ESSENTIAL DESIGN ELEMENTS FOR SUCCESSFUL ONLINE COURSES

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ABSTRACT

Over a 4-term period from Spring 2000 to Fall 2001 an introductory, non-majors geology course was offered online at Brooklyn College, and was the subject of a two-year case study of the experiences and attitudes of the enrolled students. Three major course design aspects appeared to be most important for developing a sense of comfort regardless of the specific content or delivery techniques: 1) familiarity with online learning; 2) navigation and link structure; and 3) communication. Iterative assessment and redevelopment of the course allowed for significant improvement in student comfort. Key points to consider when designing a web-based course include: 1) easing students into the new learning environment; 2) avoid complex networked navigation structures because simple, hierarchical navigation structures result in increased student comfort; 3) lead by example in email communication – email often and reply in a timely fashion; 4) let the computer act as a tutor in the form of interactive quizzes and tutorials; 5) be precise in the wording of all communication and instructions

Keywords: internet, navigation, communication

INTRODUCTION

The internet is the newest technological innovation that has been touted to have the potential to revolutionize education. It holds the promise of making learning more accessible, improving the quality of learning and reducing the cost of education (e.g., Ostow, 1997). With such remarkable possibilities it is not surprising that many colleges encourage, or even mandate, as in the case of UCLA (Noble, 1997), the development and implementation of educational websites. The devout acceptance of web education as the future of teaching and learning is reflected in statements such as the following quote from "Transforming Higher Education: A Vision for Learning in the 21st Century" (Dolence and Norris,1995): "Those who realign their practices most effectively to Information Age standards will reap the substantial benefits. Those who do not will be replaced or diminished by more nimble competitors."

Is this technological revolution likely to come to pass, or is it as Grineski (1999) argues, merely a reflection of a strong, self-sustaining societal belief that technological advances hold the key to success? Earlier technologies such as television, videotapes and computers in the classroom also held the promise of educational revolution. However, an overwhelming number of studies concluded that there was no significant difference in learning outcomes when traditional techniques were compared with learning assisted by these technologies (see the more than 350 published studies compiled at http://teleeducation.nb.ca/nosignificantdifference). Clark (1994) argued that this "no significant difference phenomenon" demonstrates that learning is caused by the instructional methods embedded in the presentation media and not the media themselves. Accordingly, it is far more important to direct our attention to understanding how learning can be facilitated on the web and what basic design elements decrease student frustration and aid learning. This information can then be directly applied to the design of a new generation of web-based courses that incorporate instructional methods that are truly appropriate and adapted to web delivery. Only then will there be a possibility for a technological revolution in education.

Media researchers have noted that when new media are introduced, they initially replicate the functions of older media. For example, early movies were essentially celluloid versions of unaltered stage productions (Carpenter, 1972). When television was young, material was transferred unaltered from radio (McLuhan, 1964). Similarly, educators have transferred existing lecture-hall courses onto the web with little or no change and so have done little to exploit the potential of this new technology (Bork, 2000; Hokanson and Hooper, 2000). In fact, a simple transition of material from the classroom to the webpage would likely lose effect because much of the communication that takes place in a classroom is not easily translated with simple text: tone of voice, facial expression, gestures, environmental cues (Kupritz, 2000)

The transfer of traditional educational media to the web appears to be the current state of web-based education. Mioduser et al. (2000) conducted a survey of over 400 science and technology educational websites to document the style of teaching and learning currently presented on the web. They concluded that educational web sites are still dominantly text-based. Only 31% used graphics commonly, and only 1% of the sites exploited interactive graphics. Less than 3% of sites supported any form of collaborative learning. Thus they concluded that modern pedagogical approaches are far from being implemented appropriately in most educational web sites. They describe the current situation as: "One step ahead for the technology, two steps back for the pedagogy".

Internet-based learning is essentially a new distance-learning phenomenon, however, one that has the potential for considerable interactivity. Many of the observations and conclusions based on other distance-learning methods will undoubtedly be applicable to web-based learning. However, it is essential to understand more fully the specific aspects of this medium that will affect learning. What impedes or promotes learning? What impedes or promotes communication and formation of community? What frustrates or motivates students? What teaching methodologies are best suited to this learning environment? Questions such as these must be answered before web-education, and the findings implemented, before web-based education can demonstrate its true potential. Accordingly, this study aimed to understand how students perceive and interact with web-based education so that the web-education experience can be improved. In particular, this study aimed to understand how undergraduate students learn classical geological laboratory ideas and skills through activity-based instruction through the internet, and how the experience can be further improved.

The focus of this case study was an embryonic web-based course in introductory geology. Over the

2-year study the website expanded and improved iteratively based on feedback from students each term. At the conclusion of this initial study in January 2002 the website was only just beginning to take on a mature form that was well adapted to the interactive and visual medium of the internet. This study intended to discover the basic nature of an effective website, regardless of its complexity. It was a descriptive study not a comparative one.

As a field geologist, I would consider it foolish to compare the details of one region to another until I had first described/investigated/researched each area independently. Only after I had gained a firm understanding of the two regions might I choose to conduct a comparative study of the two. Similarly, as an educational researcher, it would be improper of me to compare two learning media until both had been sufficiently described, documented and/or understood on their own. To date there is insufficient understanding of the online learning environment. Accordingly, this study was designed to gain broad descriptive data of a working online course rather than to compare it to a similar traditional course.

