

Stage 6: web-based references and resources

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Introduction

The introduction of five new Senior Science syllabuses has presented classroom teachers with a number of challenges. Firstly, teachers are being asked to teach physics content not covered in the previous syllabus, and some of this content is not readily available in traditional textbooks. Secondly, they are being asked to teach the material in a different way.

Within the Physics syllabus, covering the Prescribed Focus Areas: history of physics; nature and practice of physics; application and uses in physics; implications of physics for society and the environment; and current issues, research and developments in physics, will require some alternative teaching strategies.

This paper will: give an overview of alternative teaching strategies which teachers might employ to deliver the new syllabuses; give a summary of on-line resources that UniServe Science has identified for use within the new stage 6 syllabuses; and look at resources of particular interest to physics.

Learning Styles

Recent research on how learning occurs has found that knowledge is a constructed entity – i.e. it cannot be transmitted. People learn best when they actively construct their own understanding, building on existing knowledge. In addition, learning is affected by the beliefs and attitudes of the student and the context in which the learning activity takes place. Hence learning should be viewed as a process.

Researchers have also identified a variety of learners each with a different learning style, such as:

- visualisers;
- verbalisers – those who learn by explaining;
- questioners;
- socialisers – those who learn by discussing; and
- listeners.

These research findings have led to a new approach to teaching and learning termed *Constructivism* in which the emphasis is on the student. Material is presented in a variety of ways, acknowledging that students' learning styles differ. Students need to see a reason for learning hence new learning experiences should be real world situations. To build on existing knowledge the student must be able to relate to the presented material. When assessing learning the emphasis is on performance and understanding. Experience plays a critical role in learning so students are encouraged to inquire, explore, experiment and discover. Learners are encouraged to engage in dialogue with other students and the teacher because when we explain and discuss an issue we are much more likely to understand it. Students are encouraged to work together thus supporting cooperative learning.

Some of the features to be found in a constructivist classroom might be:

- the curriculum is presented with an overview followed by topics with the emphasis on big concepts;
- pursuit of student questions is highly valued;
- activities rely heavily on primary sources of data and manipulative materials;
- students are viewed as thinkers with emerging theories about the world;
- teachers generally behave in an interactive manner, mediating the environment for students;
- teachers seek the students' points of view in order to understand students' present conceptions for use in subsequent lessons;
- assessment of student learning is interwoven with teaching and occurs through teacher observations of students at work and through student exhibitions and portfolios;
- students primarily work in groups;
- cognitive terminology such as "classify", "analyse", "predict" and "create" is used when framing tasks;
- student responses are allowed to drive lessons, shift the teacher's instructional strategy and alter content;
- students are encouraged to engage in dialogue, both with the teacher and with one another;
- student inquiry is encouraged by the teacher asking thoughtful, open-ended questions and encouraging students to ask questions of each other;

- students are encouraged to elaborate on their initial responses;
- teachers engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion;
- teachers allow wait time after posing questions; and
- the students natural curiosity is nurtured through frequent use of the learning cycle model (i.e. discovery, concept introduction and concept application).

Now, we hear you all say, "that's wonderful, but ...". The learning environment described above would certainly be a stimulating, challenging situation for our students. However, as we all know our learning environments are not ideal as we are faced with constraints such as: timetables; imperfect locations; limited resources; and preparation for examinations. Consequently what we are faced with is a compromise, *controlled constructivism*. Do not despair, there are still many interesting teaching strategies which can be introduced to assist in the delivery of the new syllabuses.

Alternative Strategies

The Web is an excellent resource for exploring many of the alternative strategies that are being implemented in the constructivist classroom. Here we will explore some of those strategies which we feel may be applied to the physics syllabus and in particular the module "From Ideas to Implementation". For a more comprehensive coverage of alternative strategies in all areas of science, visit our web page at <http://science.uniserve.edu.au/school/support/strategy.html>

WebQuests

WebQuests provide a web-based constructivist learning environment. WebQuests are characterised by cooperative learning, higher-order thinking, critical thinking and the integration of technology through the use of the Web. WebQuests can be constructed easily using the on-line facility, Filamentality, from Pacific Bell's web page (<http://www.kn.pacbell.com/wired/fil/>) and the web page created is hosted on their web site. While the WebQuest is the most appropriate resource to support the constructivist learning environment, simpler resources such as Hot Lists and Treasure Hunts can also be developed using this tool. A range of such resources relating to Einstein and his work have been developed and are available from <http://www.kn.pacbell.com/search> and search on 'Einstein'. These also provide a good starting point when searching for suitable resources.

