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Chapter 2

Designing Effective Instructional Web Pages

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Abstract: Despite the proliferation of educational material on the Web, little information exists to document the strategies that have proven effective at improving pedagogy on the Internet. In 1997, we began constructing and evaluating Web-based teaching resources to improve science education. Several designs and multiple features were tested over a five-year evaluation period. Using data collected from subject comprehension exams and student evaluations, these resources were compared to each other and to a traditional textbook to determine their effect on improving student learning. The design that has proven most effective is one in which subject lessons are created in a modular format that integrates text, simulations, interactive exercises, communication features, and external links to add news, history, and other perspectives to the subject matter. This format, publicly launched at http://www.visionlearning.com, can be easily tailored to other subjects and disciplines, and this work shows that well-planned technology-based teaching materials can be more effective than traditional resources for improving student learning.

INTRODUCTION

In the decade since Tim Berners-Lee created the hypertext program that led to the development of the World Wide Web, the proliferation of material on the Internet has catalyzed a major shift in information paradigms (Cailliau, 1995). More than 2.5 billion Web pages now exist and 7.3 million new pages are added every day (Lyman and Varian, 2000). It is estimated that the Internet now contains 7,500 terabytes of data, and the amount of information accessible by the public through the Internet exceeds that available at any other time in history (Bergman, 2000).

As a result of this wealth of resources, educators now cite Internet use as the most valuable aspect of computer technology for teaching, and more than 60% of teachers use the Internet to locate curricular material (Becker, 1999). Online teaching materials have extensive advantages over traditional print materials because text and multimedia content can be seamlessly integrated to enrich the learning environment (Fraser, 1996). Web-based teaching materials also facilitate the delivery of up-to-date content on demand, and they provide an avenue for collaboration and interaction not previously possible (DiCaterino and Pardo, 1999).

Unfortunately, little research exists to guide educators on website design. The advantages of the Web do not lie in its ability to recreate the printed word and so Web-based teaching resources must go beyond simple placement of text online. Also important is the fact that students do not learn in random jumps. Web features such as interactivity, simulations, and external links must thus be organized to present a coherent picture that complements subject readings. Web-based teaching materials must be carefully planned to integrate text, animations, interactive features, communication tools, and the wealth of existing Web content in a well-organized manner to effectively leverage the robustness of the Internet.

THE CASE STUDY: DESIGNING WEB RESOURCES

In 1997, I began experimenting with the use of Web-based resources for enhancing the core non-majors science curriculum at John Jay College of the City University of New York. Located in the heart of Manhattan, John Jay draws widely on the inner-city, lower-income minority populations throughout all five boroughs of New York City and nearby suburbs. The first course in the core science curriculum is *Introduction to Science in Society* (NSC107), which is traditionally taught as a large lecture (typically 100 to 150 students) with smaller laboratory sections (<32 students). This interdisciplinary course introduces non-scientists to a broad spectrum of scientific concepts and principles and serves as a foundation for a second core science requirement at the College. As a result of the large class size and diverse science backgrounds of students, course instruction is challenged by the need to teach concepts at a level that can be understood by the least experienced students yet in a manner that is engaging to students with more extensive science backgrounds. This problem has been exacerbated by the inflexibility and inadequacy of traditional textbooks in conveying dynamic scientific concepts.

To address these issues and to improve student performance, I created a course website in 1998 titled *The Natural Science Pages* (http://web.jjay.cuny.edu/~acarpi/NSC/index.htm). The site, pictured in frame format in Figure 1, provided access to course information and lessons written specifically for NSC107. The 'Course Info' section (Figure 1, left frame, top) provided easy access to a syllabus, laboratory information, instructor contact information, and grading data. The 'Lessons' section (Figure 1, left frame, bottom) provided links to thirteen lessons that explained the core scientific concepts covered in the class.

