experiments that caused animals to suffer. Breaking this law exposed a person to possible imprisonment in a concentration camp.

Biology (and particularly genetics) and biologists played a fundamental role in Nazi Germany, with more than 60% of German biologists being members of the Nazi party. Fritz Lenz, a German human geneticist, even proclaimed Nazism to be "applied biology." What is more, United States biologists also found Nazism appealing. William Hueper, the "Father of American Occupational Cancer," applied for a position in the Reich. It is background such as this that must surely have influenced present scientific research policies, such as the need to obtain voluntary and informed consent before experimentation involving humans.

Source: Moore, R., Jensen, M., Hsu, L., & Hatch, J. (2003). Lessons of history: Ethics & the public's views of science & society. *The American Biology Teacher*, *65*, 85-89.

Using WebQuests to Successfully Engage Students in Learning Science

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Abstract

WebQuests are a powerful teaching and learning device that have developed rapidly in recent years, especially in the Humanities. In Australia, the use of WebQuests in Science has become popular. The multimedia product of students' investigations can be shared with a variety of audiences. In this article, I will explain what I understand to be a WebQuest, how I have used it to engage students in their own learning, and the important lesson that introducing WebQuests has re-taught me.

Introduction

WebQuests were first developed in the United States by Bernie Dodge and Tom March, have been used extensively there, and are now becoming popular in Australia. Teachers of humanities have been the central proponents of this approach, but it also offers much to science teachers, especially those who wish to engage their students in a critically constructive manner. Students are required to engage in an investigation of particular phenomena and to prepare a multimedia report to share with a designated audience. In this article, I will describe what I believe a WebQuest is, some of the background epistemology, and examples of how I have recently used the WebQuest in my own teaching.

What are WebQuests?

WebQuests are student-centred activities that use the Internet as the major source of information to support student investigation, which is usually carried out in small groups. I use groups of 2 or 3 students, because psychologists tell us that a phenomenon called social loafing occurs in groups any larger than three. Each WebQuest has six essential components, and these are now described.

1. There is an **introduction**, which explains clearly and concisely what the WebQuest is about and hopefully inspires students to action. For example, in my Good Nutrition WebQuest for Year 10 (16-year-old) students, developed to focus their exploration of the human digestive system and nutrient requirements, the following statement is used:

> Welcome to our WebQuest. In this activity, you will be required to investigate practices of diet and exercise that promote good nutrition in humans in order to respond to the following statement: "Western Society's obsession with body image threatens the long-term health of individuals and the species." You will need to present your findings in a way that can be shared with the class, school, and/or school community.

2. The **task** is then set out. It relates directly to the introduction, and describes and explains precisely what is required of each student. This may take the form of a focus question that defines the task, followed by a series of activities to be completed. Students receive, or can download, all the appropriate files as they require them. For example, for my Year 10 Motion WebQuest, I use the following:

> Your task is to complete the following activities with your partner(s), and to present a multimedia report that includes answers to the questions asked. Groups may have either 2 or 3 members--no more!
>
> *Experiment 1:* Interpreting Ticker Timers
> *Experiment 2:* Measuring Speed
> *Experiment 3:* Measuring Acceleration
> *Experiment 4:* Reaction Times
> *Science in Action:* SONAR: The Sight of Sound
> *Science in Action:* What Goes up . . .
> *Activity 1:* Blood Alcohol Content
> *Activity 2:* Alcohol and Driving
> *Question Sheet 1:* Velocity
> *Question Sheet 2:* Acceleration
> *Question Sheet 3:* Motion Pictures
> *Question Sheet 4:* Newton's Laws

Your report must be produced using a variety of information and communication technologies (e.g., MS Word, MS Excel, MS Publisher, MS FrontPage, MS PowerPoint, and PhotoShop) and be e-mailed to me at simpg@woodleigh.vic.edu.au . The concepts that must be explored in your report are Newton's First Law of Motion, Newton's Second Law of Motion, Newton's Third Law of Motion, speed, average speed, acceleration, velocity, force, momentum, friction, gravity, inertia, reaction time, reaction distance, stopping distance, and the effect of alcohol on stopping distance.