A WebQuest consists of:

- a problem or question;
WebQuests use a central question that honestly needs answering. When students are asked to understand, hypothesize or problem-solve an issue that confronts the real world, they face an authentic task, not something that only carries meaning in a school classroom. Although you can't count on getting a response, when students do receive feedback from someone they didn't previously know, they join a community of learners and have their presence, if not their contribution, validated. When teachers choose a topic they know their students would respond to, they add to the relevance. (March)
- a set of resources;
The second feature of WebQuests that increases student motivation is that students are given real resources to work with. Rather than turn to a dated textbook, filtered encyclopedias or middle-of-the-road magazines, with the Web students can directly access individual experts, searchable databases, current reporting, and even fringe groups to gather their insights. (March)
- group work; and
When students take on roles within a cooperative group, they must develop expertise on a particular aspect or perspective of the topic. That their teammates count on them to bring back real expertise should inspire and motivate learning. (March)
- peer assessment.
Lastly, the answer or solution the student teams develop can be posted, emailed or presented to real people for feedback and evaluation. This authentic assessment also motivates students to do their best and come up with a real group answer, not simply something to fulfill an assignment. (March)

A suitable question for such a WebQuest might be: Which of the following theories, discoveries or developments has been the most significant for physics today: an understanding of cathode rays; the reconceptualising of the model of light; the inventions of the transistor; or the identification of superconductivity. Students would need to research much of the content of the module "From Ideas to Implementation" and develop a deep enough understanding to support the theory, discovery or development that they identify as being the most significant. Students would work in cooperative groups that involve assuming roles such as the researcher, the developer and the consumer.

Posters

The poster has become one of the most important types of scientific communication at societal meetings and scientific conferences. The power of the poster is that the communicants can directly discuss their data and interpretations one-on-one or in a small group atmosphere. The feedback generated during these discussions generally proves to be more useful than the feedback in question and answer sessions following the more traditional slide presentations. The data and data analyses are visually available in a

well developed local flow in a poster presentation. Indeed the poster format or some similar format will probably become the most useful layout for electronic presentations through the "net".

Generally, scientific posters are the product of group efforts from individual laboratories or often from collegial interactions among research laboratories. In keeping with the team approach so common to the modern sciences, we have developed a cooperative learning experience in which a group of students research a topic, design posters and orally defend their presentations before students and faculty. (Fournier, Bisson and Loretz, 1999)

Posters as a form of scientific communication would be particularly suited to *gather*, *process* and *present* information on the following topics from within "From Ideas to Implementation": breathalysers; solar cells; photocells; maglev trains; photocopiers; lightning conductors; superconductors; applications of cathode ray oscilloscopes; and transistors.

Vee Diagrams

A Vee map guides students through investigations that they choose themselves. This less-structured investigative arrangement allows students to actively learn the principles of investigation. The Vee map helps students to better organize their thinking, investigate more efficiently, and create guidelines for learning.

The left and right sides of the Vee emphasize two interdependent aspects of science learning: knowing and doing, respectively. What students know at any one moment – their existing conceptions, the investigative tools available to them, and their ideas – will determine the quality and quantity of the questions they ask. Conversely, the answers students obtain to their questions will affect what they know, by changing, adding to, refining, or reconfiguring their knowledge. The Vee should lead students to discover the relationship between doing and knowing science.