Comparative study of educational media is vitally important. However, such studies would only be meaningful if the courses compared were at similar stages of development. To directly compare the effectiveness of a newly introduced online course to a long-established in-class course would more likely compare the value of preparation and revision in course development rather than the relative effectiveness of each medium. Detailed comparative studies will follow, but only after the relatively new online courses have been designed and redesigned to incorporate methods of best practice adapted to the medium of the internet. In the meantime, this paper provides data to suggest several basic rules of pedagogical design of online courses.

DESCRIPTION OF THE STUDY

Description of the College and the Course Studied - This study was undertaken at Brooklyn College of the City University of New York. The campus is non-residential and so the student body reflects the cultural and ethnic diversity of the borough itself.

Brooklyn College offers a liberal arts education for its undergraduate population. All baccalaureate students are required to take a set of 10 courses that are designed to expose students to the principal branches of learning – the arts, humanities, social sciences, and sciences – and to provide a rigorous foundation for study in a major field. This set of required courses includes 4 science courses, of which one is geology. Approximately 1,400 students enroll in this geology course (CORE 8.2) each year. The purpose of this course is to demonstrate how geology can affect the lives of the students in their urban environment, and how "thinking like a geologist" could be brought to bear on modern issues.

Students may take this course at any time before graduation so each class has a mix of students from freshmen to seniors, although students tend to take CORE 8.2 late in their academic program. Most students are not science majors and none are registered as geology majors. CORE 8.2 classes generally consist of 80 students within each lecture section that meets weekly for approximately 90 minutes. Each lecture section is divided into four lab sections of 20 students each. The typical lab meets seven times throughout the term, in addition to a local field trip. Labs meet biweekly for 2 hours. Each lecture and lab may be taught either by full-time faculty or adjuncts. Each instructor, particularly full-time faculty, generally has autonomy to choose both content and teaching style. Thus the lectures and labs are essentially independent.

Limited online labs for CORE 8.2 were first offered in spring 2000. One section each of two independent hybrid lab courses (ones that involve both online and in-class learning) have been offered each term since. The section designed and offered by D.J. Leveson was the focus of this case study. His lab course was conservative in content, focusing on classical geological skills and knowledge in 3 modules: minerals, maps, and the landforms of New York City. The current version of his webcourse can be accessed at http://academic.brooklyn.cuny.edu/geology/leveson/core/corehome.html.

Enrollment in the virtual sections of CORE 8.2was voluntary, with only two out of a minimum of 12 sections per term having an online laboratory component. Students who were interested in the online sections required departmental permission, and so, could not have enrolled in the class accidentally. Based on voluntary student surveys, approximately two-thirds of the class wished to experience the virtual geology labs, whereas the remaining students registered out of necessity because the in-class sections were full, or conflicted with their schedules.

Methods - Whereas a version of a partially online geology lab course was offered in Spring 2000, the instructor realized that this was only a first step, and that vast improvements were possible. Accordingly, the overall objective was ultimately to create a more effective web-based and eventually to adopt a student-centered, inquiry-based instructional method adapted to the internet. To achieve these goals Professor David Leveson and I needed to know more about how students dealt with this specific web-environment. What engages students? What drives them? What distracts them? What frustrates them? This information may then guide us in the development of more pedagogically sound delivery techniques, presentations and structures.

Questions like those listed above are more effectively investigated using qualitative methods such as case study (Stake, 1988; Yin, 1989). In general, quantitative studies quickly reveal broad patterns whereas qualitative studies, such as case study, elaborate on the underlying causes of the learning outcomes (Maxwell, 1996). For example, the deficiency of a purely quantitative analysis of student outcomes is illustrated in Shaw and Pieter (2000) who note that in a study of 51 advanced level health and nutrition students who participated in a quantitative analysis (Likert-type questions) of attitudes towards a particular online course, 52% felt that web-based delivery made the material easier to understand. Such borderline results are difficult to interpret without additional, meatier data. Web-delivery in this case was not an overwhelming success. Clearly it could be improved, but how? What was it about the delivery that benefited 52% of the students? What was it about the delivery that did not help 48% of the students? Without knowing this, that particular web-based course could not be improved efficiently.

Demographic	Term in Which Course was Offered			
	Spring 2000	Fall 2000	Spring 2001	Fall 2001
Students in Study	7	7	12	6
Females	7	3	8	4
Males	0	4	4	2
Freshmen	0	0	1	0
Sophomores	0	0	1	1
Juniors	3	3	7	1
Seniors	4	4	3	4
Students who had completeded previous online courses	2	6	6	1
Mean GPA	2.98	3.01	3.04	n/a
Mean Age	25	22	27	21
Minerals Module	not offered	offered	offered	offered
Maps Module	offered	offered	offered	offered
Geology of New York Module	limited offering	limited offering	offered	offered

Table 1. Summary of emails received by the instructor from students.

Case study was employed in this qualitative research project. This research method is a qualitative approach that investigates the phenomenon of interest within its real-life context (Yin, 1989). The boundaries of the phenomenon are unclear, becoming defined only as the study unfolds. Interviews, questionnaires and document analysis are commonly employed data collection techniques in case study, and each was employed here.

