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Iterative Application of Case-Study Analysis to the Design of a Web-Based Geoscience Lab

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ABSTRACT

Delivery of college courses by means of the world-wide-web is becoming more common with each passing year but our understanding of the pedagogical aspects of this new medium is only beginning. How do students learn online? What impediments to learning commonly arose? How can they be avoided? How does student-centered learning, particularly guided inquiry adapt to online delivery?

The project studied a required, introductory geology course for non-majors that was offered at a multi-ethnic four-year college in New York City. The case study began when the partially virtual course was first offered in the spring term of 2000 and followed the course through two subsequent semesters. Each term, volunteer students from classes of 20 would complete a series of questionnaires, provide an interview and allow access to course documents such as emails, exams and assignments. At the end of each term, the results and conclusions were conveyed to the instructor/web-designer so that the course could be potentially improved in subsequent terms. Thus it was a study in both web-based learning and the application of educational research to online course development.

In noting aspects of the training and development of the instructor as a web-designer during the 3 terms, it appears that the critical aspects of the training experience include: 1) Small supportive peer groups with similar knowledge level and background. Ideally this should include colleagues sharing the same discipline; 2) A mentor who understands both technical and disciplinary issues; 3) A holistic educational approach, including both technical and pedagogical aspects; 4) A realistic time-frame, a minimum of two years, in which to develop the first run of the online course; and 5) Meaningful, ongoing assessment of the website once it is offered.

Critical design aspects for student success include a relatively simple linkage so that students do not get lost or confused while navigating. However, the richness of the hyperlink could potentially be used effectively in a search-engine index. The other critical aspect is communication. This includes: 1) clear concise instructions; 2) effective and efficient communication between the students and the instructor; and 3) a means of low-stakes self-testing such as online quizzes, which is essentially a means of communicating to the student their level of personal understanding.

In terms of student-centered learning online, the web offers great potential for students taking control of their pace and be independent in their learning. However, in order to achieve this, particularly in inquiry-based learning, the following factors must be considered: 1) Students must have a means of officially corroborating their understanding and knowledge to alleviate their personal anxiety. Quizzes and answer checking tables worked effectively in the simpler modules of minerals and maps. 2) The module must not be overly ambitious or rushed. Students must have time to assimilate and interpret new information and new linkages, as well as having the opportunity to communicate their understanding. 3) The more complex and integrated the concepts are, the more detailed and extensive the communication must be. Simple email is sufficient to clarify procedural or logistical issues but fuller communication, perhaps bulletin boards, is necessary for communicating ideas.

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CHAPTER 1: INTRODUCTION AND BACKGROUND

1. INTRODUCTION

Although there is considerable discussion of web-based education, there is a general lack of original research directed at predicting and explaining phenomena associated with learning through the internet (Gold and Maitland, 1999). The majority of papers, particularly those readily available to instructors outside of schools of education, tend to be anecdotal in nature. Such anecdotal papers include discussions of the general benefits of the internet as a teaching tool (e.g., Owstow, 1997), general advice for instructors using the internet (e.g., Reichard, 1999; Cooper, 2000) and descriptions of specific applications or exercises (e.g., Slattery et al., 1999).

Gold and Maitland (1999) note that published research papers on internet-learning generally focus on three broad measures of effectiveness: 1) student outcomes (e.g., grades); 2) student attitudes; or 3) student satisfaction. Furthermore they note that in most cases there is little or no difference between results from in-class and on-line samples in each of these three categories. Gold and Maitland (1999) and Joy and Garcia (2000) both challenge these "no-significant difference" results mostly due to a lack of scientific rigor. Both studies criticize media comparisons due to, in part, a lack of control of extraneous variables such as instructor, instruction method and time on task.

Whereas these criticisms are certainly valid if one is examining the absolute value of one medium over another, they lack importance if one accepts that different media will require a different set of teaching strategies. In essence, if Clark (1994) is correct in concluding that learning is not controlled by the media, but rather, "learning is caused by the instructional methods embedded in the presentation media", then it is pointless to compare in-class and online learning based only on setting while fixing all other variables. This experiment would necessarily weaken the potential of one, or both, of the learning experiences, and therefore be an inaccurate comparison of true potential. Indeed it is far more important to uncover the subtleties of learning processes and experiences in given media so that learning can be maximized.

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 aims to understand how students perceive and interact with web-based education so that the web-education experience can be improved. In particular, this study aims 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.

