Superconductors and semiconductors: WebQuests to collect information for "From Ideas to Implementation"

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Educational justification

The new Higher School Certificate (Stage 6) syllabuses, introduced in 2000 for teaching science in NSW schools, draw on constructivism, a pedagogy based on educational research relating to teaching and learning. Constructivism introduces classroom practices such as: understanding and responding to individual student interests, strengths, experiences, and needs; focusing on student understanding and use of scientific knowledge, ideas and inquiry processes; guiding students in active and extended scientific inquiry; cooperative and collaborative learning experiences; focusing on real world situations; activities that are largely problem solving; and providing opportunities for scientific discussion and debate among students. The new syllabuses also have a strong emphasis on current scientific information and issues and require students to gather information from a range of sources, including the Internet. Given the limited amount of time available to students there is very little to be gained from having the students surf the Web looking for material. Therefore a structured and guided approach to the use of the Web is essential.

Using the Web to teach physics

The Institute of Physics journal, *Physics Education*, Volume 37(2), March 2002, contained a special feature: Untangling the Internet. The articles outlined ways in which the Internet can be used to enhance the teaching of physics. Some of the situations in which you might use the Internet are:

- where delivery of the topic via the Web enhances or extends the learning experience;
- to illustrate things that cannot be observed directly, e.g. the Photoelectric effect;
- to simulate practicals that are inaccessible to the students because of safety or availability of equipment, e.g. emission and absorption spectroscopy of gases such as lithium and mercury;
- where students need to gather information, have access to current (daily) scientific data (e.g. solar activity) and be aware of latest research and discoveries in physics; and
- facilitation of collaboration between teachers and students from different institutions.

A good interactive applet, projected onto a large screen, is an excellent stimulus for discussion (Clinch and Richards, 2002, p111). Students can be asked to predict what will happen, and then formulate an explanation for what is observed through the simulation. This activity could be combined with worksheets to be completed later. Alternatively, prepared worksheets could be used to direct their prediction, observation and encourage the explanations of the simulated phenomenon or experiment.

There are some sites set up specifically to assist physics students in gathering information e.g. Physics Central http://www.physicscentral.com/.

Sites that have short articles reporting the latest in physics research, discoveries and developments are *PhysicsWeb*, http://physicsweb.org/archive/news/ and *Physics News Update* from the American Institute of Physics, http://www.aip.org/physnews/update/.

WebQuests as a teaching and learning experience

A number of web-based teaching strategies have been developed by two American educators, Bernie Dodge and Tom March to ensure that students spend meaningful time accessing the Web. These strategies fall on a continuum from simple information retrieval through 'Treasure Hunts' to a constructivist approach in 'WebQuests'.

A WebQuest is an inquiry-oriented activity in which most or all of the information used by learners is drawn from the Web. WebQuests are designed for cooperative learning and peer assessment. The focus is on using information rather than looking for it, and supports student thinking at the levels of analysis, synthesis and evaluation. WebQuests give the students a clear well-defined task and suggested sites from which to gather information so that the students are not just surfing the Web. In addition, WebQuests not only satisfy the syllabus requirements, but also motivate the students.

To establish a WebQuest teachers do not need to possess any web authoring skills or to have access to a file server. What is crucial to a successful WebQuest is to identify a suitable topic which requires the learner to retrieve relevant material (primarily from the Web) and construct new knowledge in response to a statement, question or challenge or from a particular bias. WebQuests should target those topics where the Web provides the most current information (often not found in textbooks), specific applications and/or conflicting views on the topic. Identification of a suitable topic that satisfies the goals of WebQuests can be challenging. Incorporation of role-play into a WebQuest can encourage the cooperative learning that forms an integral part of a WebQuest.

Having decided on a suitable topic and approach, check that a suitable WebQuest is not already available. If not, then identify web sites that will provide the necessary information in order to achieve the desired outcome. Identify the various aspects of the overall topic and the possible roles that may be taken by participants and the interaction between the roles. Another important consideration is how to present the challenge in a novel but meaningful way.

Web sites such as Filamentality (http://www.kn.pacbell.com/wired/fil/) have been established to help educators create their own WebQuests and to host the resources developed. Care should be taken to maintain any WebQuest that you produce, checking for the currency of web sites, as periodic culling is carried out to remove out-of-date and poorly maintained WebQuests.

To achieve efficiency and clarity of purpose, WebQuests should contain at least the following parts:
- an introduction that sets the stage and provides some background information;
- a task where the outcome is achievable and interesting;
- a set of information sources needed to complete the task;
- a description of the process the learners should go through in accomplishing the task;
- some guidance on how to organize the information acquired; and
- a conclusion that brings closure to the quest, reminds the learners about what they've learned, and perhaps encourages them to extend the experience into other domains.

These features have been built into the template that is provided by Filamentality.