For each of four consecutive terms between fall 2000 and fall 2001, one lab-section of CORE 8.2 was scheduled for the virtual lab created and delivered by Leveson. Each lab section consisted of approximately 20 self-selected students. The paired lecture course was taught by a different instructor each term, however, the lab and lecture components of each course section run as autonomous courses for which the marks are combined at the end.

Students who wished to register in the virtual lab section of CORE 8.2 were required to request permission in person, and sign a "Student Declaration" in which they stated that they understood the nature of the course delivery. Participation in the evaluation of the course experience was voluntary, although a 5-point bonus was offered as incentive for involvement. Student participation involved: 1) an introductory questionnaire that aimed to understand the student and their experience and comfort with both computers and science; 2) post-module questionnaires to immediately assess student reactions to segments of the course; and 3) a 30-minute post-course semi-structured interview that was recorded and transcribed. Documents collected for analysis included student assignments, exams, the log of email communication between the instructor and his students and in the third term, a set of independent college-mandated surveys based on Likert-style scales.

A total of 32 students were interviewed: seven in each of the first two terms, twelve in the third term, and 6 in the fourth term. The demographic data of these samples are summarized in Table 1. This sample was composed of volunteers, of which there were ten males and twenty-two females; one freshman, two sophomores, thirteen juniors and sixteen seniors. The age of volunteers ranged from twenty to mid-forties, with twenty-seven participants being twenty-five years of age or younger. Seventeen participants had previously completed at least one other online course.

After the interviews had been analyzed, patterns in student responses were reported to the instructor and extensive discussion of potential improvements occurred between the instructor and the evaluator. Segments of the website were then redesigned prior to the next offering of the course. The process was then repeated in the following two terms. Over the 4-term study of the online CORE 8.2, student perceptions evolved as the site also evolved in response to their criticisms and the instructor's further understanding of his student's experiences. Each term the ratio of virtual to in-class work increased, from an initial 25% to a final 85%.

STUDENT EXPERIENCES WITH THE ONLINE COURSE

As is the nature of case-study, the key issues and commonalties only become apparent during the initial phases of the study. These critical aspects, once identified, become the focus of the remaining investigation. Comfort with online learning was the predominant issue that surfaced. Three major course design aspects appeared to be most important for developing a sense of comfort regardless of the specific content or delivery techniques: 1) familiarity with online learning; 2) navigation and link structure; and 3) communication. Each of these three major topics will be discussed in detail from the student perspective.

Familiarity with Online Learning - The perception of comfort with online delivery of course material, and so the acceptance of this form of instruction, changed considerably since the initial run of the virtual geology lab. The amount of in-class contact decreased progressively from term to term and yet so did the desire for additional classroom contact. In the first term, only one of the three course modules (maps) was offered as a fully online exercise. Even then, students had the option of attending the regular lab session for additional help in a tutorial format. Despite the minimal online delivery, students in Spring 2000 strongly expressed a desire for more in-class instruction from the instructor. In subsequent terms the proportion of online delivery increased progressively to 85% in the fourth term. In these later offerings with larger, and iteratively improved, online components, most students reversed the opinions of the initial class and expressed a desire for even less in-class instruction.

At the end of the first term students unanimously expressed a desire for conventional teaching methods. Such sentiments are summarized in statements such as

Figure 1. Example of an image map used for navigation in the Spring 2000 offering of CORE 8.2. Clicking on any of the labeled boxes would link to the corresponding page.

the following: "I would rather have a book in my face so I can flip to the page that I want. I find it easier to deal with than to [navigate through the website]" and "[I would have liked] More in class. Like having a lab section in class that dealt with it before you actually get on-line and start figuring out on the computer because it is more difficult without having the information at hand and saying 'what does that mean, where do I go, how do I find that?'"

Just as online teaching is a new and difficult experience for most instructors, online learning is a new and difficult experience for students. And as with so many other endeavors, practice makes perfect. One needs time and experience to build necessary skills. In Spring 2000, the class jumped from fully face-to-face labs (minerals) to a fully online lab (maps), and furthermore they made this jump on an untested and complex website. There was no opportunity to build online learning skills gradually. It was sink or swim, and unfortunately most students sank. Then once this apparently traumatic online immersion exercise was complete, they returned to the familiar in-class setting for the last course module.

In the second and third terms students were eased into online learning. Initially they met in-class for a hands-on mineral lab. The following session was fully online, but dealt with the same concepts that they had learned in class. Rather than scratching a mineral with a real nail to test hardness as they did in week one, students virtually scratched a virtual mineral with a virtual nail to collect additional hardness data. Thus students could readily relate to what outcomes were expected for their first online lesson. When the subsequent fully online maps module was presented, students had already gained some familiarity and comfort with the web as a learning medium. Students gained confidence on an easier, more familiar lesson, before attempting the more abstract concept of maps. Evidence that students had developed trust and comfort in the site was apparent in numerous statements from students, four examples of which follow. 1) "The website was helpful. We were able to really understand something we dealt with in class. We can always go back to the information as many times as we wanted to on the website, you know to clarify. And if we needed a physical person like the professor, then we could always meet up with him during his office hours."; 2) "The first two in class sessions I think were important because he said that's what we're going to have to do on the final exam, and got us ready for what we're going to do on the website."; 3) "If I don't understand it I just go further. Because if I go to other places, other sites, it will give you general feedback right away."; and 4) "I usually keep searching. I don't understand about something I try to find out where it comes from and click through that and review over it."

