Chem-Is-Try

Designing interactive tutorials and exercises for chemistry class on the Web

By

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ABSTRACT

"Chem – Is – Try"
Designing interactive tutorials and exercises for chemistry class on the Web

This research discusses applications and development of web-based interactive tutorials and exercises for redox (reduction-oxidation) chemistry. These tutorials and exercises are delivered as HTML files (created using Macromedia Dreamweaver) on the Web. The tutorials and the practice problems were developed and used by me as a classroom presentation and by students as outside class review. The learning theory that I used as the basis for the on-line materials is Constructivism, a theory that has existed for over one hundred years but has not been widely applied in schools. Modern technology is significantly impacting society and our daily life. Schools have and will continue to reflect societal change. The material created will be used as part of an on-going investigation into the strong link between effective use of modern technology and the theory of constructivism.
Acknowledgments

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Chapter 1 – Introduction

Although it took 20 years for telephones to be owned by a million people, it has only taken three years for personal computers to reach this level of ownership (Gabel 1999).

It is difficult to predict what learning will look like during the next century, but there are some indicators of what can be expected. John Peterson (2000), a U.S. futurist and author of The Road to 2015, predicted that the future will involve a revolution of scientific ideas. He indicates that the growth of scientific knowledge is proceeding at a revolutionary rather than an evolutionary rate and changing at an exponential rate rather than linearly. New technology is also expanding rapidly. He believes that there will be a power shift away from force and money to information and knowledge as the commodities of the future. Educators already know the power of the World Wide Web and the avenues this opens up for learning. The constructivist theory is the approach that we probably have to follow. This approach stresses the active role of the learner in building understanding and making sense of information (Grote, 1997). It assumes that subjectivity is critical because learners take in information and process it in unique ways that reflect their needs, dispositions, attitudes, beliefs and feelings.

Unfortunately, chemistry education research during the 20th century has had little influence on the way chemistry is taught. The changes that have occurred in textbooks during the past four
decades have not guided to any great extent. Are we going to have any change in the 21st century? As instructors, we have to realize the need to change instructional practices. As information grows, there is a need for learners to learn basic concepts and also become specialized. This requires an increased use of technology. With students immersed in virtual reality, the richness of the immersion may produce more efficient learning. Science educators should recognize the potential of the Internet as an educational tool.

As a chemistry instructor, I decided to do this project since I believe it's the right time to start incorporate, technology into my teaching methods. Technology attracted my attention because of its prevalence, its promise to provide low-cost education, and its potential to help some people participate more easily, learn more effectively and enjoy learning more. I will use this prototype as a supplemental tool for teaching a specific section of chemistry and investigating the use of technology on my chemistry instruction.

The Purpose

I developed interactive tutorials, exercises, tests, experiments and games for redox (reduction-oxidation) chemistry. All of them were designed to be delivered as html files, including some Flash files, on the web. The tutorials and the practice problems developed will be used by me, as a classroom presentation and by students as outside class review. The on-line materials were developed as an example of a course home page to support classroom teaching and later, when I return to Greece, I plan to build a more comprehensive Web-based classroom.
Redox (reduction-oxidation) is an important topic of general chemistry. But generally it is one of the most difficult subjects for students, who often have trouble applying the given rules to specific problems. The above difficulty led me to conclude that we need to give students more practice problems with instant and well-directed feedback. I had looked both the chemistry Internet resources and commercial software packages, but none of them satisfied my needs or matched what I had in mind. Most learning aids only grade the final equations, without giving enough feedback to students who answer incorrectly. However, I have found that when students do not get the equation balanced, there are many possible reasons why they have arrived at the wrong answer. I want the students to be able to track the sources of their mistakes.

I also incorporated computer-based simulations into my web-based teaching. In most Greek public schools there is not enough lab space to offer labs for students. For that reason, I present experiments that students can do in their own at home and plan to simulate experiments that are not feasible in standard lab facilities because they are too complicated or dangerous to run in the lab.

The purpose of this project is to give students more opportunities to learn and understand the importance of chemistry. The availability of my website means that students will not have to worry about copying the materials from the chalkboard because they can always review the same tutorial after class. They can also re-watch the lectures if they weren’t clear about something. With the Web site students will no longer have to compete with other students for educator’s limited time during the tests because they can take the tests on-line without the pressure of having to provide an immediate reply. It also allows students to send questions or hold electronic conversations, with the instructor. It is commonly reported that “people talk more electronically and ask questions more frequently (via e-mail or a chat program) than they do in a face-to-face
situation” (McCormack; Jones, 1997). I will encourage students to use the web site for questions, because chances are other students might like to know the answer too. In fact, when I receive an interesting question, I will put the question and its answer on the web site, with the questioner’s name deleted under the FAQ section.

Procedure

The chemistry-prototype utilized a persistent left-hand navigation scheme. The left-hand site navigation that appears on every page of the site, allows users access to other site areas without having to return to the home page or to navigate using the browser’s back button. All of the learning modules, in addition to the References, About and Glossary sections, are available to the user at all times via a single click. This style of navigation is very common on the Web, and will be immediately familiar to even novice Web users.