3. Students are given a list of **resources**, primarily from the Internet, that can be used to successfully complete the activities listed in the task. The teacher has already found the appropriate sites to inform the various questions the student will need to answer. In this way, it is possible for the students to be sheltered from inappropriate sites on the Internet and to be more successful in searching for information. In the case of my Motion WebQuest, the students received the following information:

Background Information
How Stuff Works (http://www.howstuffworks.com/), an excellent site for inventions such as how clocks work.
Beakman & Jax & Levers (http://www.beakman.com/lever/lever.html), an excellent site for students and teachers about levers. Simple language and good diagrams.
ParkPhysics (http://www.learner.org/exhibits/parkphysics), an excellent site exploring Newton's three laws of motion in relation to amusement park rides.
Johnston's Homepage (http://www.qnet.com/~johnston/index.html), a gory site, not for the faint-hearted. This page discusses the effects of car accidents on the victims, their families, and the cars.

Current News
Physics Gateway (http://www.psigate.ac.uk/ROADS?subject-listing/physics/num-physics.html), a search engine for physics websites.

Search/Resources
Physics Hot List (http://www.kn.pacbel.com/wired/fil/pages/listphysicsva.html), a WebQuest created by Deakin University students.

References
Hypertext Webster Dictionary (http://work.ucsd.edu:5141/cgi-bin/http_webster)
Roget's Internet Thesaurus (http://www2.thesaurus.com/thesaurus)

Grabbing Web Images
(http://www.kn.pacbell.com/wired/beyond/grabweb.html)

4. The **process** students should follow to successfully complete the task is laid out step by step. This gives them a strong framework to follow, so that all students should be able to complete the activities successfully. My Good Nutrition WebQuest offers a good example:

Select your partner(s).
a. Discuss the work to be completed and prepare a plan of action.
b. What questions will each of the members investigate?
c. Check out the websites listed in the reference section for helpful information.
d. Check out the Web. When you find something you like, check the Web page for a copyright notice. Often, students are encouraged to copy things that will be used in the classroom. Sometimes people don't want their work copied at all. A good practice is to look for an e-mail link on the page and then use it to ask for permission.
e. Copy any text you want.
f. Save any images you like by downloading them.
g. Be prepared to omit anything that copyright owners tell you they don't want you to have.
h. Now you have your information, you will need to sort through it. Ask yourself the following questions:
  i) Do I have enough information on each of the questions listed above?
  ii) Do I have images that will help me explain these things in my multimedia report?
  iii) Have I collected all the bibliographical details of the sites I've used, and books that I've used, for my reference list?
i. If you have answered *yes*, go to step k.
j. If you answered *no*, go back to step a. What will you need to do to complete this project successfully?
k. Prepare your multimedia report.
E-mail or present your report by the Due Date.

5. Students are supplied with an **evaluation rubric**. This ensures they are fully aware of how they will be assessed, and on what basis. I am still developing my application of these. Figure 1 provides a rubric that I am developing, with a colleague, for a Year 10 Future Space Travel WebQuest. This WebQuest invites students to question how science and technology are used by society to achieve the particular ends of the society. It is an attempt to cause students to explore the ethical dimension of the use of scientific knowledge. Each piece of work is assessed for achievement on all criteria listed in the rubric. The criteria provided address the attributes of students'

multimedia product only, but could be extended to include their presentation to an audience.

Criterion	Beginning	Developing	Accomplished	Exemplary
Explanation of concepts	The report contains answers to the questions listed in the task description.	The report contains complete answers to the questions listed in the task description.	The report contains detailed and complete answers to the questions listed in the task description.	The report contains richly detailed and thorough answers to the questions listed in the task description.
Use of inquiry scientific	The process of scientific inquiry has been used to investigate our future world.	The process of scientific inquiry has been used to effectively investigate our future world.	The process of scientific inquiry has been used thoughtfully to investigate our future world.	The process of scientific inquiry has been used thoroughly to investigate our future world.
Use of reasoning and logic	Scientific reasoning has been used to investigate our future world.	Scientific reasoning has been used effectively to investigate our future world.	Scientific reasoning has been used thoughtfully to investigate our future world.	Scientific reasoning has been used thoroughly to investigate our future world.
Use of scientific language	The student has used scientific language to communicate what they understand about our future world in a simple manner.	The student has accurately used scientific language to communicate what they understand about our future world in a simple manner.	The student has used detailed scientific language to communicate what they understand about our future world in an accurate manner.	The student has used richly detailed scientific language to communicate what they understand about our future world in an effective manner.
Statement of values	The student has stated a straightforward viewpoint that displays a view of the role of science and technology in our society.	The student has stated a detailed viewpoint that displays a view of the role of science and technology in our society.	The student has stated a thoughtful viewpoint that displays a detailed view of the role of science and technology in our society.	The student has stated a complex viewpoint that displays a richly detailed view of the role of science and technology in our society.