Familiarity is essential for comfort. Students should have the opportunity to gradually develop proficiencies in an online learning environment. Initial face-to-face contact and explanation appears to be of great benefit in this regard. Content design is also important. Placing the most familiar, least abstract, and perhaps most fun modules at the front end of the course allows students to settle comfortably into the online course. If the course is only partially virtual, build towards increased online delivery. Provide web-enhancements to the course before modules that replace classroom sessions or make the initial online activities direct continuations of concepts learned in the classroom. And of course, make the site easy to use and keep lines of communication open.

Navigation and Link Structure - The first class had great difficulty navigating the site. The site was initially constructed with the idea that the site should allow students to jump back and forth readily from almost any point in the site. In designing the site in this potentially non-linear fashion the designer/instructor had intended to give each student more control over his/her own learning. Ideally each student could choose a path that best suited them, and be able to link to related concepts to discover connections, or review necessary material. For example, while learning latitude and longitude, a student might choose to divert their attention to a review of direction or the compass, if they felt such a review necessary. A schematic flowchart of the Spring 2000 maps module is illustrated in figure 1. Note that a distinctive feature of this layout is the ability to arrive at the same page from a number of different paths.

The concept of a non-linear educational site exploiting complex navigational tools such as image maps, and containing multiple links per page is one that is commonly believed to be best suited for the web environment. Mioduser et al. (2000) reported their surprise that such navigation structures appear in a relatively small number of science education websites. Furthermore, they advocated a networked structure as the desired template for webpage design.

Such non-linear navigation mechanisms created great confusion and frustration for students in this study. In the example of the student who diverted his/her attention from "Latitude and Longitude" to a review of "Direction", the following scenario could have occurred: the student could have proceeded from "Direction" to "The Compass" and from there to "Magnetic North" and from there to "Conversion" and from there to "Rounding Off". At this point it would be highly unlikely that the student would be able to easily return to the point where

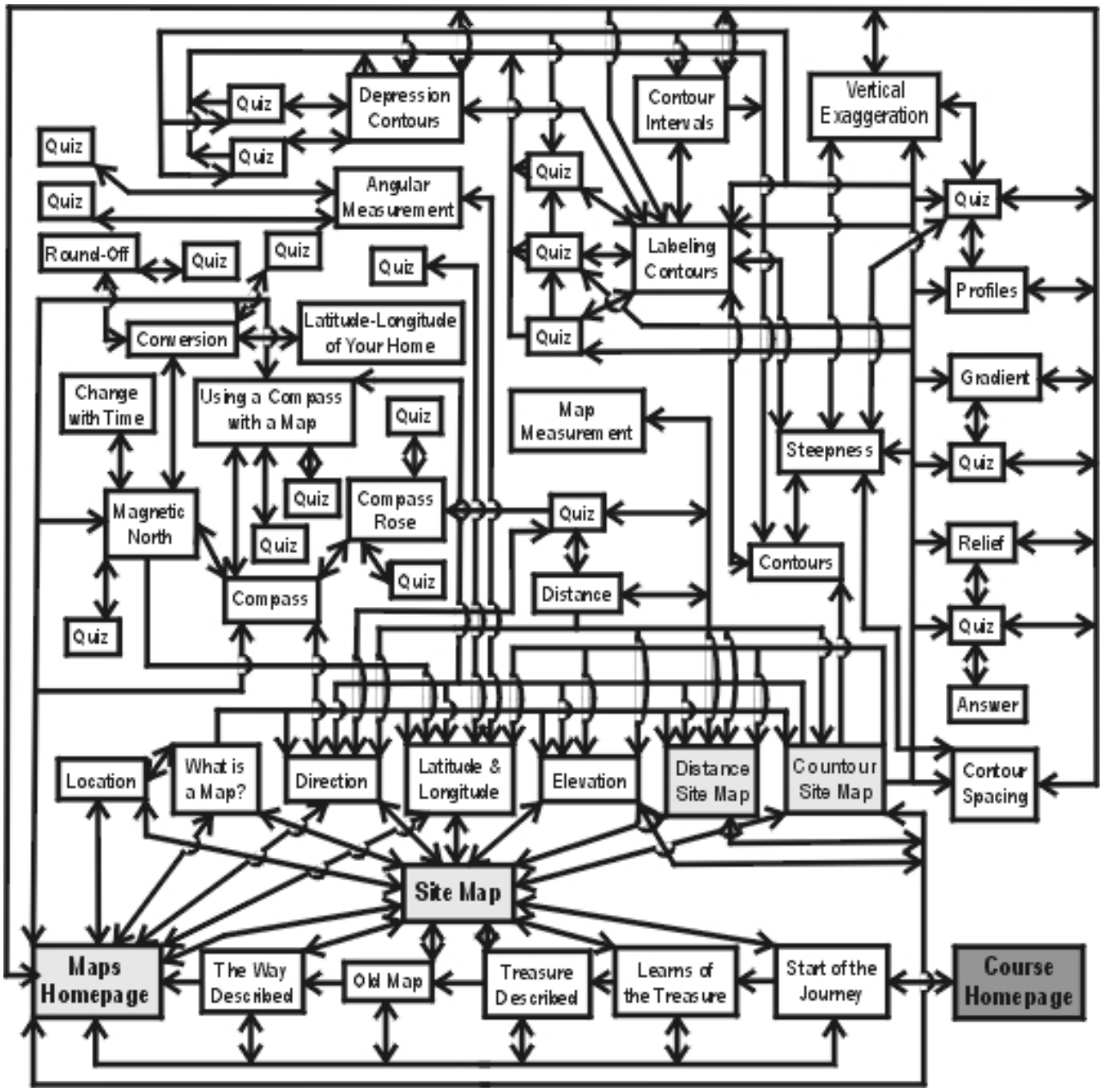

Figure 2. Schematic flowchart of the maps module offered in Spring 2000. Note that there are multiple routes to and from most of the content pages in the module.

he/she began their digression (surfing). The student would be lost in the website.