Learning modules
The content was organized into Learning Modules, which will be accessed via the main navigation windows. Once the desired Learning Module is clicked on the left, the content for that module appears in the main content frame to the right. Learning Modules consist of learning objectives and instructional content.

Learning objectives
Each module begins with clearly presented learning objectives. These objectives help to frame the instruction and provide a context for students to interact with the material. Learning objectives attempt to address student learning in the cognitive, affective, and psychomotor domains.
Content
Each module contains text, graphics, animation, tutorials, glossary, experiments and interactive exercises that both support the learning objectives for the module.

Experiments
I present experiments that students can do in their own at home and plan to simulate experiments that are not feasible in standard lab facilities because they are too complicated or dangerous to run in the lab.

Glossary
The glossary contains definitions for key words and important concepts. These words appear within the Web pages as hyperlinks. Clicking on the hyper linked word brings up the definition in a new browser window, allowing the user to view the definition and the module content simultaneously. In addition, the glossary is accessible via the main navigation window, and will feature an internal alphabetical navigation scheme.

References
The Reference section consists of cited online and offline references. The Reference section is accessed via the main navigation window or via hyperlinks within the content text.

About
The About section contains information about the author (myself), tools and techniques used to create the website, acknowledgments, and other relevant information.

Steps
A project can be broken down into four steps: analysis, design, implementation and use of the site.

The first step for my project was to define my objectives and answer the question “why build a web based chemistry instructional site.” Having decided that it is worthwhile for me to
build it: I analyzed the resources and characteristics of the students, staff, and raw materials (educational & equipment), which would be used to build it, and decided what I hoped to achieve. Also I assessed the personal impact of the project: How much time will I have to commit, and what gains can I expect to achieve? I defined my objectives and determined how extensively I would incorporate the Web into my curriculum.

The second step was to design the structure and components of my Web-based classroom. Developing materials for the Web means finding ways to provide valuable content within the constraints of a networked environment. Much of what I did as a course Web site author is to try to make my teaching materials suitable for networked delivery.

The third step was to carry out the design and construct the various components of my Web-based classroom, by learning to use “Dreamweaver 4 software”, “Coursebuilder software” and the “Flash 5 software.” The task of creating a Web site can be approached in many ways, and the success of each method may have more to do with one’s working style and preferences than with methodological effectiveness. What I have learned, however, is that I must have an approach. Web sites that are built page by page, without a unifying design and structure, lack coherence and are hard to maintain. The approach outlined from all my reading is similar to building a house: I have to move systematically from designing to framing to finishing. First I created a page design template for my pages and then I used the template to construct a framework for the site. Once the framework was solidly in place, I added the Web site content. The Macromedia Dreamweaver software was used to create the pages and navigation, and to format the bulk of the text. Graphics were created using Adobe Photoshop, a scanner and Macromedia Flash. Animations, simulations and interactive exercises were created using Macromedia Flash, Macromedia Dreamweaver and Coursebuilder. Finally, a Quality Assurance
(QA) process and testing was undertaken. This process consisted of testing the web page in Microsoft Internet Explorer to ensure that all links, flow and navigational elements functioned according to the flowchart and storyboards.

The **fourth step** (this and the following step will implement in Greece since I am not teaching Chemistry at the moment) is to incorporate the site into my teaching method effectively. This project will be useful only if my students work with it. Because the course site will be supplemental, I will probably need to coax students into using it. Some ideas for encouraging participation are: I will encourage online discussion by offering course credit to those who are active participants and I will include questions based on content from the site on exams. Also, when students ask me directly about something that is available on the site, I will send them to the Web site to look up their answers.

The **last step** is site assessment. It is well worth the effort to evaluate a site's effectiveness. Two main areas of my project will be assessed: its usability and its effectiveness as a teaching tool. Usability testing is a method for evaluating the effectiveness of my site information architecture, navigation and design. It will measure how successful users are in locating information on my site and how they felt about the experience. Conducting learning assessment will measure the effect my site has on the learning process: Did the students learn the materials as presented? The information and insights I will gain through evaluation will help me to refine my Web teaching method.
Delimitations of the Project

The website is meant to supplement my teaching of reduction - oxidation chemistry reactions. It is only for high school and college students and the language that I used was English. Later, I am going to build the same thing for Greek schools because Greece is the place where I am going to apply this project.

Since everyone does not have access to computers and to the Internet, the project is limited to places where computers are available and can be housed securely. It’s for students who are familiar with technology or can easily adjust to new approaches. Because the users are the only one to motivate themselves to completing assignments, there is no professor giving them an evil eye, there are no classmates to raise their eyebrows at them. They’re on their own and they’ve got to be able to move. This program is not for students who are not motivated to study or use the Web.

Any Web-based classroom that emphasizes interaction will usually rely heavily on the written word via e-mail or other web-based communication systems. This project is not for students who are not comfortable with the written word.