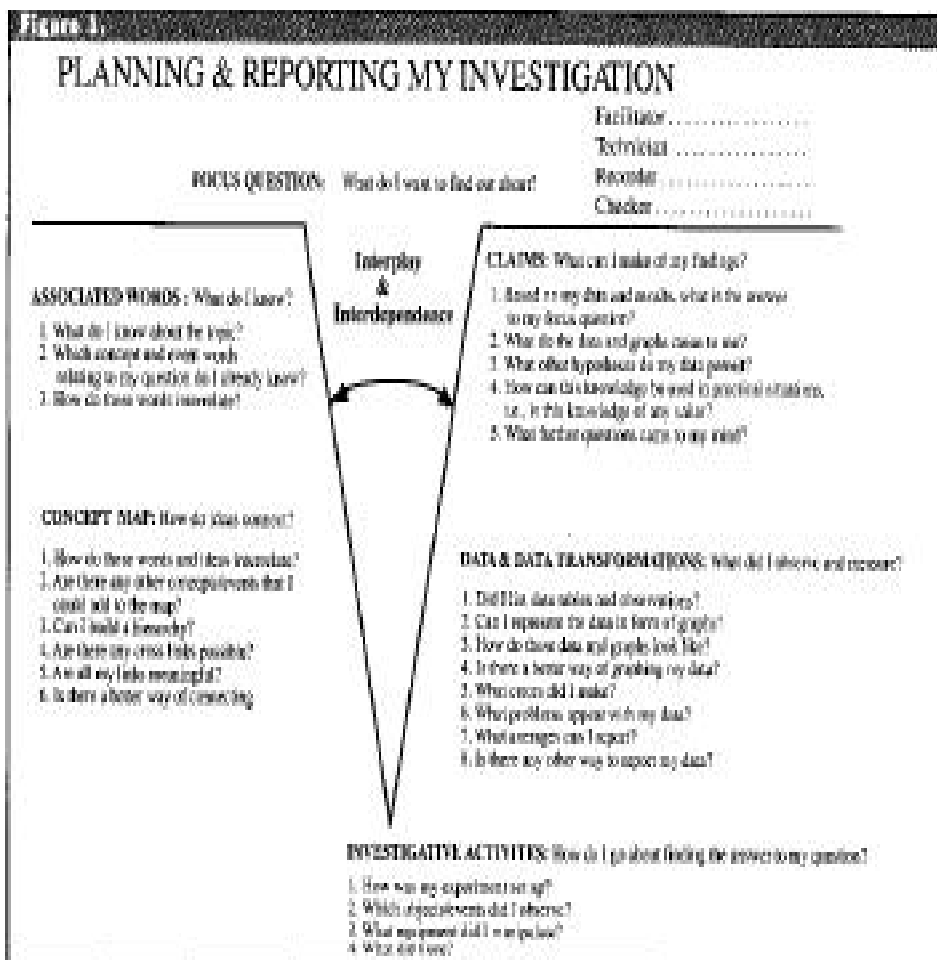


Figure 1. A Vee diagram for planning and reporting an investigation

The following six questions lead students through the discovery process, guiding them toward what they need to think about in order to complete their investigation:

1. The focus question is "What do I want to find out about?"
2. "What do I know about the topic?" elicits associated words.

3. "How do I go about finding the answer to my question?" inspires thinking about investigative activities.
4. "What did I observe and measure?" solicits the appropriate data and data transformations to provide meaningful records.
5. "What can I make of my findings?" inspires students to make claims in terms of the knowledge obtained and its value.
6. "How do the concepts and events interrelate?" encourages students to construct a concept map.

The six guiding questions encourage students to reflect in an orderly manner, providing them with a sort of road map toward new knowledge. Supporting questions to each of the six major headings encourage students to consider the questions more specifically in the process of acquiring information to complete their maps. (Roth and Bowen, 1993)

In the "From Ideas to Implementation" module, students are required to "plan, choose equipment or resources for, and perform a first-hand investigation to observe the heating effects of current in a range of conductors". The guiding questions and the Vee diagram on "Planning and Reporting My Investigation" may assist the carrying out of this investigation.

Concept Maps

The use of concept maps as a teaching strategy was first developed by J. D. Novak of Cornell University in the early 1980s. It was derived from Ausubel's learning theory which places central emphasis on the influence of students' prior knowledge on subsequent meaningful learning. Meaningful learning results when a person consciously and explicitly ties new knowledge to relevant concepts they already possess. Ausubel suggests that when meaningful learning occurs, it produces a series of changes within our entire cognitive structure, modifying existing concepts and forming new linkages between concepts. This is why meaningful learning is lasting and powerful whereas rote learning is easily forgotten and not easily applied in new learning or problem solving situations.

The Concept Map is a device for representing the conceptual structure of a topic in a two dimensional form which is analogous to a road map. Concept maps are diagrammatic representations which show meaningful relationships between concepts in the form of propositions. Propositions are two or more concept labels linked by words which provide information on relationships or describing connections between concepts.

In the teaching and learning of science, concepts do not exist in isolation. Each concept depends on its relationships to many others for meaning. A concept map depicts hierarchy and relationships among concepts. The concept map construction process requires one to think in multiple directions and to switch back and forth between different levels of abstraction. In attempting to identify the key and associated concepts of a particular topic or sub-topic, one will usually acquire a deeper understanding of the topic and clarification of any prior misconceptions.