2. DESCRIPTION OF PROJECT

I. Purpose

It is obvious that asynchronous learning opportunities provided by new information technology have the potential to benefit greatly the busy urban student community. This includes greater personal control and flexibility of scheduling for current students, as well as potentially providing opportunities to people who cannot access the standard campus environment because of geographic or time limitations. However, if poorly designed web courses result in negative experiences then students may avoid future encounters with the technology. Accordingly, it is not a question of whether or not online courses should be developed and offered. Neither should we initially concentrate our attention on the relative effectiveness of learning delivered through the internet as compared to conventional delivery methods. Rather, the central purposes of this investigation are: 1) to study how students interact with web-delivered courses in earth science in order to incrementally improve the learning experience for the

class; and, 2) to document how a particular earth-science web site developed over time, particularly in regard to critical feedback from an educational researcher.

II. Description of the College and the Course Studied

This study was undertaken at an American, urban, state-funded, post-secondary institution (hereafter referred to as Urban College). The campus is non-residential and so the student body reflects the cultural and ethnic diversity of the city itself. Many students are burdened with major responsibilities such as family care and employment, in addition to their scholarly responsibilities. Asynchronous learning opportunities, made possible with internet-based courses, could have profound benefits for this busy student population, and so the institution has promoted the development of online courses through programs that provide extensive technical support and training to faculty members committed to developing and implementing web-based courses.

Urban 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 (hereafter referred to as GEO 101) each year. The purpose of this course is to demonstrate how geology can affect the lives of Urban College students, and how "thinking like a geologist" could help to face some modern issues. The specific content varies with the instructor but most sections have a lean toward broad environmental topics that involve geology.

Students may take this course at any time before graduation so each class has a mix of students from freshmen to seniors, most students are not science majors and none are registered as geology majors. GEO 101 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 labs meet 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.

The Geology Department at Urban College initiated limited online labs for GEO 101 in the spring of 2000. Since that time two professors have each offered one online lab section each term using their own, self-designed and self-constructed websites. Construction of these online lab courses was supported by voluntary involvement in a campus-wide program that provided released time, technical support and advice on practical and pedagogical considerations. Participants in this program, who included professors from a range of disciplines, met biweekly for two-hour discussions led by an experienced web-instructor.

One professor (hereafter referred to as Prof. Brook) from the Department of Geology expressed interest in receiving more feedback on his website and the impact it was having on his students, and agreed to participate in this three-term study. His lab course was conservative in content, focusing on classical geological skills and knowledge in 3 modules: minerals, maps, and the geology of New York City.

Enrollment in the virtual sections of GEO 101 was 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 all full or conflicted with their schedules.

III. Brief Description of Personnel Involved

The project involved one educational researcher and one instructor. The instructor, Prof. Brook, is a senior faculty member with over 40 years of teaching experience at Urban College. Throughout the latter half of his career, Prof. Brook has focused his research predominantly on the history of geology and geoscience education. He has a strong

commitment to collaborative learning and active learning. He entered into this web-development project skeptically but curious about the potential of the medium. As the project evolved his interest increased, and now web-development accounts for the majority of his non-teaching activities. However, he still is committed to maintaining an active learning environment for his online students and developing/adapting strategies that will permit the transition of this teaching/learning style to the internet.

My personal background is predominantly within the Earth sciences. I hold a faculty position within a department of geology. In addition, I have an interest in post-secondary earth-science education. Similar to Prof. Brook, I approached the realm of web-based education skeptically but with curiosity about the potential of the medium. As with Prof. Brook, the main motivation in pursuing web-education related research was general support and encouragement by administration and senior faculty members.

An adjunct geology professor with an interest in geoscience education was included in the study to provide independent perspective from the point of view of the instructor. The adjunct taught several versions of the classroom-based GEO 101 lab and helped Prof. Brook develop a collaborative-education-based manual for the lab several years earlier. In addition, the adjunct taught at another local college where web-enhanced geology labs have recently been implemented. Consequently, he has experience with web-based education and significant familiarity with the student population experiencing the virtual GEO 101 course. It should be noted that the adjunct described his attitude regarding web-based education as "skeptical". This general attitude was expressed during the initial minutes of our first 60-minute interview:

> *"I am more of a hands-on guy, especially for geology and the sciences. Doing just hands-on is a lot. I think it is easier for the students to remember things and it is more interesting for them rather seeing it on a blank screen... I think that having a science, especially like geology, just web-interactive-based pages, well, I am a little skeptical."*

IV. Methodology

The overall objective was ultimately to create more effective web-based course than that which was initially introduced by Prof. Brook in spring 2000 and to adopt a student-centered, inquiry-based instructional method adapted to the internet. To do that we 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.