With the Web, my primary limitation is bandwidth. Secondary limitations include proprietary technologies and plug-ins, browser inconsistencies, and display differences. Nonetheless, my biggest battle is dealing with the limits imposed on what I can deliver through that narrow pipe leading to my audience. High-quality audio, video, animation and graphics typically require much bandwidth to download, for that reason I included only a few representative animations on my website.
Another limitation of the study is the lack of time for a formal assessment of the materials created. I am really developing a prototype in this project and the evaluation of the materials would be a second project, that I am not planning to do at the moment.

Definitions of terms

Throughout this project the following terms will be used:

World Wide Web (www) is an Internet service used for information retrieval. This service takes advantage of seamless linkage of key terms in a document with related information in other documents.

Internet refers to the world-wide electronic network constructed by interconnecting the networks of participating countries. It serves as the worldwide information superhighway.

Distance education is defined as the linking of a teacher and students in several geographic locations via technology that allows for interaction.

Browser describes a software program used to navigate and render Web-based content. As of this writing, the most widely used browsers are Netscape Communicator and Microsoft Internet Explorer.

Hyperlink describes the mechanism by which Web-based documents are navigated using a browser.

Multimedia combines media in multiple forms, including graphics, text, audio, and animation.
Macromedia Dreamweaver is software that allows you to create full-featured web pages. It is a visual HTML tool. But it assumes no knowledge of HTML and web design. It creates tables, edits frames and switches easily from page view to HTML view.

Macromedia Flash is the newest software that allows you to create sophisticated animations and vector-based graphics that please the visual sense and communicate more effectively. Vector graphics emerged as a new way of creating graphics consisting of small mathematically based objects.

Coursebuilder is software that allows you to create online quizzes and provide feedback throughout the quizzing process, so that students learn while they are assessed.

Redox is the term used to label chemical reactions in which the acceptance of an electron (Reduction) by a material is matched with the donation of an electron (Oxidation). Generally this is one of the most difficult subjects for students.

Chemical Reaction is material changing from a beginning mass to a resulting substance. The hallmark of a chemical reaction is that new material or materials are made, along with the disappearance of the mass that changed to make new. Chemical reactions, also called chemical changes, are not limited to happening in a chemistry lab. Here are some examples of chemical reactions with the corresponding chemical equations:

A silver spoon tarnishes. The silver reacts with sulfur in the air to make silver sulfide, the black material we call tarnish. \( 2 \text{Ag} + \text{S} \rightarrow \text{Ag}_2\text{S} \)

An iron bar rusts. The iron reacts with oxygen in the air to make rust.

\( 4 \text{Fe} + 3 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3 \)
Organization of Thesis

In Chapter two I will review the literature on constructivist theory. Reviewing this theory is important because I will also provide an in-depth view of the benefits learning science using the Internet. Then I will discuss the complexity of chemistry and I will try to make recommendations for teaching to improve students’ conceptual understanding. Chapter three provides an overview of what I did to design and implement my project. I will describe the tools that I used and why I chose them. Chapter four is the project, the web page. In chapter five I will explain how I am going to use that project and how I will continue to develop the project.
Chapter 2 - Literature review

Constructivism

Constructivism has become a popular term in education circles during the last few years. It refers to a philosophical view about the nature of reality and perception, is a theory about how people learn, and more often the term constructivism represents an array of teaching strategies. Essentially, constructivists claim that students construct knowledge rather than merely receive and store knowledge transmitted from the teacher (Mordechai, 2001).

Although constructivist theory has become popular in recent years, the idea of constructivism is not new. Aspects of constructivist theory can be found among the work of Socrates, Plato, and Aristotle (ranging from 470 – 320 B.C.), all of which speak of the formation of knowledge. For example, Saint Augustine (mid 300s A.D.) taught that in the search for truth, people must depend on sensory experience. More recent philosophers, such as John Locke (17th century), taught that no man's experiences can go beyond his experience. Additionally, Kant (late 18th century) explained that the logical analysis of actions and objects leads to the growth of knowledge and the view that one's individual experiences generate new knowledge (Brooks, 1993). Although the main philosophy of constructivism is generally credited to Jean Piaget (1896-1980), Heinrich Pestalozzi (1746-1827), also from Switzerland, came to many similar conclusions more than a century earlier.

Pestalozzi maintained that the educational process should be based on the natural development of the child and his or her sensory influences. Pestalozzi's basic pedagogical innovation was his insistence that children learn through the senses rather than with words. He labeled rote learning as mindless, and he emphasized linking the curriculum to children's
experiences in their homes and family lives (Fabricius, 1983). This perspective is supported by
the work of Manges and Wigle (1997). They believed that through constructivist teaching,
students can tap into their natural learning potential because their experiences, prior knowledge,
and personal interpretations become essential components of all classroom activities.