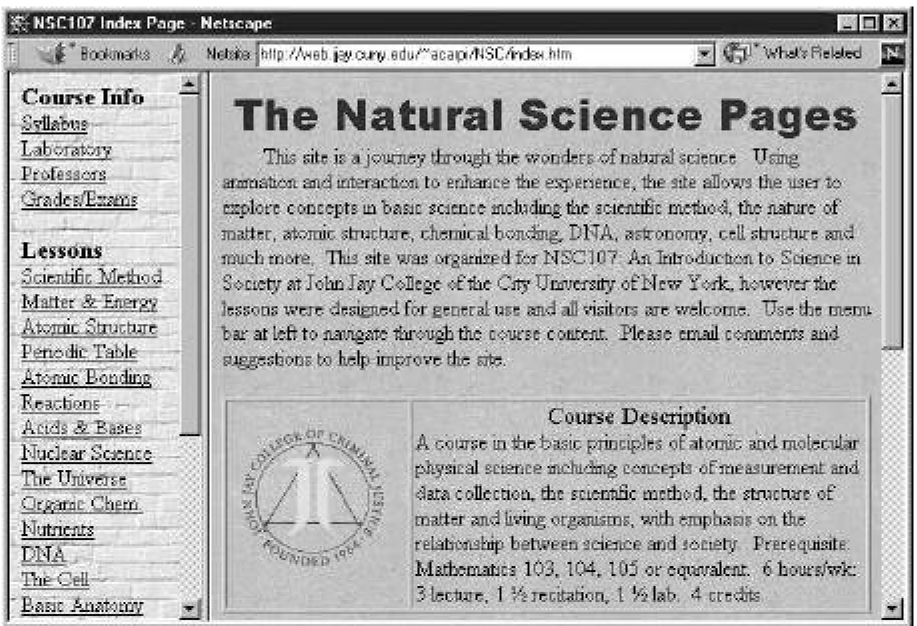


Figure 1. Homepage of The Natural Science Pages course website. This was the first prototype of our Web education research. It provided course information such as a syllabus, etc. (upper left menu) and concept lessons presented in a modular format to help students focus on individual topics (lower left menu).

The site lessons were written in modular form to correspond to the course syllabus. The modular nature of the site lessons encouraged students to focus on the specific topics being covered in the course. By providing core readings and supplementary material in a single unit, the modules were planned to allow students to progress through the subject matter at their own pace and in as much depth as they preferred. The modules contained text-based explanations of the core subject matter. Additionally, original animations integrated into the text helped convey dynamic scientific concepts such as electron orbital theory, chemical bonding, protein synthesis, etc. All of the modules also included a list of links to relevant external Web pages at the bottom of the page. These external links were meant to serve several purposes. First, external links to background readings were included to provide additional resources for those students who found themselves struggling with the materials. For example, a site lesson on chemical reactions included a link to a chemical equations page from the ThinkQuest library (Bishop et al., 1998). Since additional readings are difficult to make available offline, it was thought that this would be a significant advantage of the course website over a traditional text. External links were also incorporated into the lessons to provide advanced readings. These were intended to give students who found a lesson particularly interesting an opportunity to explore the concept in more depth than is taught in class. This was especially important in a large lecture class where individual contact time between the instructor and students was limited. A module on atomic structure, for example, included a link to *The Particle Adventure*, a site at the Lawrence Berkeley National Laboratory that details the history of subatomic particle discoveries (CERN, 2000). External links were also included to help ground the lessons in historical research discoveries. A module on the structure of DNA, for example, linked directly to James Watson and Francis Crick's pioneering paper "A Structure for Deoxyribose Nucleic Acid" (Watson and Crick, 1953).

PROJECT EVALUATION

Internet access and Web use were important considerations for this project given the large population of minority (29% African-American and 37% Hispanic in the Fall 1998 undergraduate enrollment) and lower income students at John Jay College for whom Internet use is traditionally less widespread (U.S. Department of Commerce, 1999). Prior to the launch of *The Natural Science Pages* site, an anonymous survey was given to course students regarding their computer and Internet experience. Of those students responding (N=172), 98% stated that they had some computer experience and 77% had experience using the World Wide Web and Internet. Over 50% of students stated that they had access to the Internet at home, and over 60% of students stated that they had regular access to the Internet outside of college (at home or work). All of the students in the course also had access to the Internet via one of four College student computer rooms.

The Natural Science Pages website was publicly launched on August 12, 1998, prior to the start of the Fall 1998 semester. To gauge interest and acceptance of the site, course students were given the site address on the first day of the semester and they were informed of its contents. However, they were not required to use the site. As in previous semesters, students were required to purchase an introductory science textbook for the course.