Our WebQuests

In the syllabus topic From Ideas to Implementation (9.4), students are required to address two physical phenomena that are having increasing impact in our daily life. These are:
- semiconductors (limitations of past technologies and increased research into the structure of the atom resulted in the invention of transistors); and
- superconductors (investigations into the electrical properties of particular metals at different temperatures led to the identification of superconductivity and the exploration of possible applications).

Both of these topics (semiconductors and superconductors) require considerable background information before the student can appreciate the effect they are having on our everyday lives. While much of this background information can be found in school textbooks, the topic can be greatly enhanced by the graphics, interactive multimedia and applets on this topic available on the Web.

In order to meet the requirements of these first syllabus items, **semiconductors and transistors**, students will have to find for themselves information on some or all of the following subtopics:
- Describe the difference between energy levels and energy bands;
- Compare and contrast the electrical properties of conductors, insulators and semiconductors;
- Describe what is meant by a 'hole' and outline its properties;
- Describe how the behaviour of semiconductors depends on density of electrons or holes;
- Identify and explain the use of germanium in early semiconductor devices;
- Describe how doping a semiconductor changes its electrical properties;
- Identify differences between p-type and n-type semiconductors;
- Describe the operation and electrical properties of a p-n junction;
- Describe the operation and the general electrical properties of an n-p-n and a p-n-p junction;
- Describe some of the various kinds of transistors that are available today;
- Describe the construction of integrated circuits and microchips;
- Investigate the rectification of an oscillating electrical signal and how it is performed by a p-n junction;
- Investigate the amplification of an electrical signal and how it is performed by a transistor;
- Investigate the modulation of an electrical signal and how it is performed by a transistor;
- Investigate the digitization of an electrical signal and how it is performed by a transistor;
- Describe thermionic emission and the construction a radio valve;
- Describe how thermionic devices can be used to perform the above four signal processing functions; and
- Compare and contrast the efficiency of thermionic and solid-state devices in terms of size, speed, energy usage and cost.

The students are also required to "identify data sources, gather, process, analyse information and use available evidence to assess the impact of the invention of the transistor on society with particular reference to their use in microchips and microprocessors".

This makes the content related to semiconductors as identified in the syllabus an ideal topic to be organized into a WebQuest.

The WebQuest that has been developed by UniServe Science is entitled "Semiconductors and Modern Living" and can be found at http://science.uniserve.edu.au/school/quests/semiwq.html. Rather than dividing the information to be collected on possible role-plays, this WebQuest addresses three main areas for consideration – what is a semiconductor, what is a transistor and the impact the transistor on many aspects of our daily life, these includes: music recording and performance; movies, videos and DVDs; computers; information technology and the Internet; and devices which emit and absorb light. Finally it is suggested that students view movies from different time periods to examine evidences for changes in lifestyle attributed to the technological areas investigated by the WebQuest.

A second WebQuest which covers the topic of Superconductors (http://science.uniserve.edu.au/school/quests/superwq.html) covers the background information needed by the students to satisfy the requirements of the syllabus. Students then address the applications of superconductors in scientific occupations (role play) such as:

- medical researcher (covering SQUIDs and medical imaging);
- transport engineer (Maglev trains);
- computer science engineers (supercomputers);
- power generation and storage engineers; and
- geoscientist and space scientist.

Having identified suitable web sites and the focus to be addressed by participants in the group, using a resource such as 'Filamentality', web sites can be easily assigned to roles or tasks. Some web sites may be allocated for study by all groups; others might be confined to a particular task or focus. The solution to the overall task is achieved by collaboration and cooperation between all members each now a specialist in their own field of research.

Having prepared a WebQuest, the information gathered and entered into *Filamentality* can easily be transformed into a Treasure Hunt which might be used for revision purposes, or if time is limited. With a web-based treasure hunt, students are provided with a fixed number of questions and a single web site that will provide the answer. The student must access the site and analyse the information in order to obtain the solution. This might involve some calculations based on information given on a site, or a response based on accessing an online simulation.

Conclusion

The preparation of effective web-based learning activities such as WebQuests is challenging and time consuming. However, tools are available to facilitate the procedure and web access is available to ensure schools can make use of these resources.

To support these WebQuests, UniServe Science has also established two new pages for Physics teachers, one of which provides access to relevant Applets and interactive physics resources and some ideas for using data loggers in the classroom.

References

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Hammond, R. (2002) Using the Internet to teach physics, *Physics Education,* **37**(2), 115-117.

Hannam, N. and Wilde, J. (2002) Physics.org - a window to the web, *Physics Education*, **37**(2), 122-127.