However, Piaget provided the foundation for modern-day constructivism and its
hybridization (Schunk & Zimmerman, 1998). In his view, intelligence consists of two
interrelated processes: organization and adaptation. People organize their thoughts so that they
make sense, separating the more important thoughts from the less important ones, as well as
connecting one idea to another. At the same time, people adapt their thinking to include new
ideas, as new experiences provide additional information. This adaptation occurs in two ways:
through assimilation and accommodation. In the former process, new information is simply
added to the cognitive organization already there. In the latter, the intellectual organization has to
change somewhat to adjust to the new idea (Berger, 1978).

The basic idea of constructivism is that the learner must construct knowledge; the teacher
cannot supply it (Bringuier, 1980). This is vividly expressed by the Farsi proverb: a well must
produce its own water. The constructivist approach is a view that emphasizes the active role of
the learner in building understanding and making sense of information. More specifically,
according to constructivist theory, children learn whole parts, not incrementally. Furthermore,
the ideas and interests of children should drive the learning process. Teachers are flexible;
sometimes they are the giver of knowledge, but more often they serve as facilitators (Strommen
& Lincoln, 1992). Dwyer (1991) asserts that this approach is child centered rather then
curriculum centered, while Bagley and Hunter (1992) state that learning becomes a dynamic
process. Bagley and Hunter (1992) go on to say that active learning leads to greater retention and
higher-level thinking. And as knowledge continues to double every two years, and since it also has a short "shelf life," students must learn to find information; there is now far too much information to memorize.

Constructivist approaches to learning assume that subjectivity is critical because learners take in information and process it in unique ways that reflect their needs, dispositions, attitudes, beliefs, and feelings. Constructivism espouses creating meaning from experience (Jonassen, 1991). It stresses the interaction between learner and the environment, and that learning is embedded in the context in which it occurs. Thereby learners are encouraged to develop their own understanding of knowledge. Brooks and Brooks (1993) state that constructivism is not a theory about learning. Rather is a theory about knowledge and learning that process and learning occur daily and relentlessly in classrooms. It is a philosophy that encompasses knowledge, learning and thinking.

The sketch by Krajcik (1994) shown in the Figure (ProQuest, 1999) below provides a commonly held current view on how students learn. According to this position, students construct new understanding only after they have considered their current understanding. This is facilitated through social interaction with their instructors, other students or perhaps a computer.
Many educators link constructivist-learning theories to the use of classroom activities. The use of activities to teach science is not simply a way to keep children occupied or busy. Activities have the potential of engaging students' curiosity, causing them to question their prior and sometimes naïve understandings of natural phenomenon. Although "telling" is faster, it does not always produce true understanding because the teacher may say one thing, while the child comprehends another. The constructivist perspective is more than just activities (Grote, 1997). It is not treating children as empty vessels into which teachers pour their knowledge, rather more respect is shown to students as learners and as human beings.
Technology meets constructivism

Technology has always impacted education; the printing press allowed textbooks to be developed, and the replacement of slates and chalk by pencil and paper permitted a permanent record of one’s writing to be preserved. In the late 1950s and 1960s television was utilized as a means of teaching large groups of students, albeit ineffectively. Today, a new wave of technology is beginning to have repercussions in schools that will forever change how students are taught.

Hawkridge, Jaworske and McMahon (1990) identify four main reasons for using technology in schools. The first reason is social: students need to know how to use technology because technology is everywhere. A second reason is vocational: students need to learn technology because they may need it in their future careers. The third reason is pedagogic: students can learn better from a computer. Fourth, some reformers assert that computers themselves can be a catalyst for systemic change in education. Essentially, technology has gained attention in education today because of its prevalence, its promise to provide low-cost education, and its potential to help some people participate more easily, learn more effectively and enjoy learning more (Palmieri, 1997).

In classrooms using technology one must remember that the educational focus is on learning and instructional goals instead of the technology itself, because technology is merely a tool or vehicle for delivering instruction (Campoy, 1992). Studies show that in these classrooms there are many observable changes and advantages such as:

- A shift from whole class to small group instruction;
- Coaching rather than lecture and recitation;
- Teachers working with weaker students more often, rather than focusing attention on brighter students as in traditional settings;
• Students more actively engaged;
• Students becoming more cooperative and less competitive;
• Students learning different things instead of all students learning the same thing; and
• An integration of both visual and verbal thinking instead of just verbal thinking (Collins, 1991).

According to Mann (1994), the use of new technologies in an educational setting has caused constructivism, to receive new attention. Students in these settings become empowered by gaining access to real data and work on authentic problems. Furthermore, it has been suggested by LeBaron and Bragg (1994) that the role of technology in education is so important, it will force the issue of didactic versus constructivist teaching. Teachers will no longer have a choice but will be compelled to use a constructivist approach in a technology-rich environment. Strommen and Lincoln, (1992) make the point that it is not what equipment is used, but how the equipment is used that makes the difference. “The key to success lies in finding the appropriate points for integrating technology into a new pedagogical practice, so that it supports the deeper, more reflective self-directed activity children must use if they are to be competent adults in the future” (Strommen & Lincoln, 1992). In other words computers and other technology should be viewed as tools, which are an integral part of a child’s learning experience.