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.

For each of three consecutive terms between fall 2000 and spring 2001, one lab-section of GEO 101 was scheduled for the virtual lab created by Prof. Brook. Each lab section consisted of approximately 20 self-selected students who were required to receive departmental permission before registering. Each term the virtual lab section was

organized and taught by Prof. Brook. The paired lecture course was taught by a different instructor each term, however, the lab and lecture courses run as autonomous courses for which the marks are combined at the end. It should be noted that due to scheduling constraints, in Spring 2001, I was assigned as lecture instructor of the 80-student lecture class that included the Prof. Brook's virtual lab class. It was emphasized that the lab and lecture components of the course were autonomous and that the lecture instructor had no control of content or assessment of the lab component of the course.

Students who wished to register in the virtual lab section of GEO 101 were required to request permission in person, and sign a "Student Declaration" in which they stated that they understood the following:

- *That this class requires use of the Internet and familiarity with the World Wide Web*
- *That significant course work available ONLY through this medium should be anticipated*
- *That the on-line component of the course will replace parts of the course work required in "non-web" lab sections.*
- *That the on-line course work is associated with the lab ONLY. The lecture portion of the course is a traditional, on-site component and must be attended on a weekly basis in order to complete course requirements.*

During the Fall 2000 and Spring 2001 terms, students were also required to email Prof. Brook and the departmental secretary directly with a message that read:

My name is (insert your name here). I wish to register in [Virtual GEO 101].

I attended the first meeting of the class each term to introduce myself and my role as educational researcher in the course, describe the project, invite the students to volunteer to participate in the study and describe the scope of their potential involvement. Prof. Brook offered a five-point bonus to students who volunteered to participate. After this introduction and invitation, letters of informed consent were distributed to those students who volunteered to participate, along with an introductory questionnaire. I continued to

visit the in-class meetings to observe the in-class activities and discussions, as well as distribute questionnaires at the end of each module.

After the class had completed the lab course, including the final lab exam, the volunteers scheduled a 30-minute interview that was conducted in my office. The interviews were semi-structured and were designed to explore students' likes, dislikes, levels of satisfaction and familiarity with the lab course as a whole. This involved a 20-minute question and answer interview and a ten minute student-directed exploration of the website in which they were encouraged to navigate freely, showing me anything they considered to be significant. These interviews were recorded and transcribed. Seven students were interviewed in each of the first two terms. Twelve students were interviewed at the end of the Spring 2001 term.

Documents collected for analysis included student assignments, exams, the log of email communication between Prof Brook and his students and in the final term, a set of independent college-mandated surveys based on Likert-style scales.

Prof. Brook is a colleague and so interactions with him were generally informal. Commonly he would ask advice regarding minor revisions of classroom or online material throughout the term. We also talked freely about the course and about pedagogical concepts, particularly those associated with online education. After submission of grades, completion of interviews and initial interpretation of these interviews, transcripts of the interviews (names removed) and my initial interpretations were given to Prof. Brook, after which we met for a formal discussion of the results. Prof. Brook would then set about modifying the website for the following term. Upon completion of the modifications, we would meet again to critique the site. At the end, a formal interview was conducted with Prof. Brook to document his thoughts on the evolution of the course and the role that my educational research played in its development and metamorphosis.

An independent instructor's opinion was also gained through the interview of an adjunct geology instructor who was familiar with the standard in-class GEO 101 lab. These two semi- structured interviews took place in the spring 2001 term. The adjunct was provided with a CD ROM containing archived versions of the three term offerings. First he was

asked to act as a student and work through the Spring 2000 and Fall 2000 offerings. When he had completed this task he was interviewed for 45 minutes regarding his thoughts and experiences. The adjunct was then charged with the task of working through the Spring 2001 version and again submitting to a semi-structured interview.

Each term's data were interpreted independently seeking common themes displayed in each iteration of the course. Questions in surveys and interviews were modified each term as patterns emerged and ideas coalesced from the previous term's data. At the end the entire data set was reflected upon to search for trends and patterns throughout the run of the study.