In two independent surveys administered to the Fall 1998 classes, 63% of registered students (N=148) indicated they had used the site by the end of the first month of the semester, and 82% indicated they had used the site by the end of the semester. Of those students who had indicated they used the site by the end of the term, 92% stated that the course website helped them to understand the material taught in the course. Almost 74% of students who responded to the survey stated that the course website helped improve their grade. In addition, over 75% of students who had used the site stated that the course website was more helpful than the required introductory textbook. One student who submitted written comments on the survey instrument said, "…I think that the website is an excellent idea. It should replace the book! I have the book, but I don't have a computer. However, I have visited the website more times than I have opened the book."

The course website also improved overall student performance in the course. Course performance was gauged by a series of three standard, multiple-choice examinations given during the semester. In two semesters after the launch of *The Natural Science Pages* website (Fall 1998 and Spring 1999), average scores on two of three exams increased significantly compared to the one semester prior to the launch of the website (Fall 1997, see Table 1). No significant differences were apparent between test scores on the second examination. It is likely that the website had a more significant effect on performance for exams 1 and 3 because these two exams covered material that is more highly technical in nature.

Table 1. Mean examination scores (%) ± 99% confidence intervals before and after launch of *The Natural Science Pages* website. Significant improvements in examination scores, student satisfaction, and overall student performance were observed after implementation of the website.

	Fall 1997 (N = 197) (before Web launch)	Fall 1998 (N = 257) (after Web launch)	Spring 1999 (N = 139) (after Web launch)
Exam 1	56.3 ± 2.6	64.5 ± 2.2†	67.5 ± 2.8†
Exam 2	72.6 ± 2.5	70.7 ± 2.1	67.7 ± 3.0
Exam 3	70.0 ± 3.0	80.1 ± 1.9†	77.7 ± 2.5†

† Indicates statistically higher mean score compared to Fall 1997 (*P*=0.01).

Overall performance in the course also improved in the semesters following the launch of the website. The number of students who received a letter grade of C (satisfactory) or better increased from 68% in Fall 1997 (prior to the launch of the site) to 82% and 74% in the Fall 1998 and Spring 1999 semesters, respectively. Course failures decreased from 8.5% prior to the website launch to 4.2% and 5.0% in the two semesters following site launch.

In addition to improving performance, launch of the *Natural Science Pages* website expanded communication and teaching opportunities in the course. In the semester prior to site launch (Fall 1997), 18.1% of enrolled students sought outside help from the instructor by means of in-person office-hours meetings. In the two semesters following the site launch, in-person office-hours appointments remained comparatively constant at 19.6% and 17.1% of enrolled students in the Fall 1998 and Spring 1999 semesters, respectively. However, in the two semesters following launch of the site, an additional 5% of enrolled students contacted the instructor via email to ask questions and seek extra tutoring in the course (see Figure 2). The relatively anonymous nature of email communication appears to allow otherwise inhibited students to more actively participate in course discussions. In one particularly memorable email message, an enrolled student inquired about the similarity between intercellular cooperation and the population of 'Borg' from the television program *Star Trek: The Next Generation*.

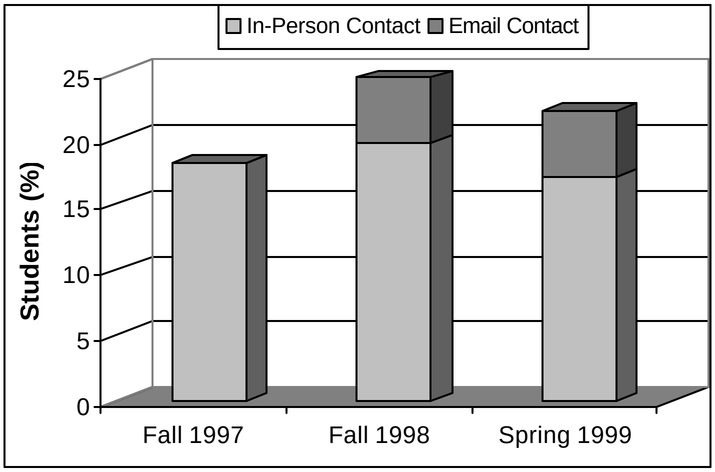


Figure 2. Student/Instructor communication before and after launch of *The Natural Science Pages* course website. While in-person contact remained relatively consistent before and after launch of the website, the number of students asking the instructor subject-related questions increased significantly after launch as a result of email communication.