Children’s traditional tools – pencils, notebooks and texts- are still vital. But for children to assemble and modify their ideas, access and study information, for a lot of students the traditional tools are just the beginning. Computers, video and other technologies engage children with the immediacy they are used to in their everyday lives and bend it to a new pedagogical purpose. Really, it is not what equipment is used in the classroom, but how that equipment is used that will make the difference. I think that technology must be thought of as an integral component of the curriculum, a tool that can be used with almost any content. For example,
computers can be used as writing tools, spreadsheets and mathematical problem-solvers. They allow access to databases, software and diverse multimedia resources such as interactive audio, video and digital photographs.

It is important to mention the use of computers in science education. Computers are often seen as a tool to increase the constructive content of science education. Using more visual imagery in class will help to improve the student's observational ability and proficiency at visualizing chemical principles. This skill is extremely important for chemists, since the level of professional development in this field is closely related to the sophistication of the mental imagery that is used (Kleinman, 1987).

**Science Education**

Didactic (or direct) instruction traditionally has been conceptualized as the transmission of facts or knowledge to students, who are seen as passive receptors. In classrooms where this type of teaching predominates, teachers typically conduct lessons using a lecture format. They often instruct the entire class as a unit, write notes on the chalkboard, and pass out worksheets for students to complete.

For example, didactic science instruction relies on the five instructional practices where students:

- Listen to the teacher lecture;
- Copy the teacher's notes from the blackboard;
- Watch the teacher demonstrate or lead them in an experiment or systematic observation;
• Use a book or other written instructions that show them how to do an experiment;

and

• Review work from previous day.

In traditional classrooms, knowledge is presented as fact, students' prior experiences are not seen as important, and students typically are not free to experiment with different methods to solve problems. Moreover, traditional views of teacher-student relationships are characterized as distant, with the teacher as an authority figure (Waller, 1932).

In traditional classrooms, it is teachers who are active; they convey facts and inculcate knowledge. Students are passive receptors of this knowledge. These classrooms typically consist of teachers presenting the "right" way to solve problems. Knowledge, in this situation, is symbolic and isolated; learning does not typically motivate students or provide them with problem-solving skills they can apply to other situations. High-school classrooms for most of this century have looked this way (Boyer, 1983; Goodlad, 1984; Powell, Farrar, Cohen, 1985) and most still do.

Current trends such as Constructivism in Science education suggest that traditional approaches are inadequate. Studies have shown that relatively few students reach an acceptable level of achievement in high-school science (Duit, 1991). Physics teachers seem to have the worst time, as students retain a naïve theory of physics despite intensive instruction in Newtonian mechanics (McCloskey, 1983). For constructivists this is not surprising: everyone who has ever thrown a ball, knows that if you don't keep applying force, an object in motion will eventually come to rest. Apparently, these ideas are so entrenched that mere lectures and even experiments have a difficult time of displacing these naïve motions. At most, a certain facility in
manipulating formulas is achieved, but this fails as soon as the student attempts to solve problems that require a deeper understanding.

In most fields of science education there is a large body of research that catalogs misconceptions. A constructivist perspective, views a misconception not as a mistake, but as a logical construction based on a consistent, through nonstandard theory held by the student. According to constructivism, a teacher cannot ignore the student's existing knowledge; instead, he or she must question the student in order to understand exactly what theory the student is currently using, and attempt to guide the student to the "correct" theory. It is perhaps an axiom for constructivists that students have consistent theories that are at variance with currently accepted scientific theory.

Constructivist instruction loads predominantly on five instructional practices involving students who:

- Make up their own problems and work out their own methods to investigate problems;
- Design and conduct experiments and projects on their own;
- Make their own choice of science topic or problem to study;
- Write up reports of laboratory and practical work; and
- Discuss career opportunities in scientific and technological fields.

**Teaching redox**

Redox (reduction – oxidation) chemistry is an important topic of general chemistry. Redox chemistry is, however, generally one of the most difficult subjects for students, who often have
trouble applying the given rules to specific problems. To master the subject, students need to work through a number of practice problems themselves. The more they practice, the better they understand what they are doing (Wong, 1999). But a key to their success is that they be given consistent feedback on their work. Immediate and well thought out feedback can be a significant benefit in helping students master redox chemistry.

The main difficulties students experience when studying redox chemistry are assigning oxidation numbers, identifying oxidizing and reducing agents and balancing redox equations (King, 1999). To address these difficulties, I decided to develop tutorials and provided the rules for assigning oxidation numbers. Moreover to help student learn how to balance a redox equation, I provided the specific stepwise procedure. The tutorial also provides examples to demonstrate the application of the rules. The practice problems that I included on my “computer-assisted learning environment” give the students plenty of practice with instantaneous feedback on their answers, so that students know whether their approach to the problems are correct. I designed these instructional activities because I think that learning has to incorporate technology. Utilizing technology will allow learners to be more independent and learning to be more individualized, interactive, interdisciplinary and intuitive. These are basically the five goals that should be applied to meaningful educational reform (Barr, 1990).
Chapter 3 – Methodology

Bad enough! Again the same old story! When you’re finished building your house, you realize that in doing so you unexpectedly learned something that you absolutely had to know—before you began to build (Friedrich Nietzsche, 1999).