The complexity of the link structure was a primary concern for students in the first incarnation of the course. Many statements such as the ones that follow emphasized this point: 1) "Every place I went to I was able to click and I didn't know what to click on first and it was getting so confusing."; 2) "At first when I looked on the website for the maps I found it intimidating because it had a lot of links and sometimes it is confusing."; 3) "It took me a while to get used to the layout, and to figure out where I was, because with "directions" there are several different pages within "directions". Sometimes I would be somewhere in direction and it was kind of difficult to find out where I had left off."; and 4) "I had a little difficulty finding the sites. I think a lot of difficulty. I missed a bunch of them."

The use of image maps was provided as a means of facilitating navigation in the network of webpages, a strategy advocated by Mioduser et al. (2000). The pages and their linkages were displayed graphically. The intent was to allow students to see the connections between pages, provide a suggested navigation route, and allow students to move directly from page to page within a submodule. An example of such a site map is illustrated in figure 1.

Despite the potential benefits of these site maps, not a single student that was interviewed had made use of these navigation tools. Students knew that these site maps existed but chose to navigate solely by the links embedded in each content page. This suggests that the concept of an image map was unfamiliar to students, and so they felt uncomfortable using this tool. This should be a warning to webmasters who are considering the

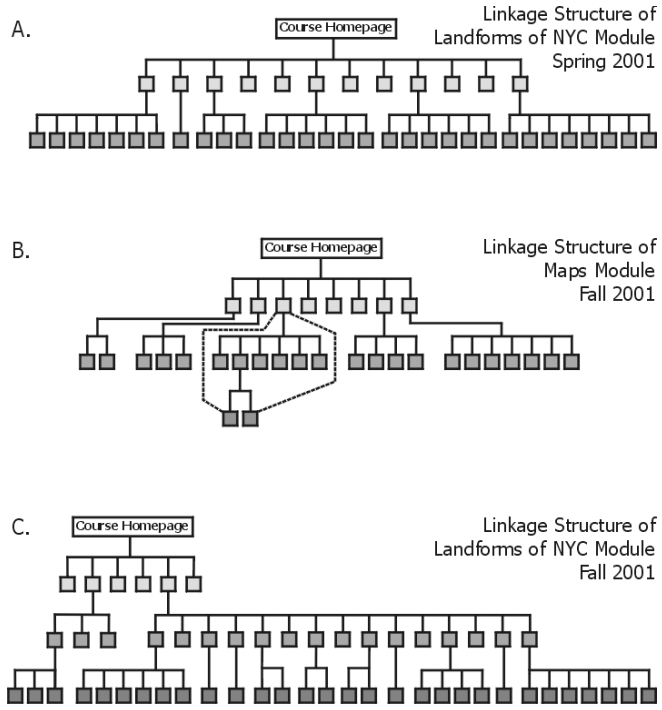

Figure 3. Schematic flowcharts of modules from Spring and Fall 2001 offerings emphasizing the hierarchical structure. A) Landforms of New York City, Spring 2001 designed in a two-tier hierarchy. B) Maps, Fall 2001 designed essentially as a two-tier hierarchy. Note that two links are provided (dashed lines) directly from the first-tier to the only two pages on the third-tier. C) Landforms of New York City, Fall 2001 designed as a three-tier hierarchy.

adoption of such complex forms of navigation. The use of image maps is not intuitive for the average student. Thus it is likely that specific coaching and introduction to image maps would be necessary for them to be effectively used by students.

Responses from students in the Fall 2000 class indicate three major impediments to learning that are caused by non-linear or networked navigation structures. First, if confusion continues, it quickly leads to frustration . Such a mental state both closes the mind to learning and reduces the desire to invest further effort (Hara and Kling, 1999). Secondly, without a clearly defined path it is far too easy for a student to miss pages altogether. Thus students could miss critical content and have no way of realizing their oversight. Finally, review (relearning) is an essential component of the learning process. In a complex, networked navigation structure students may not be able to easily find and return to pages of interest or concern.

In response to the above issues, the course structure was modified for Spring 2001 to restrict the possible navigation paths of a student. A potential pitfall of a restrictive structure is that it could overly limit a student's opportunities to review or make connections between concepts. To avoid this the designer/instructor created a nested hierarchical network. One menu linked each of the essential parts. Each complex topic was deconstructed into its essential parts. Each part was the focus of one page and each page was linked from a menu page. Accordingly, the linkage of concepts was implicit in the structure of the navigation links. An example of this structure is presented as a flowchart in figure 3. In contrast to the networked structure illustrated in figure 2, the nested hierarchical structure allows only one path to arrive at any given page.