In addition to its utility in the target course, *The Natural Science Pages* site generated widespread interest outside of John Jay College. In its first semester of use, the site received more than 9,000 visits; it has logged more than 80,000 visits to date and the site has been accessed from over 67 different countries (FXWeb, 2001).

As a means of evaluating and improving the conceptual design of the website, the project solicited feedback from NSC107 students and external users through in-class surveys, email comments, and student interviews. This feedback helped to clarify strengths and identify needed modifications in the website's design.

The modular design of the lessons was identified as a significant strength of the site because, as intended, it helped to focus users on a given topic and allowed them to progress through the content at their own pace. One student's evaluation comments summed up this sentiment, "I found that the website was more to the point, yet more detailed and more helpful than the textbook. The lessons contain all of the information you need, and the links are nice to give more detail." During extensive interviews with site users, it was discovered that many students were printing the lessons, reading them at their leisure and then returning to the site (usually via the high-speed connection available at the College) to view the animations and links connected to the lessons. This was especially true for those students who had little or no Internet access from their home. It was therefore recognized that modifying the lesson format to facilitate printing would significantly enhance the utility of the material to minority and underprivileged populations that have less access to computer technology.

User comments were overwhelmingly supportive of the animations that illustrated many of the concepts. Over 89% of students responding to the class survey (N=121) identified the animations as “helpful,” and 60% identified them as “very helpful.” However, the practice of placing animations directly on the lesson pages was identified as problematic. Users found that background motion was distracting when they were trying to read the lessons and embedded animations were cumbersome when a user tried to print lesson material. Also, because animations tend to have large file sizes, placing them directly on the lesson pages slowed loading times. User comments suggested that separating animations from the main module window would improve the site design.

Site users were also strongly supportive of the external links placed on the module pages. Almost 66% of students identified the external links as ”helpful,” and 32% identified them as “very helpful.” Most users recommended extending the diversity of links on the module pages to include news, experiments, and current events. Site users also suggested that the external links would be more helpful if they were categorically arranged to differentiate background reading from advanced material from historical references. Over 82% of students responded that they would use the external links more if they were broken into categories such as news articles, additional readings, etc.

SITE REDESIGN

As a result of the success of this prototype and in response to the suggestions for improvement, I began work on a public science education Web portal, *Visionlearning* (http://www.visionlearning.com), in summer 2000. The evaluations from *The Natural Science Pages* project were used to identify improvements for the new *Visionlearning* website. In addition, published science education standards were used in the development of the new site lessons to ensure that they would promote inquiry, place subject matter in the context of current and historical research discoveries, and place emphasis on understanding by integrating related scientific concepts (AAAS, 2000; NSF, 1997; Pratt, 1997; NAS, 1996). In August 2000, the *Visionlearning* website was publicly launched for evaluation with support from the National Science Foundation’s Educational Materials Development program (Figure 3).