Planning

Planning was the first step in implementing my Web-based classroom. I began with finding out what software, facilities, funding and development support were available at CSUMB as well as how much time I had to commit and what gains I expected to achieve. Understanding the above helped me to define my objectives within the context of what was possible.

Then I looked at other sites on the Web. With the sense of what others were trying to accomplish, I devised my own goals and determined how extensively I would incorporate the Web into my curriculum. Once I assessed my means and formulated my goals, I was ready to start making an organizational structure for my Web site.

The success of a Web site depends as much on how well we organize our content as on the content we offer (Horton, 2000). For that reason I created a list of items I wanted to include as content on the site. I also established priorities and expectations. I revised my content list many times during the development process and I removed items that seemed untenable.

The next step was to organize my content list into an organizational architecture that would comfortably house my content. I created a classification system that effectively described the items on my content list. Labeling was another important consideration while I classified my content. A robust organizational structure and well-defined navigation system would not serve unless I communicate it to users in a language they could understand. Labeling is particularly
challenging on the web because the labels serve multiple purposes: they are descriptors of the content as well as navigational pointers.

It was also remained to plan the site structure, so that users could retain a sense of context as they moved through the information. That is, users should be able to tell where they were, where they’ve been, and where they could still go. There are multiple structures that could have been effective for my site. I chose a hierarchical structure, in which the content of the site is grouped into main categories and subsections, for the reason that it is easier for the user to understand and navigate. As I developed a hierarchy for my Web there were a few things that I had in mind. I decided against a deep structure, which means that users must click through several menu pages to reach the information, because they would be liked to become frustrated and may give up. I shouldn’t make all my content accessible directly from my home page, this is too shallow, and users may be overwhelmed by too many unrelated choices on the main page. A good web site hierarchically presents eight or fewer main level options and incorporates the content only a level or two away from the main page (Boettcher; 1999, Conrad; 1999). After considering the above my Web structure was organized as such:
At this point, I have to mention that I returned to the plan stage many times to refine the structure. Sound planning is essential because ill-defined concepts or an unstable structure will cause trouble later on.

**Site Development**

*It is easy to make something difficult, but difficult to make something easy* (Brecht, 2000).

Developing material for the Web requires finding ways to provide valuable content within the constraints of a networked environment. Thus the second stage of this project required gathering the materials on the content list.

While creating my Web page I realized that the *keep it simple* rule resonates in everything we do. Hix (1993) stated, “Reducing complexity for users is still a very difficult aspect in interaction design”. After all, the computer is “lecturing” the student and the student is reading form the computer. The content needed to be presented, so that the students would not become inundated with too much information.

I also tried to keep the content organized and as consistent as possible. Hyperlinks played an important role in affecting how the content was organized. Most of the hyperlinks were placed at the end of paragraphs and after the presentation of content. This ensured that students read the information first and then used the hyperlink to explore more about the content.

I also built online quizzes for my web-class. The best online quiz module does not simply collect responses, but provides feedback throughout the quizzing process, so that the students learn while they are assessed (Horton, 2000). Through feedback, the computer can point out
errors and provide explanations, as well as reward successes. Student performance improves as they make their way through the questions, because they are learning as they go. The purpose of the quiz is knowledge assessment and learning. For these reasons I allowed students to repeat the quiz as often as they wish.

Most instructors answer the same questions every time they teach a course. Many have devised methods to preempt these questions, perhaps in the form of a handout distributed at the beginning of term. Instructors using a course Web site can answer common questions on a course FAQ (Frequently Asked Questions) page. A FAQ is a compilation of frequently asked questions with their answers. FAQs are often searchable to help users find answers to specific queries. Although creating the FAQ required an initial time expense, I hope that it may reduce the everyday demands on my time and free me for more challenging tasks. I developed the content of the FAQ by reviewing student questions while I taught chemistry classroom with traditional methods. I wrote answers to these questions and I placed them on a page on my course site. If the student question is not included on that page he/she can e-mail me and I will answer the question directly on-line.

I have also included a glossary, references, and about. Glossary contains definitions of key words and important concepts. These words appear within the content text as hyperlinks. Clicking on the hyper linked word brings up the definition in a new browser window, allowing the student to view the definition and the module content simultaneously. The References section consists of online and offline citations. The References section is accessed via the main navigation or via hyperlinks within the content text. The About section contains information about myself, as well as tools and techniques used to create the website, acknowledgments, and other relevant information.
The last and the most important part of designing a web page is the incorporation of multimedia. The greatest advantage of Web-based instruction is the ability to employ multiple media types to present ideas and concepts. With Web multimedia, you can combine text, images, sound and videos. For that purpose I learned the use of the Dreamweaver 4, Coursebuilder and Flash 5 software. I did not complain about the many-many days it took me to learn the software because it was a great experience and all software served multiple purposes. With the Macromedia Dreamweaver software I created full-featured web pages, tables, and edit frames. With the Macromedia Flash software I created all of my animations and graphics that would help to please the visual sense and communicate more effectively.