One big advantage of using concept maps is that it provides a visual image of the concepts under study. They can be readily revised any time when necessary. During the formulation process it consolidates a concrete and precise understanding of the meanings and inter-relations of concepts. Thus it makes learning an active process, not a passive one. In presenting concepts to students, teachers should never ask students to memorize prepared concept maps. This could merely promote rote learning and so defeat the purpose of encouraging active meaningful learning on the part of the learner. Concept maps may be used to: teach a topic; reinforce understanding; and check learning and identify misconceptions.

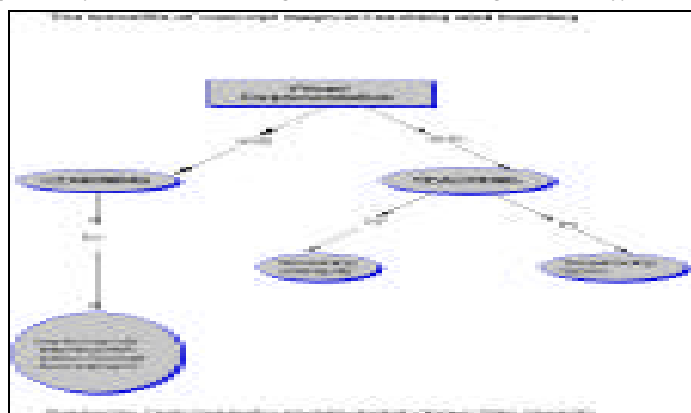


Figure 2. The benefits of concept maps in teaching and learning



Figure 3. Concept mapping process



Figure 4. A concept map for Atoms/Orbitals

Debates

“How Far Does Light Go?” is a debate project which engages students in an examination of the scientific properties of light by engaging them with relevant evidence from the Web. It culminates in an informal classroom debate where groups present their arguments about how far light goes and respond to questions from other students. The project takes approximately six fifty-minute periods to complete with 30 students as it is described here.

This project has been used in middle and high school physical science classes. It works very well as a culminating project where students have spent significant time learning about various properties of light through previous instruction. The resources for the debate can be accessed from <http://www.kie.berkeley.edu/KIE/web/hf-description.html>

One debate that is specifically referred to within this module is the one between Planck and Einstein about whether science research is removed from social and political forces. Although it has proved difficult to find references to this particular debate, there are many sources on the Web for papers, articles and quotations by Einstein: students may benefit by trying to establish what Einstein may have argued.

Problem Based Learning

An essential component of problem based learning is that content is introduced in the context of complex real-world problems. This contrasts with prevalent teaching strategies where the concepts, presented in a “chalk and talk” format,

precede “end-of-the-chapter” problems. In problem based learning, students working in small groups must identify what they know, and more importantly, what they don't know and must learn to solve a problem. Students must go beyond their textbooks to pursue knowledge in other resources in between their group meetings. The primary role of the instructor is to facilitate group process and learning, not to provide easy answers. PBL encourages students to take charge of their education. It emphasizes critical thinking skills, understanding, learning how to learn, and working cooperatively with others. While not directly related to the modules “From Ideas to Implementation”, there are a number of web-based physics examples. These include: OVERLOAD <http://www.udel.edu/pbl/overload.html> and Lights Out! <http://www.physics.udel.edu/wwwusers/watson/phys345/lab/flashlight.html>

Applets and Interactive Simulations

Physics is well catered for on the Web with applets and other interactive simulations. Two of particular use with this module are shown in Figure 5. They are the Oscilloscope at <http://plabpc.csustan.edu/general/Tutorials/EM/Oscilloscope/Oscilloscope.htm> and the Photoelectric effect by Phillip Warner at <http://wigner.byu.edu/Photoelectric/Photoelectric.html>.

The Photoelectric applet is a simple applet that allows the user to explore the photoelectric effect of fourteen different metals including potassium, cesium, platinum under varying light intensities and wavelengths.