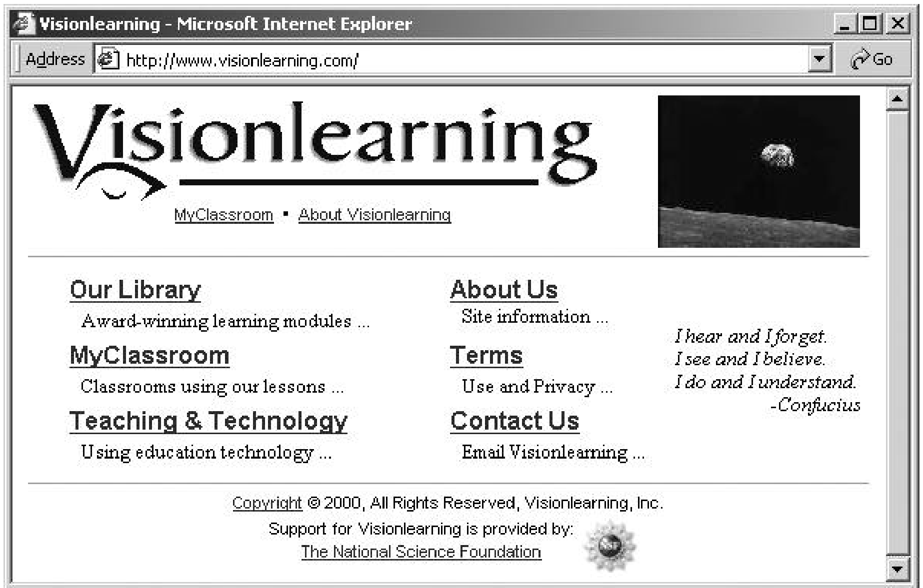
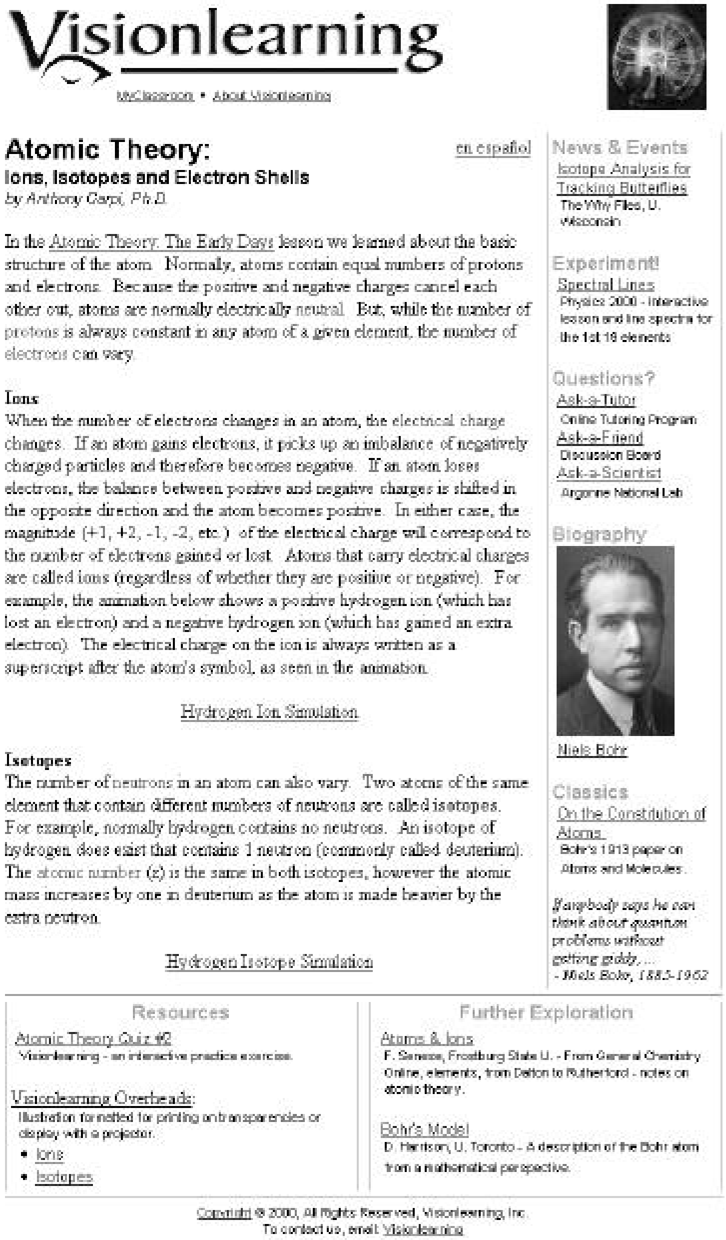


Figure 3. Homepage of the *Visionlearning* science education Web portal (http://www.visionlearning.com). The portal offers a library of teaching modules that have been developed using information from our ongoing evaluations. These modules have been shown to help improve student comprehension and interest in science.

The core aspect of the *Visionlearning* portal is a set of interdisciplinary science education modules (“Our Library”). The design of these modules draws on our evaluation of *The Natural Science Pages* project and on published educational website design standards (Carpi, 2001; Manske, 2001; Brown, 1997). All of the modules have consistent and distinct features to facilitate their use in the classroom. Each module contains a core written lesson. These lessons cover fundamental scientific concepts that are widely taught in introductory science courses. The module pages have been created with a fixed width to enable easy printing. All technical terms in the core lesson are linked to an external pop-up glossary. The glossary allows students to spend less time looking up terms and more time focused on the subject matter. The core lessons also include animations that help illustrate the scientific concepts covered in the lesson. Learning from the evaluation of *The Natural Science Pages* project, the animations on the *Visionlearning* website are not embedded in the core lesson but load in secondary pop-up windows.