Most content pages were terminal; once a student finished a page, the only navigation choice was a "Go Back" button at the bottom of the page that returned the student to the last page that he/she had visited (usually a menu). With this one-step-forward, one-step-backward approach to navigation within a nested hierarchy a student could not get lost, and furthermore the student would only be one, two, or at most, three clicks away from all major menus in the webpage. A study sequence was implicit in the presented order of the links, however, students were free to choose a different sequence if they preferred, but could not easily get lost.

Once these organizational changes were made, for the Fall 2000 term, students were generally satisfied with the navigational structure of the established modules of maps and minerals. However, in the third term, the instructor/designer introduced a wholly revamped module for "Landforms of New York City". This module required students to link together concepts from the previous two modules, along with new material, and use the information to evaluate three possible hypotheses for the formation of the landforms of New York. As a capstone investigation, and one that involved comparative evaluation of relatively complex concepts, the linkage of ideas was substantially more complex than in either of the preceding online modules. Nevertheless, the navigation structure for the Landforms of New York City was again based upon a hierarchical, branching structure, similar to that used in both minerals and maps. (Figure 3a and 3b)

Unfortunately, some of the content in this new module had not been fully deconstructed; several segments required students to jump back and forth between pages. In these cases the concern was not getting lost, but rather loosing the train of thought: "I didn't like the way the website was set up. It wasn't linear. It was like 'We are going to explain this, but as we explain this, let's go off on a tangent and let's talk about this. Let's explain more about this, and then, oh, let's explain more on that page' and so by the time they finished explaining something that they had to explain, and you went back to the first page, you were confused again."

In Fall 2001, the instructor/designer again redesigned the Landforms of New York City module. Content was exchanged between the pre-existing maps module and Landforms of New York City module (e.g., discussion of geological maps was moved from the landforms module to the map module) in order to improve the logical progression of concepts. In terms of the structural design, the main change was the introduction of a third hierarchical level in the landforms module (Figure 3c).

Although the architecture style of the two modules was similar, the use of a third hierarchical level resulted in an alarming rise in student frustration and dissatisfaction. In the first three offerings of the course, student concerns with navigation continually decreased. Only 2 out of 12 interviewed students from the Spring 2001 class expressed any concerns at all regarding navigation. However, 5 out of the 6 students interviewed after the Fall 2001 offering considered navigation to be among the most problematic issues encountered in the website. Specifically, this frustration was focused on the landforms module as the following statements indicate:

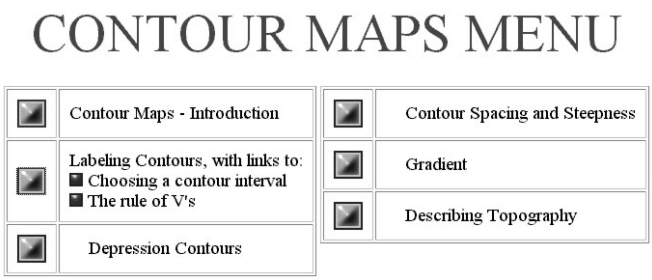

Figure 4. Contour Maps Menu from the Fall 2001 offering of the maps module. Note that links are provided from this first-tier menu both to second-tier pages (large buttons) and third-tier pages (small buttons).

1) "The landforms assignment was really difficult for me. I had to go to him several times to find out exactly what the hypotheses were, like differential deposition and all those things. It was kind of difficult for me to understand from the website. I kind of understood the rollovers but a lot of the requirements for the assignments were things that were located inside the website, that you had to go all over the website to search for, rather than having them clearly defined."; 2) "I just have a big problem with the navigation. I just felt there should be a navigation bar so you could constantly keep going back and forth. It was too much. I had to write down where I went and where I saw something and then I had to try to go all the way back there."; 3) 'There was a lot of back and forth. I couldn't follow it. I was like 'where was that?'. I had to go back 16 times and go forward to try to find things. It was so difficult."; 4) "The worst part was that I kept getting lost. There were so many different places you could go to. I was like 'is it this one? Is it that one?'. I wasn't exactly sure where I had to go for certain things."; and 5) "The New York City landforms one was a little tricky in finding certain things like certain rollover images."

Interestingly, the instructor/designer appeared to have intuitively predicted the problems that would result from the addition of a third content level. In the Fall 2001 maps module, a third hierarchical level was added for only one topic, "Labeling Contour Maps". The "Maps Homepage" linked to the "Contour Maps Menu", which linked to the "Labeling Contours" page. This page then linked to two additional pages, "Choosing a Contour Interval" and "The Rule of V's". However, when designing the "Contour Maps Menu" Leveson described the nested links in the menu and even provided direct links to the third tier (Figure 4).

Note that in this particular case, there were two different routes that could lead a student to the third tier pages; they could link from either the first or second tier menus. However, the use of the "Go Back" button permitted this minor example of networked architecture. Regardless of which path a student chose to reach the third tier pages, they could only jump back from their point of origin (A student that linked to "The Rule of V's" from the "Contour Maps Menu" had to return to the "Contour Maps Menu". A student that linked to "The Rule of V's" from the "Labeling Contours" page could only return to the "Labeling Contours" page.) Thus it was not possible for a student to get lost in the process.

