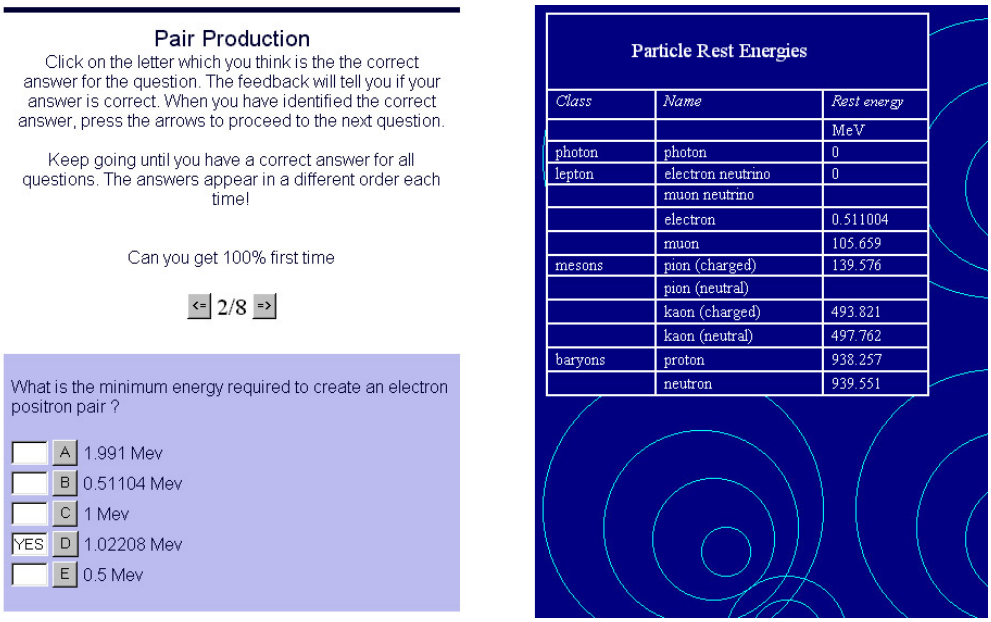

Figure 4. Sample multiple choice test produced using the Hot Potatoes software.

and among students themselves, is an integral part of the teaching and learning process, and the advent of ICT in the classroom doesn't make it any less important.

Our webs, in common with the rest of the Internet, are a working tool, which we can use to motivate students and enhance learning. The distinguishing feature of web-based learning is that it provides a modest opportunity for students to learn physics anytime, anywhere.

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