Yore, L. (2001) What is meant by constructivist science teaching and will the science education community stay the course for meaningful reform? *Electronic Journal of Science Education,* **5**(4) http://unr.edu/homepage/crowther/ejse/yore.html

Web sites for physics applets

Web address	Title	Syllabus reference
http://www.colorado.edu/physics/2000/waves_particles/wavpart3.html	Electric field due to point charges	8.3 Electrical Energy in the Home
http://vsg.quasihome.com/interf.htm	Young's slits simulation using variable wavelengths	8.2 The World Communicates
http://physics.berea.edu/~king/Teaching/ModPhys/QM/Photoelectric/Photoelectric.html	The Photoelectric Effect	9.4 From Ideas to Implementation
http://home.a-city.de/walter.fendt/phe/phe.htm	The Photoelectric Effect	9.4 From Ideas to Implementation

Physics web sites

Web address	Title	Syllabus reference
http://www.Colorado.EDU/physics/2000/index.pl	Physics 2000	various
http://www.exploratorium.edu/observatory/	The Observatory (includes Auroras: Paintings in the Sky, Solar Max and Sunspots)	9.2 Space
http://particleadventure.org/particleadventure/	The Particle Adventure	9.8 From Quanta to Quarks
http://www.glenbrook.k12.il.us/gbssci/phys/Class/BBoard.html	The Physics Classroom	various
http://amazing-space.stsci.edu/	Amazing Space	9.7 Astrophysics
http://www.explorelearning.com/	Explore Learning – experience math and science with gizmos	various
http://www.kie.berkeley.edu/KIE/web/hf.html	How far does light go? Debate	8.2 The World Communicates
http://education.nasa.gov/	NASA Education	9.2 Space 9.7 Astrophysics 8.5 The Cosmic Engine
http://teachspacescience.stsci.edu/cgi-bin/ssrtop.plex	Space Science Education Resource Directory	9.2 Space 9.7 Astrophysics 8.5 The Cosmic Engine

Information about WebQuests

Web address	Title	Comments
http://science.uniserve.edu.au/school/tutes/webquest/	WebQuests - A Web-based Tool for Teachers	Tutorial developed by UniServe Science
http://www.ozline.com/	Ozline	
http://edweb.sdsu.edu/webquest/webquest.html	The WebQuest Page	
http://www.kn.pacbell.com/wired/fil/	Filamentality	
http://www.edhelper.com/cat246.htm#wq	More Science WebQuests from edhelper.com	
http://209.15.142.32/cat246_more_webquests.htm	More Science	
http://www.glencoe.com/sec/science/webquest/	WebQuest Science	click on activities to activate menu

Physics WebQuests

Web address	Title	Syllabus reference
http://www.esc20.net/etprojects/formats/webquests/summer99/northside/margaretquest.html/default.html	A Star's Life	Stages 4 - 5
http://www.lfelem.lfc.edu/tech/DuBose/webquest/pictor/space.html	Are We Ready for Life in Space?	Stages 4 - 5
http://www.esc20.net/etprojects/formats/webquests/misc99/ASTEROIDS/Default.htm	"Deep Impact" Can It Really Happen?	
http://education.nmsu.edu/webquest/wq/blackhole_webquest/hole5.html	Blackholes: Journey into the Unknown	9.7 Astrophysics
http://powayusd.sdcoe.k12.ca.us/projects/NUKEWEB/default.htm	Nuclear power in seaside	
http://can-do.com/uci/lessons99/skateboard.html	The Physics of Skateboarding	8.4 Moving About
http://www.glencoe.com/sec/science/webquest/content/rollercoast.shtml	Roller Coaster Physics	8.4 Moving About
http://www.glencoe.com/sec/science/webquest/content/maglevtrains.shtml	Mag Lev Trains: Floating Locomotives	9.4 From Ideas to Implementation
http://btc.montana.edu/ceres/html/disks1.html	Searching for Proplanetary Disks	8.5 The Cosmic Engine 9.7 Astrophysics
http://oncampus.richmond.edu/academics/education/projects/webquests/mars/	Human Life on Mars: What's it like?	Stages 4 – 5
http://oncampus.richmond.edu/academics/education/projects/webquests/space/	Let's Build a City in the Solar System	Stages 4 – 5
http://www.mhcbe.ab.ca/ict/Projects/technology_files/technology.htm	Impact of Technology (microchip and genetic engineering)	Stages 4 – 5

Constructivism and science teaching on the Web

Web address	Title
http://www.miamisci.org/ph/lpintro5e.html	Constructivism and the Five E's
http://umperg.physics.umass.edu/perspective/constructivism	A Constructivist View of Science Education
http://www.caosclub.org/constructivism.html	The Constructivist Theory of Instruction
http://www.physics.umd.edu/rgroups/ripe/papers/millikan.htm	Millikan Award Lecture (1998): Building a Science of Teaching Physics
http://www.if.ufrgs.br/public/ensino/N1/3artigo.htm	The Constructivist View In Science Education -- What It Has To Offer And What Should Not Be Expected From It
http://www.exploratorium.edu/IFI/resources/research/constructivism.html	Constructivism as a Referent for Science Teaching
http://unr.edu/homepage/jcannon/ejse/mcdermott.html	How we teach and how students learn — A mismatch?
http://pixel.cs.vt.edu/edu/fis/techcons.html	School Reform: What Role can Technology Play in a Constructivist Setting?