The previous evaluation of *The Natural Science Pages* website suggested that students would use the external links more if they were arranged into distinct categories (Carpi, 2001). In response, a standard set of link categories was incorporated into the *Visionlearning* modules. To illustrate the design of these modules, an abridged version of an "Atomic Theory" lesson is included in Figure 4. Starting in the upper right corner of Figure 4 and moving clockwise, the first link category is *News & Events*, which integrates current news articles and research discoveries, helping to present the subject matter in the context of research and societal perspectives. *Experiment!* links incorporate material that permits user interaction and discovery. *Questions?* links provide access to communication resources such as an online tutoring system, student discussion boards, and 'Ask-a-Scientist' pages. *Biography* links add scientific history by integrating the life stories of key scientific figures. *Classics* links provide actual historical articles, recordings, or speeches of scientists. *Quotations* help ground concepts in real-life thoughts and statements. A *Further Exploration* section provides links to complementary lessons that allow the student or instructor to easily explore a subject in more detail. Finally, a *Resources* area provides material such as interactive practice tests, overheads for class presentations, scientific calculators, and more. In this way, each module serves as a homepage for a specific concept, allowing the student to explore the topic in as much detail as desired.



Visionlearning

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Atomic Theory:
Ions, Isotopes and Electron Shells
by Anthony Carpi, Ph.D.

en español

In the Atomic Theory: The Early Days lesson we learned about the basic structure of the atom. Normally, atoms contain equal numbers of protons and electrons. Because the positive and negative charges cancel each other out, atoms are normally electrically neutral. But, while the number of protons is always constant in any atom of a given element, the number of electrons can vary.

Ions
When the number of electrons changes in an atom, the electrical charge changes. If an atom gains electrons, it picks up an imbalance of negatively charged particles and therefore becomes negative. If an atom loses electrons, the balance between positive and negative charges is shifted in the opposite direction and the atom becomes positive. In either case, the magnitude (+1, +2, -1, -2, etc.) of the electrical charge will correspond to the number of electrons gained or lost. Atoms that carry electrical charges are called ions (regardless of whether they are positive or negative). For example, the animation below shows a positive hydrogen ion (which has lost an electron) and a negative hydrogen ion (which has gained an extra electron). The electrical charge on the ion is always written as a superscript after the atom's symbol, as seen in the animation.

Hydrogen Ion Simulation

Isotopes
The number of neutrons in an atom can also vary. Two atoms of the same element that contain different numbers of neutrons are called isotopes. For example, normally hydrogen contains no neutrons. An isotope of hydrogen does exist that contains 1 neutron (commonly called deuterium). The atomic number (z) is the same in both isotopes, however the atomic mass increases by one in deuterium as the atom is made heavier by the extra neutron.

Hydrogen Isotope Simulation

News & Events
Isotope Analysis for Tracking Butterflies
The Why Files, U. Wisconsin

Experiment!
Spectral Lines
Physics 2000 - interactive lesson and line spectra for the 1st 18 elements

Questions?
Ask-a-Tutor
Online Tutoring Program
Ask-a-Friend
Discussion Board
Ask-a-Scientist
Argonne National Lab

Biography
Niels Bohr

Classics
On the Constitution of Atoms
Bohr's 1913 paper on Atoms and Molecules.

If anybody says he can think about quantum problems without getting giddy, ...
- Niels Bohr, 1885-1962

Resources

Atomic Theory Quiz #2
Visionlearning - an interactive practice exercise.

Visionlearning Overheads:
Illustration formatted for printing on transparencies or display with a projector.
- Ions
- Isotopes

Further Exploration

Atoms & Ions
F. Senese, Frostburg State U. - From General Chemistry Online, elements, from Dalton to Rutherford - notes on atomic theory.

Bohr's Model
D. Harrison, U. Toronto - A description of the Bohr atom from a mathematical perspective.

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Figure 4. Illustration of the layout on the *Visionlearning* website. Each module in the *Visionlearning* library contains a similar layout with pop-up glossary definitions and pop-up animations integrated into the body of text, as well as categorized links to resources such as news stories, scientist biographies, etc. Students using the *Visionlearning* modules scored significantly higher on subject comprehension quizzes than students who used a traditional textbook.