3. PRE-IMPLEMENTATION HISTORY

In order to better understand the state of mind and intentions of Prof. Brook in creating his website, I requested that he write a brief account of the history of his course prior to its initial implementation in Spring 2000. The following text was written by Prof. Brook in December 2000. The text was edited to remove specific names or other identifiers.

About four years ago faculty were invited to participate in a series of 'classes' designed to teach them how to create a web site to be used in conjunction with the courses they taught. The carrot extended was a modern computer and a cable connection to the internet. I signed up and attended the first class. It was attended by faculty with a great range of expertise, from those like myself who were complete tyros to those who could write Java. I was quite lost but persisted for a few sessions in the hope that by practicing with the promised computer and cable connection I would get the hang of it. However, the computer and connection did not materialize. I gave up on the classes, but kept pushing for the computer and cable. Almost a year later, the computer finally arrived and then, again with some pestering on my part, the cable connection.

About that time (Fall, 1998), [another faculty member] sent out a call to faculty to participate in a [large external] grant designed to create virtual modules for use in core courses. Faculty would commit themselves for two and a half years, by the end of which

time they were to have a fully functional, partially virtual course in operation. To prepare the modules, they were promised:

(a) All the necessary hardware, software, and cable connection.

(b) A faculty mentor to assist them either in small groups or individually.

(c) All needed assistance from an Academic Support Team.

(d) Released time of three hours per semester for five semesters.

I thought about it and at first was quite skeptical. I was not convinced that I could master the necessary computer techniques (I was at that time new to Windows, to using a mouse, to using a modern word processor), that I would receive meaningful help, or that the results of all the effort to create virtual modules would be other than trivial compared to time tested value of "real" teaching. I learned, however, that [another departmental colleague] was going to commit himself and that [the department chair] wanted the Geology Department to be involved. I decided to have a chat with [the grant's principal investigator].

I told [the grant's principal investigator, hereafter referred to as PI] that I was ambivalent about joining – that I was not convinced of the advantages of virtual teaching, but that I was attracted by the opportunity to learn about creating a web site and also the chance to work with [my departmental colleague]. (At that time, [the colleague] and I had talked about working together to create a web site that would incorporate elements of both his and my versions of the [GEO 101] labs.) [PI] was understanding and encouraging and so I took the leap.

Under the [grant's] arrangement, I was assigned together with four other faculty to work with/be mentored by [another science faculty member]. [My mentor] immediately separated out myself and the other beginners, a step by which I was immediately encouraged. In a very systematic fashion, he began to teach us the elements of HTML and Adobe Photoshop 5. His philosophy was that it was important to first understand how to write HTML and then, if we wished, to make use of HTML-writing programs, such as Front Page. In addition to technical matters, he spent a lot of time discussing the

unique pedagogic advantages and possibilities of an 'asynchronous', interactive website. He also stressed the appropriate look and organization of the website.

It had become apparent by that time that if [my colleague's] [grant] creations and mine were to be linked, it would be after we had each created our own modules, rather than trying to co-create modules. Our collaboration concretized in the form of mutual support and exchanges of ideas about broad rather than specific problems.

In addition to meeting with our Faculty Mentors, larger groups of [the grant's] developers met monthly. It was always interesting to learn what others were doing, and to engage in discussions of the merits of 'Technology Mediated Instruction' and 'Technology Mediated Exchange'. However, these largely show-and-tell meetings did not, due to the limited time available and the diverse directions in which participants were headed with their websites, have the same value as sessions with Faculty Mentors. Attempts at exchanging ideas via [online bulletin boards] suffered the same drawbacks.

One of my first tasks was to decide what material in my [GEO 101] lab was most suitable for virtual presentation. I decided that teaching the reading and construction of contour maps and profiles was an obvious candidate. In my Freshman Year [course], I had already introduced an introductory contour map lab leading up to consideration of the Geology of New York City. My experience from many years of teaching [the first years majors geology course] was that while some students immediately grasped the concept, many others never felt comfortable with contours. I hoped that through the magic of animated, interactive images, contours would become more transparent.