The evolution of student perceptions of ease of navigation over the 4 term study indicates that the simplest navigation structures are the best received and result in the least student frustration. Networked navigational structures should be avoided, particularly with students with limited experience in online learning. A more rigid structure, such as a hierarchical, branching structure can be an effective means of facilitating learning for students by imposing a learning structure on the course. Such a rigid structure is something to which students are accustomed and comfortable, possibly because such structure exists in the more classical delivery methods of the textbook and the lecture. Furthermore, the hierarchical structure should be simple. Most of the information should be contained within two tiers (i.e., no more than two nested menus). If more levels appear to be necessary, then it would be best to further deconstruct the content in order to maintain the simple 2-level structure. Alternatively, if a third level is necessary, for limited use, then the menu descriptions for the first and second levels should be worded carefully and fully so that a student can predict the content of each of the lower hierarchical levels.

Communication - Communication problems were noted by students in each of the four classes. However, only in the first term was communication considered to be a major impediment by the class. Most students interviewed from the Spring 2000 class expressed a desire for an increase in face-to-face communication with the instructor. The perceived need for such face-to-face communication dropped sharply in the Fall 2000 class, and remained low through the successive two terms. This change in attitude certainly resulted, in part, from the simplification of the webpage's navigation structure, thereby making the site easier to use and giving students confidence in their use of the site: 1) "We can always go back to the information as many times as we wanted to on the website, you know to clarify. And if we needed a physical person like the professor, then we could always meet up with him during his office hours."; and 2) "If I don't understand it I just go further. Because if I go to other places, other sites, it will give you general feedback right away." However, the style and level of student-instructor communication also varied, and so these variables must also be considered.

The Spring 2000 offering was predominantly delivered in the classroom. Only the maps module was delivered online, and even for this unit students could attend face-to-face question and answer sessions scheduled during regular class time. Communication between the instructor and student occurred mostly by means of these classroom sessions or through messages posted to the website under the heading "Late Breaking News". Although each student had the instructor's email address, he received only 10 student emails throughout the term, only two of which involved questions that directly related to the online assignments.

At the end of the Spring 2000 term, it was clear from both student test results and the responses documented in this study that communication in general was terribly inadequate. In particular, the lack of student emails troubled the instructor. The instructor knew that he had to take a stronger, proactive role in developing and maintaining more rapid and convenient communication with his students, and perhaps between the students themselves.

Subject of Emails	Number of Email Messages			
	Spring 2000	Fall 2000	Spring 2001	Fall 2001
Assignment Questions	2	20	33	23
Content Questions		6	2	
Logistical Questions			9	7
Lateness/Absence	3	9	8	9
Web Errors	5	2	8	5
Submission		11	6	6
Booking Meetings		11	16	2
Replies/Confirmations		5	8	3
Technical Problems			6	2
TOTAL	**10**	**62**	**96**	**57**

Table 2. Summary of emails received by the instructor from students over the 4 terms of the study.

Improving the quality and quantity of email-based communication became a priority in subsequent offerings of the course. In the following three terms, each student was required to email the instructor to request permission to register in the online lab section. This both demonstrated that each student had some access to the internet, and more importantly, allowed the instructor to compile a complete email contact list for the class. Furthermore, during in-class meetings the instructor more actively encouraged emails as an effective form of communication between face-to-face sessions. Total emails received by the instructor were significantly higher in the later terms, 62, 96 and 57 for the latter three terms respectively (Table 2).

Students in the third offering of the web course had a significantly different view regarding communication with the instructor. All students that were interviewed remarked on the effectiveness of email communication with the instructor because his responses were rapid and directly applicable. In fact, several students considered the quality of student-instructor communication in the online geology lab to have been better than other in-class science labs: "When we have labs, it is hard to communicate because there are 40 or 50 people in the lab. Everyone is screaming and shouting. Everyone needs help. It's one professor and in the end you don't understand anything and you go and copy your lab from other students. While in the virtual lab you are doing your job by yourself from home. And if you have any problems you explain to the professor what is your problem and he explains to you. And you in the end learn more because you think and you study by yourself. While in the regular lab you try to do it because the professor sits there and you have to finish in one hour and you don't learn anything because you are just copying from other students. While you talk I copy."

Interestingly, the change in attitude had nothing to do with a change in the instructor's response time to emails, nor with the quality of his replies. The only significant difference in communication strategy between Fall 2000 and Spring 2001 was that rather than post messages on the website for students to read when they logged on, the instructor chose to send class-wide email messages. Over the 14-week term he sent a total of 19 class-wide emails. In Fall 2001 he sent a total of 11 class-wide emails, in addition to the personal responses to each students to document their results on each lab assignment. By doing so the instructor led by example and the students followed; the total number of emails received from students increased by 50% from the previous term to a total of 96 (Table 2).

Why student emails in Fall 2001 dropped is unclear. However, it can be seen that the most significant decrease in emails corresponded to those sent to set-up or confirm appointments, as well as those sent to seek clarification or assistance with specifics of lab assignments. This might have resulted from the improved wording and clarity of instructions delivered through the webpage, thereby avoiding many of the miscommunications present in earlier terms. Four of the six students interviewed after the Fall 2001 course stated that they never sought to communicate with the instructor, nor did they ever feel the need. Rather they felt that the resources were available for them to solve their own problems if they were patient and persistent.