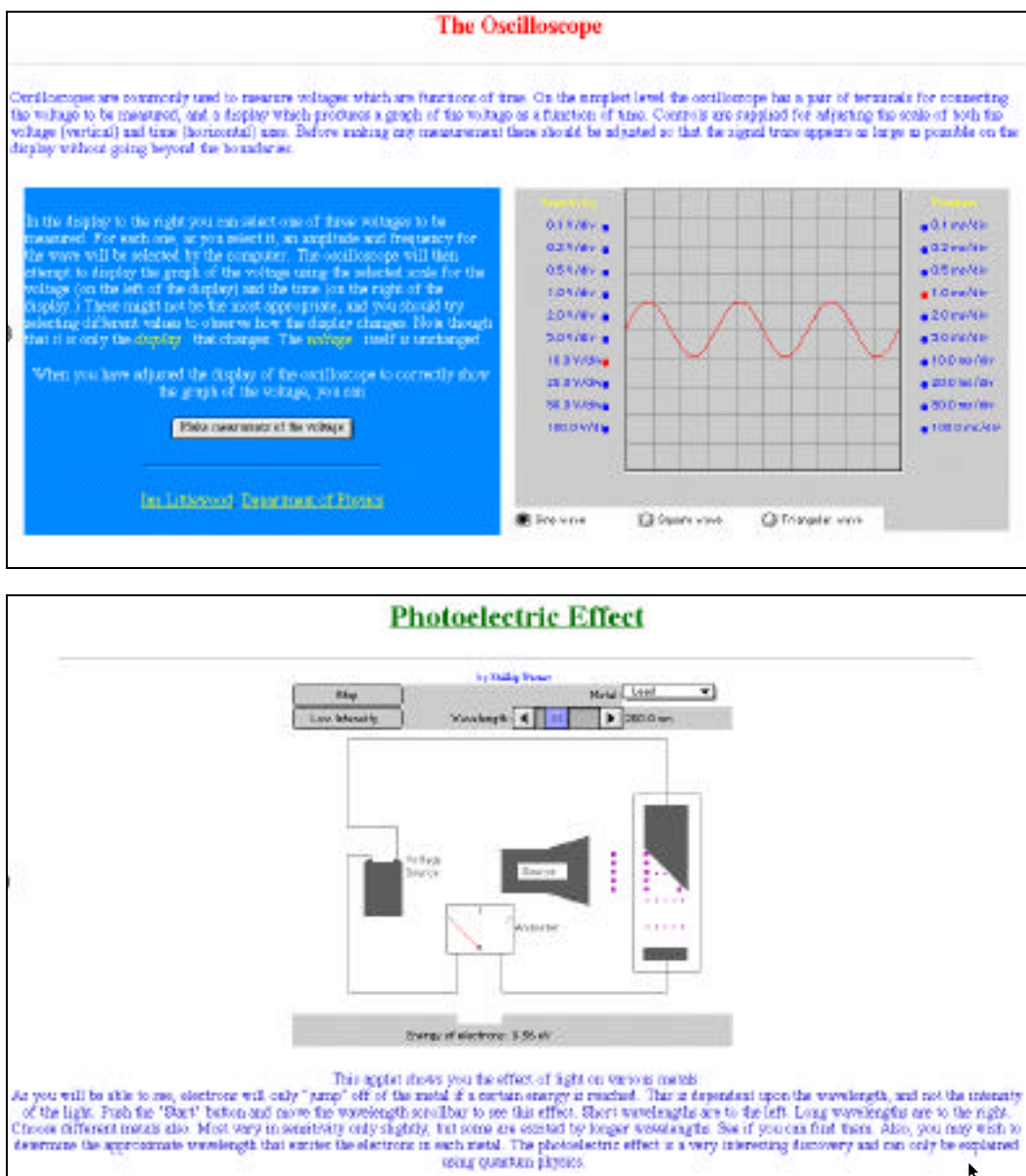


Figure 5. Screen images from useful physics applets

On-line resources for Stage 6 Physics

UniServe Science is building up an on-line list of resources <http://science.uniserve.edu.au/> that may be used to provide science teachers with ideas for activities that can be used in today's constructivist learning environments. While sourcing this material we are ever mindful of the Prescribed Focus Areas and required course outcomes as documented within each science syllabus.

These resources are selected on the basis of being, wherever possible, an interactive resource that provides the classroom teacher with a resource that supplements the textbook and laboratory exercises.

Our aim is to prepare a web page for each of the modules in each of the new senior science syllabuses. This is an enormous task so we are concentrating on those that have been identified as modules that contain substantial new content areas or for which it is difficult to find resources. Also, initially we will concentrate on those option topics which we feel will attract a larger candidature.

These pages will be accompanied by a web page identifying appropriate computer software that covers material within the particular syllabus.

We welcome contributions from classroom teachers in identifying useful web sites and software.

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