I suggested to [my mentor] that rather than try to create the magic myself, I should make use of the Academic Support Team – specifically [the college's webpage technician]. [My mentor] warned me that before approaching [the technician], I should have a very clear and precise idea of what I wanted him to create and what it would accomplish pedagogically. That was not an easy task. I didn't really know what was technically feasible, and as to what it would accomplish successfully, I hoped to discover that upon its implementation. When I spoke to [the technician], I found that much of what I had envisioned would require the acquisition of software that [the college] did not possess, and that his own schedule was already quite crowded with other projects. [The

technician] said he would do some research to pinpoint the best software and then try to get it purchased. It soon became clear that if anything was going to happen on this front, it would be way in the future. (Indeed, [the technician] shortly after left [the college], presumably for greener fields.) [My mentor] had a good chuckle and reassured me that if I could break down what I wanted to do into simple steps, I would be able, with his help, to get it done. And that's what happened.

I began to meet with [my mentor] for multi-hour tutorials on a weekly basis. In addition to HTML and Adobe Photoshop, he began to introduce me to the elements of JavaScript. By the end of the Spring, 1999 semester, my web page was on-line and the magic had begun to appear.

At that point I learned that the first test of the website with a live class with real students was due in the Fall. That was a surprise. I had thought I had another year or so to prepare. [My mentor] said, however, that the only way I would learn what was working and what wasn't, both technically and pedagogically, was to 'go live'. Again he would prove to be right.

I borrowed a laptop computer from the College for the summer, and set to work upstate to get a usable 'first draft' version of the website ready. The laptop was minimally satisfactory, chugging along laboriously with Photoshop, which was very frustrating. I found [two college technicians] very helpful in solving technical problems, both in person before the summer and over the phone during the summer. I kept in contact with [my mentor] via email.

Working non-stop, I readied the first offering of my [GEO 101] partially virtual lab. It contained the usual course calendar, syllabus, and statements of requirements. There were three lab topics: minerals, maps, and the geology of NYC. The first topic, minerals, was to be done in class. The map material was totally on-line. It was interactive in the sense that it had on-line self-test quizzes with answers and dozens of internal and external links. The NYC Geology was a simple transposition, only somewhat altered, of the existing [GEO 101] Manual exercise to the web. Examining NYC rocks and sediments was to be done in class; the rest of the lab was virtual. Instead of the usual six scheduled

meetings, the class was to meet only three times. Gradually my website was uploaded and ready for the start of the term.

The course ran smoothly enough. The students were self-selected for their willingness to do much of the work on-line. However, I felt that during the term up until the final exam, I had an insufficient sense of how the students were succeeding and how they felt about the course. Part of this perceived lack of contact was due to the paucity of email exchange between the students and myself. Despite the advice of several 'webmasters', I had omitted making email submission part of the registration process. In consequence, I didn't have everybody's email address and the students didn't develop the habit of emailing me.

CHAPTER 2: LITERATURE REVIEW

The internet is the newest technological innovation that has been touted to be able 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."*

Countering the predicted benefits of internet education are researchers such as Healy (1997) who argue that web-based education is limited because it is merely a visual, two-dimensional representation that lacks the complexity and involvement of the first-hand experience. While some researchers suggest that the use of internet in education will require greater reading and writing skills, and thus a greater ability to organize thoughts (e.g. Ostow, 1997), the findings of Birkerts (1994) suggest that the non-linear medium of the web develops a haphazard thought process in students.

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) argues this "no significant difference phenomenon" demonstrates that learning is caused by the instructional methods embedded in the presentation media and not the media themselves.

Thus the only way that one medium can have superiority over another is if it allows for a better and unique instructional method.

The internet, unlike earlier technological media, has the potential to be truly interactive, and so perhaps has the possibility of supporting instructional methods that other distance learning methods cannot match. But how can this new medium be exploited to its greatest educational potential? Are we exploiting its potential now? 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)

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".

The goal of developing a student-centered learning experience online is described commonly in current educational literature despite the fact that it is rarely, if ever, attained. Many researchers feel that this lack of constructivist pedagogy online is due to our lack of familiarity with the medium and will evolve as educators better understand the internet as a learning medium (e.g., Jonassen et al., 1995; Hokanson, 2000; Mioduser

et al., 2000). Hokanson and Hooper (2000) stressed that we must break out of our current mindset which sees computers as merely a tool to increase efficiency:

> *"We should compare the computer not to books but to a blank sheet of paper, a notepad, an artist's canvas or a blackboard. The computer may be a tool, but the act of computing itself is a medium for thought."*

Saunders and Weible (1999) reported another important, and potentially limiting, mindset regarding web-education. In a survey of chairpersons of accounting departments in US colleges, they found that although a majority of respondents agreed that web-based courses should be offered in non-business courses, fewer felt that they should be offered within business departments and only a minority of respondents agreed that such courses had a place in accounting programs. Saunders and Weible (1999) interpreted these results as possibly indicating that faculty consider web-based courses to be an inferior educational experience relative to the lecture hall. A similar mindset is tacitly assumed in statements such as, "the internet is an appropriate medium for instruction when the instruction is designed for many learners separated geographically...", which was reported in Federico (2000).