EVALUATION OF THE REDESIGN

To determine if this new Web page design improved student learning, the *Visionlearning* modules were used and evaluated in *Introduction to Science in Society* (NSC107) at John Jay College in Fall 2000 (N=454 students). During this semester, eight lecture sections of NSC107 were taught (N=42 to 73 students per section) and all sections shared the same syllabus and requirements. The eight sections were broken into three groups that used different educational resources to support the faculty lectures. Group 1 consisted of three sections that relied solely on a series of education modules on the *Visionlearning* website for required readings (Visionlearning, 2000). Group 2 (four sections) relied on a combination of a published introductory science textbook (used previously in the course) and the earlier *Natural Science Pages* website. Group 3 (one section) relied solely upon the published introductory science textbook.

At the end of the semester, a standardized, multiple-choice assessment quiz was administered to all eight sections. The assessment quiz focused on core scientific principles taught in the course and was reviewed by the introductory science faculty at John Jay to ensure fairness and relevance. Results from this assessment quiz indicate that the *Visionlearning* resources significantly improved science comprehension (see Table 2).

Table 2. Mean scores (%) ± 95% Confidence Interval (CI) on a science comprehension assessment quiz in 8 sections of the interdisciplinary science course NSC107 (N=454). Students who used the *Visionlearning* website for course readings scored significantly higher than all other students on the quiz. Students who used the earlier website plus the textbook for readings scored higher than those who used the same textbook alone.

	Group 1: Class sections (N=177) using the *Visionlearning* website	Group 2: Sections (N=234) using *Natural Science* website and textbook	Group 3: Section (N=43) using textbook only
Mean Quiz Score by Section (%) ± 95% CI	77.0 ± 3.0 76.3 ± 3.9 77.8 ± 3.3	61.6 ± 4.7 61.3 ± 2.8 66.1 ± 4.7 62.8 ± 3.5	54.8 ± 6.0
Group Mean (%) ± 95% CI	77.2 ± 1.9	62.7 ± 1.9	54.8 ± 6.0

Students in group 1, the *Visionlearning* group, earned scores on the assessment quiz that were 24% higher than all other groups. The *Visionlearning* students had an average quiz score of 77 points, significantly higher (P <0.001) than the average of 62 for students in all other course sections. The course sections that used the textbook and *Natural Science*

Pages website scored significantly higher on the quiz (average = 63.0) than the one section using the textbook alone (average = 54.8, $P \leq 0.04$), confirming our earlier findings that this resource was pedagogically beneficial.

Additional data were collected during classroom testing to assure the accuracy and objectivity of the evaluation. Students were asked to self-report their use of the *Visionlearning* website during the assessment on a scale from "often" to "never." Actual use of the website is an important factor to measure since many students do not complete required course readings, and, since the *Visionlearning* modules are publicly available, students were able to access them regardless of the class section in which they were enrolled.

Those students who categorized their use of the *Visionlearning* website as "often" had an average score of 75.6 ± 2.0% on the assessment quiz, more than 7 points higher than students that used the site less frequently ($P \leq 0.007$, Table 3). Students who reported "occasional" use of the website scored significantly higher (mean = 68.5 ± 5.1%) than those who reported "never" using the site (mean = 61.6%). No statistically significant difference in quiz scores was found between students who reported "seldom" use and those who reported "never" using the site (mean = 64.4% and 61.6%, respectively).

Table 3. Mean student scores (%) ± 95% Confidence Interval (CI) on the science assessment quiz categorized by self-reported use of the *Visionlearning* website. Those students who reported using the website at least once per week scored highest.

Use of the *Visionlearning* website	Often: once or more per week (N=157)	Occasional: once or twice per month (N=60)	Seldom: once or twice during semester (N=39)	Never (N=198)
Mean Score (%) ± 95% CI	75.6 ± 2.0	68.5 ± 5.1	64.4 ± 4.4	61.6 ± 2.2

Students who used the *Visionlearning* modules were also asked to report their satisfaction with the materials in a separate, anonymous survey instrument. Approximately 70% of students responding to the survey (N=184) felt that the *Visionlearning* content helped improve their performance in the required course. More significantly, over 90% of students responded that the *Visionlearning* materials helped increase their understanding of science (Carpi & Mikhailova, 2002).