Figure 1. Evaluation rubric for a Future Space Travel WebQuest.

6. In addition to sharing their mutimedia reports with the class, school (e.g., peer-selected best work presented at an assembly), or the broader community, the quest is brought to a close with a **conclusion** that challenges learners to act upon what they have achieved. For example, following the Good Nutrition WebQuest and follow-up work on the human circulatory and respiratory systems, I asked students to consider how they might promote the work of the Heart Foundation. They have negotiated,

and are presently organising, a Dance-A-Thon. The idea is to raise awareness of how to keep a healthy heart, promote the work of the Heart Foundation, and raise money for this Foundation.

There are many WebQuests on the Web that deal with political, social, and environmental issues and inspire students to take a position and act upon that position. A quick Web search will uncover some great examples, with the Queensland University of Technology hosting an excellent teacher resource at http://rite.ed.qut.edu.au/oz-teachernet/projects/webquests/index.html .

Constructivist Post-Epistemology

This use of WebQuests is based upon the constructivist approach to learning. That is, learners create knowledge and understanding through meaningful and purposeful engagement with tacit and propositional objects, and this knowledge creation is mediated through social contact (i.e., communication with other students and their teacher). The WebQuests suit my own constructivist-inspired, student-centred learning approach, because they are so flexible. I am able to create a series of linked tasks which have enough direction and structure to assist students who require that, but which also allow more able independent students to negotiate their own path to the students' conclusion. Students who come to my class with a diverse range of learning style, learning ability, multiple intelligence, prior knowledge and experience, and personal enculturation (process by which one learns by engaging with one's culture) are able to share what they have and build upon these foundations in the way most appropriate to them.

WebQuests are excellent vehicles for engaging students with information and communication technologies, as students are able to use the Web to find information and share it, and deliver their completed work electronically. I require my students to use readily available programs such as Microsoft's PowerPoint, Front Page, Publisher, and Excel to complete their tasks and then e-mail them to me. Students are encouraged to use a multimedia format to explain what they have learned from the WebQuest, and to share this with their peers (as a minimum) and within the greater school community, as appropriate.

Webquests can also be used to answer a criticism of constructivism that it fails to consider ethics and values. Ernst von Glasersfeld (2000) did not intend the radical constructivism he developed to include a consideration of ethics and values but, with the move toward critical constructivism, this has become a concern (Lewin, 2000). Teachers and educational bureaucracies have become interested in the development of ethical positions by students, particularly in regard to the use of information in our society. With WebQuests, students can be required to respond to questions that focus on the appropriateness of the application of scientific and technological

developments in relation to, for example, the environment, genetics, or issues of social justice.

How I Have Used WebQuests

I must confess to being a self-taught novice. During 2002, a colleague showed me some work he had completed on a WebQuest following a professional development session he had attended. He encouraged me to look on the Web for some ideas for my own classes. The Web contains thousands of examples of WebQuests designed by teachers for all subjects and all sorts of topics. Most of them are free. The author of the WebQuest usually just requires that you acknowledge them as the original author. As little has been done in Science, and most are from the United States and not directly applicable to my Australian setting, I have adapted some I've found on the Web or just used the format and developed my own.

During the early part of 2003, I became concerned that my students and I were operating in a teacher-directed manner. As it is my first year in a new school, I had been getting to know both the students and the school's systems, so I had not been innovative in my teaching approach. Rather, I had been working with the materials in the form presented to me by the existing staff. I decided to prepare the WebQuests in reaction to my own disenchantment with the students' preference for a teacher-directed transmission model, and the students' apparent disengagement with learning Science. During the second term this year, I developed and used two WebQuests--one to investigate Newton's Laws of Motion for my two Year 10 classes (16-year-olds in their final year of compulsory secondary schooling) and the other to investigate cells and microscopes for my Year 7 class (13-year-olds in their first year of secondary schooling). I do not claim my work to be exemplary applications of the WebQuest approach, but rather offer some of it to exemplify this curriculum innovation. For the second semester (Terms 3 and 4), I have developed a Good Nutrition WebQuest and a Future Space Travel WebQuest for use with my two Year 10 Science classes.