But are internet courses simply correspondence courses using new technology, or do they have potential benefits to the on-campus student body as well? In-depth study of internet education is required to answer this important question.

Within the existing educational research literature "advice from the trenches" papers from experienced web instructors are fairly common (e.g., Cooper, 2000; Patterson, 2000) but rarely are they rigorous in their research approach because they are based primarily on personal reflection. Thus they fall far short of determining the potential value of web courses. In an effort to make a web-based course more effective Weston et al. (1999) combined personal experience with a synthesis of published material to compile a checklist of considerations when thinking about developing an online course. The two key pedagogical issues raised by Weston et al. (1999), but which remain unanswered are:

1) Will the impact on learning be great enough to justify the time?

2) How can the site be made effectively interactive?

Until these questions are answered satisfactorily web-based courses will most likely be inferior to more traditional offerings because the web-based courses will not be effectively designed for delivery through the medium of the internet.

Rigorous educational research focused on web-based teaching and learning can broadly be categorized into two broad themes: 1) evaluation of efficacy, usually through comparison with similar classroom-based classes; and 2) understanding of the student's learning experience. If it is the instructional method that affects learning and not the medium itself, as argued by Clark (1994) and as supported by the "no significant difference phenomenon", then it would be premature to compare learning effectiveness until we have a better understanding of the learning experience which can be used to develop an appropriate and effective instructional method.

Published studies of student attitudes and experiences online can be broadly subdivided into primarily quantitative studies that rely on Likert-style surveys and primarily qualitative studies, most commonly employing case study techniques. The questionnaire-based survey studies generally attempt to document broad patterns in student perception and attitudes. A sampling of the recent findings of such survey studies follows:

- Hiltz (1997) surveyed >350 students enrolled in virtual courses at New Jersey Institute of Technology

  71% of students agreed that they had better access to professors in online courses

  69% agreed that online courses were more convenient

  52% agreed that they were more active and involved

  67% agreed that they work as hard in an online course

  58% agreed that they would take another online course

  40% agreed that they learned more in an online course (21% disagreed)

- Angulo and Bruce (1999) surveyed students from 5 web-enhanced classes at the University of Georgia

  Almost all students would not consider taking a fully virtual course.

Students logged in primarily to access grades and lecture notes

- Motiwalla and Tello (2000) surveyed 190 undergraduate students in 31 online courses.

  74% of students would recommend online courses to other students.

  67% agreed that online tools assisted their ability to communicate with the instructor.

  47% agreed that online tools assisted their ability to communicate with classmates.

- Shaw and Pieter (2000) surveyed 51 undergraduate students in an online module within a second years Human Nutrition course.

  76% of students preferred the lecture-based environment

  80% would recommend this module to a friend

  52% agreed that the online delivery made the material easier to understand

  66% agreed that the technology made the instructor more accessible

  55% agreed that the online delivery enabled them to take a more active role in learning.

Certainly such data can be useful and can potentially highlight trends. For example, each of the researchers who surveyed their students about student-instructor communication found that a majority of the class perceived an increased level of communication. However, even from this minor sampling of the published research it is evident that whereas there is significant information recorded, there are great difficulties in fully interpreting and generalizing the results. What aspects of their experiences and inconsistencies in thought would cause 76% of a class to prefer in-class instruction, and yet 80% of the class would recommend the online module to a friend? What experiences made 52% of respondents feel more active during online learning, and why did the remaining 48% not feel that way? How can we reproduce the successes and avoid the failures in future courses?

Some insight into students' experience online learning has been gained through a limited number of published case studies. Communication was the predominant and most recurrent theme that emerged from these studies. Yakimovicz and Murphy (1995)

reported on a very positive experience of a graduate education course on distance learning that was offered online. They were astonished at how quickly the class coalesced into a single co-operative entity that fostered personal construction of knowledge. Communication was required through several different means: email, bulletin boards and chat rooms. Students "probed, questioned, debated and evaluated". Initial motivation for use of student online communication was due to its heavy weighting in the course grade. Of course, given that the class was studying distance learning, considerable interest in online communication probably existed within the class from the start.