Any perceptions of inadequate communication with the instructor stemmed from the fact that class sessions and office hours were scheduled, whereas the times at which students tended to work online were not. The result was a perceived mismatch between when a student worked and when corresponding feedback would be given; in each of the four terms, but particularly in the first term, there were students who did not feel that they could receive answers when they wanted them: "If I have questions I like to be able to ask right then and there." and "I emailed him. It bothered me so much especially when I was like "OK, I'm going to sit down and do this now", and then I got stuck on the first thing and I was like "great". Now maybe he will email me right back but what if he doesn't, then the rest of the night that I planned on doing this is done with. That was very very irritating."

This issue, is certainly an important one, in that certain students find the lag in communication to be truly frustrating. However, the problem may be intractable if students are permitted to exploit the asynchronous nature inherent to web-education. While the course is available at any time of the day, it is not possible to make the same promise of the instructor. Accordingly, it seems that perhaps it would be better to try to identify those students who would be troubled by this form of communication and steer them towards enrolling in conventionally delivered courses because their expectations for communication might be unattainable

in a truly asynchronous course. The words below are from one such student. While she "didn't want to go to class", she seemed to feel that the instructor should be available to her at whatever time she desired: "Especially if it was at night he didn't email me back right away. But any time during the day up till six or seven maybe he was very very quick. And every time I have a question he totally answered my question, no problem. That was good. Because I thought that maybe it would be hard to explain what my problem was coming across on email. So I really didn't have a problem with that. I was just really annoyed to not have an immediate response that's all. Maybe instant messenger would be a good idea."

A perception of delayed communication can lead to more than a general feeling of frustration. A number of student's learning was directly diminished because of their tendency to avoid asking necessary questions. This was particularly evident in the Spring 2000 class, members of which expressed statements such as the following: 1) "I should have asked more questions with the formulas and all that, but I figured that I would teach myself."; 2) "I was totally lost in class and it was too overwhelming and I couldn't pinpoint one specific thing and so I decided 'I don't get it. Leave it alone'."; and 3) "I hate to have to go back and forth from the computer. You know, writing notes back and forth to say 'I am not getting this'. And no one is there to really help try to understand what is happening."

The experiences with the four classes studied here suggest that online classes will always contain students that expect conventional synchronous communication despite the fact that the medium is asynchronous. However, the marked improvement in student attitudes toward instructor-student communication during this study suggest that the impact of this issue can be greatly reduced if the following steps are taken:

1) Provide detailed and tested instructions within the website. It is safer to err on the side of wordiness, than to skip steps that may seem self-evident to you.
2) Be proactive and open email communication yourself at the beginning of the course. Continually remind the class of your presence with email messages of clarification or encouragement.
3) Respond to email promptly and define for the class the response time that they can expect from you. Whether it be 12 hours, 24 hours, or whatever you feel is both possible and reasonable, maintain your commitment to the students.
4) Define specific times when you will be available for immediate email response, and/or times when response times will be shortest. Concerned students could then adapt their work schedule around those times.
5) Increase opportunities for student-computer communication. Incorporating quizzes that include correction/validation allows students to identify problems and/or recognize their understanding of the material. Students need confidence born from the validation of their responses, if the computer can take on this communication role, then students will be less reliant on the immediate response of the instructor.

Of course student-student communication is another form of interaction, but one that was not explored significantly in this project. Throughout the four terms of the study student-student communication remained minimal outside of the lab room. Each term students were encouraged to exchange emails and were required to work in groups during their in-class sessions in order to facilitate the forging of bonds between students in the class. In response to the recognition that student-student communication had been minimal during the first term's online activities, an assignment was introduced in the second term that required the online co-operation of four group members: each member was required to forward a piece of the solution to the other members, and thereby allow the group to complete the entire project. This experiment was disastrous, with half of the groups complaining of members who did not distribute their answers. This experiment in student-student communication was not repeated.

A few students attempted to get help from classmates through email communication. However, in each case the student found that the peer would either respond late or not at all. Thus students discovered that they could expect a faster and more accurate response from their instructor than they could from their peers. Thus students came to rely on electronic interactions with the instructor as their primary form of feedback in the course.

CONCLUSIONS

The internet is a relatively new educational medium. This means that internet-based teachers must adapt their instruction style and methodology to suit the web. Also it means that internet-based students must adapt their learning style methodology to suit the new mode of delivery. As teachers we must strive to make the learning process as effective and comfortable as possible for our students, and that cannot be accomplished without a clear understanding of the educational medium that we employ.

Understanding the processes of teaching and learning in an online environment is difficult because we do not have direct contact with our students. We loose critical cues such as body language, and immediate and spontaneous responses and questions. Case study involving detailed follow-up of student experiences is a vital tool for understanding the new world of online education.

We are only just scraping the surface of this new realm of pedagogy. Many of the rules that applied to conventional in-class education are inappropriate to web-based education, the problem is that we are still just discovering which rules are inappropriate and what new web-adapted rules must replace them. This study attempted to understand some of the basic design elements and rules that are essential to effective teaching on the web. The course and content was specific to earth science, but at this base level of pedagogical understanding the rules should certainly be applicable to a greater community of educators.

Comfort is a critical factor in learning potential. Students who are at ease with the learning environment are more likely to learn because their mind can focus on the tasks at hand (Caine and Caine, 1991). Responses of students in this study suggest that there are three critical aspects of course design that appeared to be most important for developing a sense of comfort regardless of the specific content or delivery techniques: 1) establishing familiarity with online learning; 2) creating

a simple and intuitive navigation and link structure; and 3) establishing effective and efficient communication.

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