To evaluate the use and utility of the external links and simulations on the modules, students were asked to report how often they used these materials on the survey instrument. The most commonly used resources were the *News & Events* links and the concept simulations with approximately 75% and 70% of students, respectively, reporting frequent use of these tools. Approximately 50% of students reported using the *Experiment!* links and the glossary definitions; approximately 30% reported using the *Biography* and *Further Exploration* links (these readings were not required in the course). Almost 75% of students reported that these external links helped increase their understanding of the subject matter (see Table 4).

Table 4. Percentage of students reporting use of the supplementary readings linked to the *Visionlearning* lessons. Despite the fact that these readings were not required for the course, a significant number of students used all of the materials.

Category of supplementary readings linked to the lessons	Percentage of students reporting use of readings (%)
News & Event links	75
Concept simulations	70
Experiment! links	50
Glossary definitions	50
Biography links	30
Further Exploration links	30

Students were also asked to list on the survey instrument any additional module features that they felt would be helpful. The two most commonly listed features were practice quizzes and communication tools. In response, interactive practice tests were added to the *Resources* section of all lessons in June 2000. In addition, the *Questions?* section was added to all modules in July 2000 to add advanced communication features such as an online tutoring system and an 'Ask-a-Friend' discussion board. In our most recent evaluation of the project (Fall 2001), it was found that students who reported using the external links on the core lessons scored an average of 7 points higher (P = 0.007) on the course exams than those students who reported not using the external links (Carpi, 2002).

APPLICABILITY

The design concepts discussed in this chapter can be easily applied to other subjects and disciplines. What we have discovered is that students learn better when the subject matter is taught within the context of current news, history, key figure biographies, and other interesting information. With the possible exception of the *Experiment!* section used in our lessons, other disciplines could benefit from using Web link sections that add contextual and historical relevance as well as communication tools to student lessons. A literature class website, for example, could benefit from the addition of literary news and biographies of key authors discussed in the class. A history course would benefit from the addition of current events, biographies, and "further exploration" links that present events from different perspectives. By adding supplementary resources to course material through the use of a website, and clearly categorizing these links for students, instructors can significantly extend teaching opportunities in their courses.

The beauty of this system lies in the fact that an instructor can supply students with a wealth of learning opportunities, significantly beyond those which can be presented in a traditional textbook, while not inundating students with irrelevant information. In a printed textbook, an author struggles to balance the need to incorporate anecdotes and history with the desire to keep the textbook a reasonable length. Unfortunately, this often leads to textbook chapters that contain significant amounts of irrelevant information, while at the same time lacking quality. In a modular, Web-based system like that created in the *Visionlearning* project, an instructor can choose which supplementary readings he or she wants to require that their students read. More significantly, in this type of system the required concept readings are clearly defined, and the student is free to choose related supplementary readings (news, biographies, etc.) that they feel might help them learn the subject matter. In this way, the system adapts to individual learning styles rather than forcing all students to learn according to a textbook formula.

CONCLUSIONS

Web content can significantly extend traditional teaching resources by providing interactive multimedia material not available with static printed pages, and by leveraging the wealth of existing Web content to provide a rich learning environment. This project has demonstrated that well-planned Web-based materials can be more effective than a traditional textbook in teaching. Web-based materials must integrate text, animations, interactive features, communication tools, and Web content in a carefully planned design to effectively use the strengths of the Internet for education.

By using lessons that are created in a concise modular format that contains links to supplementary readings, an instructor can help focus students on the core concepts while significantly extending the learning opportunities presented to students. In evaluations of the *Visionlearning* system, students stated that the site lessons were both more focused and precise than a traditional textbook while also being more detailed and robust than a text. These seemingly contradictory results are achieved by creating lessons with relevant content, yet enriching these lessons with optional supplementary readings gathered from the wealth of content already available on the World Wide Web. A significant number of students used all of the different categories of links that were provided despite the fact that these links were not required for the course.

To take advantage of modular Web pages as described here, it may seem that instructors must add a large amount of new material to their existing curriculum, but that is not necessarily the case. By making optional linked material available to students through the creation of a well-planned course website, the instructor extends the possible avenues through which the student can learn the required subject matter. Different people learn best through different methods. By creating a rich learning environment that is filled with a range of optional teaching resources, instructors allow students to make individual decisions regarding their strengths and preferred learning strategies.

ACKNOWLEDGEMENTS

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