In Wegerif's (1998) study of a similar course, "Teaching and Learning Online" he concluded that the degree of interaction and communication that a student had within the course was the most important variable in predicting a student's success. If students felt like outsiders, then they did poorly. If they felt a part of the class, then they did well. Considering that this was a collaborative learning-based course, effective communication would have been necessary for success.

Similar conclusions were reached by Kazmer (2000) in her analysis of distance learning program for graduate students in library and information science. However, in this case students also had face-to-face contact. This included a mandatory initiation meeting at the beginning of the program but also students communicated through an online medium to organize informal meetings with each other over coffee or dinner. Additional issues that were of concern to this group of students were the importance of organization on the part of the instructor, access to reliable and friendly technical assistance, and a balanced and flexible workload.

Significant causes of student frustration, which led to reduced learning in an online graduate course in computer-enhanced language learning included lack of prompt feedback from the instructor, ambiguous online instructions, and technical problems (Hara and Kling, 1999). All three of these issues are essentially related to insufficient or ineffective communication.

In a case study of three separate courses, two MBA courses and an ESL course, Soong et al. (2001) concluded that success in an online course could not be easily predicted by a single variable. Rather, a set of key elements must be put in place. These critical course

elements are: 1) a motivational instructor who puts time and effort into the course; 2) technical competence of both the instructor and the students; 3) a constructivist mindset for both the instructor and students; 4) a high level of collaboration; and 5) no perceived problems in the technology infrastructure.

The concept of constructivist web-based learning has been discussed as a possibility (e.g., Jonassen et al., 1995). It has also been studied and shown to be viable in education, social science and business courses at the graduate level (Yakimovicz and Murphy, 1995; Wegerif, 1998; Soong et al., 2001). In fact some researchers such as Soong et al. (2001) conclude that it is a necessary aspect of a successful online course. However, creating authentic, constructivist learning opportunities in science requires far more than open discussion. In online courses this must involve interactive graphics and simulations as well as communication and discussion.

The technical and pedagogical complexities that would necessarily be present for an online constructivist science course probably account for the paucity of such sites with approximately 28% of sites using some form of inquiry-based learning and less than 3% of sites using some form of online collaborative learning (Mioduser et al., 2000). No such inquiry-based sites or collaborative sites were documented in the earth sciences (Kusnick, 2001). Thus the study of student-centered science education online, exploiting the interactivity of the internet, is essentially a virgin field of study. Accordingly, this study was intended to document one instructor's attempt to develop a student-centered college geology course and the reaction of the students to his evolving course.

CHAPTER 3: SPRING 2000 STUDY

1. WEBPAGE DESCRIPTION

Once permission was granted to register in the experimental online section of GEO101, each student was given a form that stated the URL of the GEO 101 homepage. Students were not required to access the website until their maps exercise (i.e., after two in-class meetings) and so Prof. Brook was able to remind students of the homepage location in person.

When students went to the GEO 101 Homepage they saw one screen of simply laid-out graphics and text that included a course banner and the following 5 links:

- *Late Breaking News*
- *How to Use the GEO 101 Web Site*
- *Explore the Course*
- *Start the Search for Leo's Treasure*
- *The Geology of New York City*

The first three links provided logistical information. This component of the website will be described in Section I below. The latter two links took students to the two online content modules of maps and the geology of New York City. These two links will be described in Section II. A schematic flowchart of the website presented in Spring 2000, including pages and link structures, is provided in figure 3.1.

I. Introduction, Background and Initial Instructions

"Late Breaking News" consisted of a sequence of bulletins regarding changes to the course, corrections, suggestions, instructions and contact information. The messages were listed in chronological order with the most recent messages at the top. Instructions were generally written in point-form. Critical points were highlighted in red and links were underlined. This venue was used primarily to alert students of errors on the webpage and to remind students of impending deadlines or meetings. Contact information included an email link to Prof. Brook. Like all other pages on the site, a "GEO 101 Homepage" link was provided at the bottom of the page.