At the end, I simulated experiments that students can do on their own at home. This required describing the experiment and then I acquiring some images using a digital camera. Shooting photographs was an ideal way to get visual content for my web site. By doing so, I owned the rights to the images and could customize them to fit my pedagogical needs. A digital camera has many benefits for Web site projects. Images can be transferred directly from camera to computer: no film, no developing costs, and no delays. After working with images, my suggestion is use the highest quality settings available on your camera. Even if the files are large, you will have more data to work with and fewer compression artifacts to work around. And keep in mind: shoot close-ups against a simple background whenever possible.

**Create the site**

The third step was to create the site.

Figure 1 shows the homepage of the course.
The first link in the homepage requires choosing the language that the students prefer to work in.

![Diagram of homepage](image)

Figure 1 - Homepage

Then students read the contents of the site and navigate through them using the appropriate links. An image on the screen helps them to visualize the meaning of redox (reduction-oxidation). See Figure 2.
The first option is to take the tutorials (Figure 3).
As soon as a lesson (tutorials) is completed, students are asked if they want to proceed to the quiz-practice problems or pause and come back later. Thus, they can prepare themselves for the test and take it when they will feel ready. The quizzes have the format of multiple choices, drag/drop questions and fill in the blanks as in Figures 4, 5, 6, and 7.

**Figure 4**

**REDOX REACTIONS**

**PRACTICE PROBLEMS**

Select the category of practice problems you want to take:

- A. Assigning oxidation numbers
- B. Identifying redox agents and reactions
- C. Balancing redox equations
- A. Assigning oxidation numbers
**REDOX REACTIONS**

**A. Assigning Oxidation Numbers**

This part of the practice has totally 10 questions. You should answer the questions by checking the oxidation number for each element. If you do not get a question correct, a brief explanation for the wrong answer is given.

1. What is the oxidation number for Cl in the ClO?
   - 2
   - 1
   - 0
   - Not listed

   Correct: -1

2. What is the oxidation number for S in the SrSO4?
   - 2
   - 0
   - -2
   - Not listed

   Correct: -2

**Figure 5**

**REDOX REACTIONS**

**B. Identifying Redox Agents and Reactions**

This part of the practice has 5 questions. You should identify the oxidizing and reducing agents by dragging all the objects on the left (in red boxes) to the correct targets on the right (in blue boxes), and then press the "Submit" button to check the answer.

1. Identify the oxidizing agent and reducing agent in the equation 2Fe^3+ + 3Cl^- → 2Fe^2+ + 3Cl^-

   Oxidizing: 2Fe^3+
   Reducing: 3Cl^-

2. Identify the oxidizing agent and reducing agent in the equation 2CrCl_3 + 3H_2O_2 → 2CrO_4^{2-} + 6HCl + 3H_2O

   Oxidizing: 3H_2O_2
   Reducing: 2CrCl_3

**Figure 6**
C. Balancing redox equations

Drag the numbers on bottom to the correct targets (components, elements) on the top, then press the "Submit" button to check the answer.

1. Put the correct numbers beside the components

$$\text{ZnS} + \text{HNO}_3 \rightarrow ? + \text{NO} + \text{H}_2\text{O}$$

1 1 2 2 3 3 4 5

Submit  | Pass/Fail

Figure 7

It is vital to the success of the learning process, to give students instant feedback on the correctness of their answers and their final score. As soon as the quiz is submitted, the score and the correct answers are displayed on the screen. Students can repeat the quiz as many times as they would like.

As I mentioned before an experiment is also presented on my Web site. I tried to find an experiment with reduction-oxidation reactions, that is based on every day occurrence. The experiment has the title “Clean your objects with electrons” so as to emphasize the role of chemistry in daily use. Basically, I described how we could make tarnished silver shiny again.
The procedures and the explanation of the experiment were written out and then using photographs, I conduct the experiment (Figure 8, 9).

Figure 8
The tarnish will begin to disappear. If the silver is only lightly tarnished, all of the tarnish will disappear within several minutes. If the silver is badly tarnished, you may need to重复the baking soda and water mixture, and give the silver several treatments to remove all of the tarnish.

Exploration:

When silver tarnishes, it combines with sulfur and forms silver sulfide. Silver sulfide is black. When a thin coating of silver sulfide forms on the surface of silver, it darkens the silver. The silver can be returned to its former luster by removing the silver sulfide coating from the surface. There are two ways to remove the coating of silver sulfide. One way is to remove the silver sulfide from the surface. The other way...