The school has an Intranet powered by a product called "Learning Point," which allowed me to set up a folder for each of the WebQuests and associated tasks for students to access either in the class or from home. I booked eight notebook computers, for regular student use, from the school's notebook collection, and asked the Laboratory Technician to establish a trolley of experimental equipment for student use for each class. I explained what was required of the students, giving each of them a copy of the WebQuests and all the tasks, but not the supporting notes, which were available on the Intranet. It would also be possible to run a WebQuest-style project with limited access to computers. Having prepared all the materials in advance, one could give the students the materials either as required or as a booklet,

and either book computer time or require the computer component to be completed for homework.

The tasks were a collection of experiments to complete, some question-and-answer style assignments, and some research activities. I assisted students with planning their team's approach to the work, and set a timeframe for completion of all the tasks and submission of a final multimedia report. The students then set to work. During each class, they would choose what they needed to work on and I would move from group to group, encouraging them to engage with the concepts and helping students requiring assistance. In some classes, I gave short lectures on major concepts to ensure that all students had a few notes on the most important ideas. This was usually done in response to lots of questions about a particular concept highlighting a need to intervene and direct the students' knowledge-making.

Ramifications for my Teaching

Student responses to the WebQuests reflected the commonly experienced phenomenon that conceptual change takes time. Not only did I ask students to question their prior constructions of motion (Year 10) and the cellular basis of life (Year 7), but I also required them to question their deeply-encultured construction of the teaching and learning process. In conversation, the Year 10 students described a difficulty with the WebQuest approach, feeling that I did not explain enough to them. In contrast, the Year 7 students expressed satisfaction with the amount of teacher direction and responded to questioning that they preferred the freedom to choose what they were doing.

As the teacher, I was satisfied with the manner in which the students responded to the challenges of the WebQuest approach. I was also quite surprised by the response of the Year 10 students, as they were their most productive and most engaged during the semester when working with the WebQuest. The experience has reminded me that I must hasten slowly to achieve conceptual change and pedagogical change. Vygotsky (1962) suggested that concept formation is only truly possible at or following puberty, and that it is a creative process that is applied when a problem arises that cannot be solved by existing concepts. This theory of concept formation was expanded by Posner, Strike, Hewson, and Gertzog (1982) when they stated that conceptual change requires four phenomena:

a) dissatisfaction with existing conceptions,
b) presentation of intelligible new conceptions,
c) new conceptions that are initially plausible, and
d) new conceptions that hold the promise of further fruitful applications.

Teaching Science involves providing a rational basis for conceptual change, change that will be resisted by the student (Posner et al., 1982). This view of conceptual change is shared by constructivism, which can be used as a tool for teachers to guide the conceptual change of their students.

My students were asked to question the teacher-directed nature of their previous science education experiences. For some, this was the first time they had been caused to do so. I will continue to develop my students as focussed learners, less in need of teacher direction and more interested in collaborating with their peers and sharing control of the learning environment. I will certainly continue to use WebQuests frequently with these groups, but I will ensure that they feel more supported by the teacher, at least in the early stages.

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Demonstrations

While the activities in this section of *SER* have been designated demonstrations, they might easily be structured as hands-on student learning experiences. Although some sample lesson sequences may be included, the notes provided both here and in the following *Student Experiments* section are meant to act primarily as stimuli for classroom activities and to provide teachers with background information, so please modify any sample pedagogy as you see fit.

Teaching General Chemistry Concepts, to Blind and Visually Impaired Students, Through Hands-On Demonstrations Inclusive of Sighted Students

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Introduction. It is usually taken for granted that the physical sciences, which include chemistry, are visual subjects. In chemistry, for example, acid-base indicators and color changes during a host of different types of reactions are considered quite normal, and are taken as mainstay concepts of any chemistry, or chemistry-related, science course. This holds true whether the material is taught in middle school, high