The last link is the glossary that contains definitions for key words and important concepts. The glossary is accessible via the main navigation window, and will feature an internal alphabetical navigation scheme (Figure 10).
Using the site

The next step is using the site. My course web site is a tool, and a tool by itself has little effect, so I need to incorporate the site into my teaching methods effectively. The site is useful only if my students work with it. Student participation is one of the wildest wildcards in the success of a course Web site. As the saying goes, you can lead a horse to water but you cannot make it drink. Since I am not teaching chemistry at this time, this step will have to take place in 6 months when I am going to have a teaching position as chemistry instructor in Greece. But I am thinking that the most important factor in encouraging participation will be my own attitude.
toward the site. I will make it clear to my students that I consider it to be an essential tool by integrating the site into my teaching method. To promote my site at the beginning I will give my students a full tour of the site and emphasize the aspects that I feel are particularly valuable. I will encourage students to report problems they have with the site and include the problems with resolutions in the FAQ section. I will give credit, which means I will include questions based on content from the site, on exams. I will make them "look it up", when students ask me directly about something that was available on the site.
Chapter 4 – Project

The traditional way to delivery tutorial material is by application programs, but they tend to be large and hard to deliver. Most do not fit on a floppy; they need a CD-ROM and they are costly to update. We have been moving to using the Web for delivery of programs, that’s the reason and I decided to use the Web.

Materials are authored using Macromedia Dreamweaver 4 because the material created can be played back using an Internet browser. In addition to the advantages of interactivity and multimedia capability, Macromedia has the added advantages of fast download, streaming capability and ease to update.

No special installation is required for my students to access the prototype. At the moment the project files are put on California State University Web server for them to access and practice. The URL is http://student.csumb.edu/Students_1-M/leivadarouiren/world/Index2.htm. Additionally, there is a CD-ROM version of the website that can be checked out at the CSUMB library.
Chapter 5 – Conclusions

Many reformers advocate a move away from traditional, teacher –centered (didactic) direct instruction, where students are passive receptors of knowledge, toward more student-centered understanding-based (constructivist) teaching that focuses on exploration and experimentation. In this study, I tried to design a prototype to facilitate understanding the basic concepts and practice with one of the most difficult chapters in chemistry (redox).

The aim of the computer-assisted learning environment that I tried to construct is to assist students in developing their understanding of redox chemistry concepts. The computer-assisted learning environment was to be nonlinear and facilitate student-centered exploration of the relevant material. That is, students are afforded opportunities to examine the material in any order and at their own pace.

Much of the current software is marketed as constructivist, primarily because access to information is nonlinear and because it offers opportunities for personal or communal interaction. As a result, instructional systems designed along the lines of open access are often considered constructivist, simply because the user’s pathway is determined by the user and not overtly preordained by the designer. Furthermore, in my prototype, most practice-problems written using the software-Coursebuilder, required either a multiple-choice format or a one-word answer. When a user gives an incorrect answer, a window appears that gives corrective “why” and “how” feedback to the learner. Thus the assessment process is interactive and formative, not merely summative. This is one of the fundamental differences between didactic and constructivist views of learning.

Designing for navigation ease should make it relatively simple for students to find responses to questions by simply going to appropriate screens. For example, if a student is faced with a question pertaining to the oxidizing number of hydrogen, the student could simply go to the screen of oxidizing rules of hydrogen and read the value. Therefore, for the purpose of assessment, incorporated questions needed to be easily accessed more than once. The nature of the questions and their roles in terms of diagnostic assessment were important and valuable features of the multimedia learning environment.

Technology has effectively revolutionized American and European society. An unexpected byproduct of this revolution has been the emergence of a generation of children weaned on
multidimensional interactive media sources, a generation whose understanding and expectations of the world differ profoundly from that of the generations preceding them. If we are to give these children the education necessary to succeed in our technologically intense, and global future, a new form of educational practice must replace our existing methods. The theoretical foundation for such changes exists, and the time to implement them is now. We have allowed our schools to remain in the past, while our children have been born in the future. The result is a mismatch of learner and educator. But it is not the children who are mismatched to the schools; the schools are mismatched to the children. Only by revising educational practice in light of how our culture has changed can we close this gap, and reunite our schools with our children and the rest of our society.

**Future Research**

As the current project is continued, one of the goals will be to seek ways to determine whether or not the above assumptions can be confirmed in the classroom. The initial theoretical results of this project suggest that important benefits can be obtained by combining multimedia and traditional techniques into a unified system.

Evaluations can be conducted in many different ways and the evaluation data can serve many purposes. I am planning to create a page that the user-learners can evaluate the usability of my web page and the usefulness of the information it provides. The learners will evaluate the prototype at the end of the course to determine the ease of access, delivery of the material, and quality of support provided (mainly technical). Faculty, also, will be asked to evaluate all of the above, as well as provide additional suggestions they might think will help to support web-based instruction.

If most of the above is confirmed, then I am planning to design interactive tutorials and practice problems for the rest of the chemistry chapters.
References