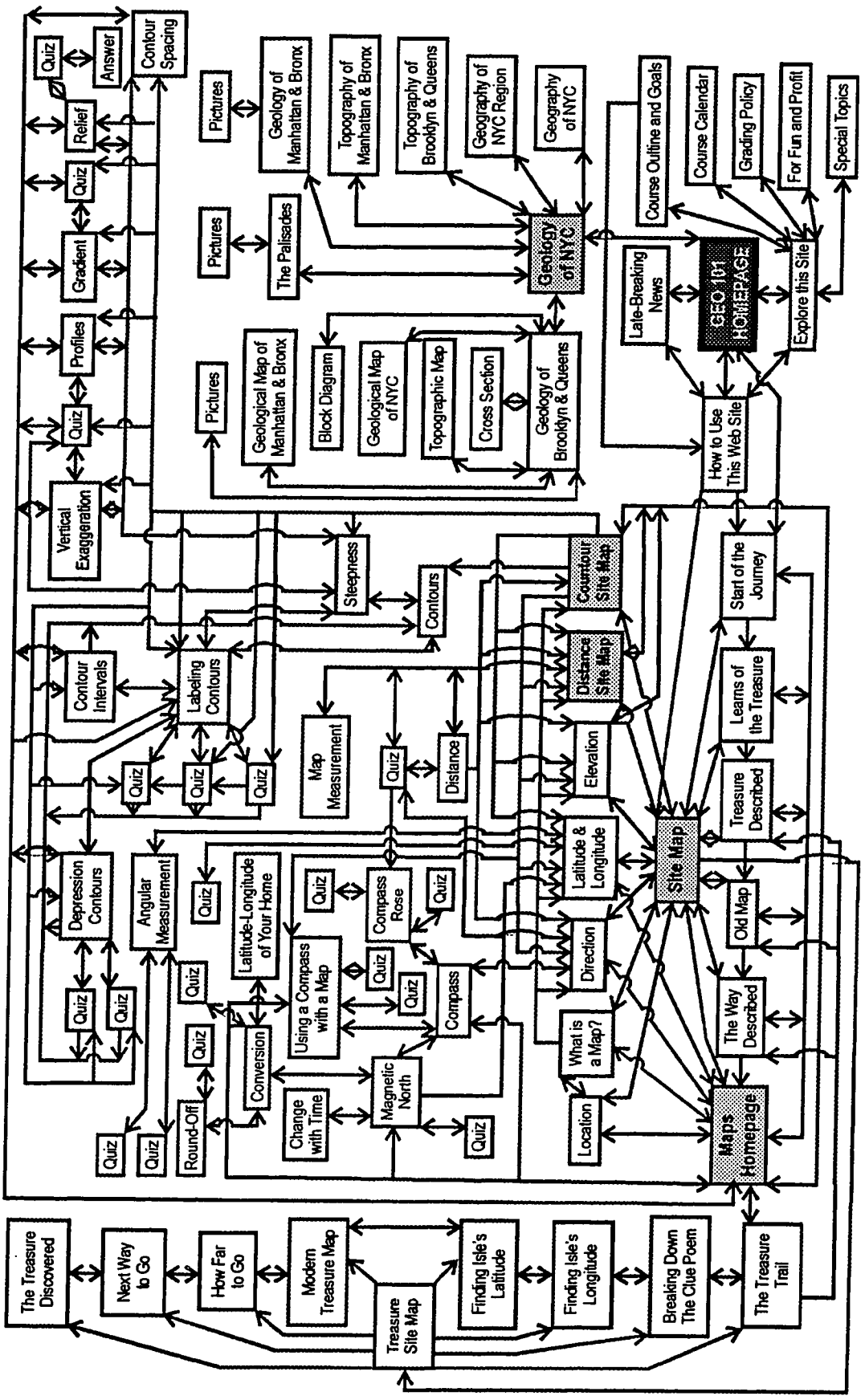


Figure 3.1. Linkage flowchart of the GEO 101 website as offered in Spring 2000.

"How to Use the GEO 101 Web Site" consisted of a numbered list of instructions for using the site. The first 3 points essentially provided a checklist of pages to see. The first point provided the access address for the GEO 101 website. The second point instructed students to check "Late Breaking News" at the beginning of each session. This was accompanied by a link to "Late Breaking News". The third point instructed them to briefly investigate what they would be doing for the term by going to "Explore the Course. A link to "Explore the Course" was provided.

The final point in the list provided tips for "Leo's Treasure Trove Online Investigation of Maps". A special sidebar text entry provided the specific navigation tip below, along with a link to the 'Master Site Map".

> *As you try to find Leo's Treasure Trove, if you get lost in the maze of links, click on the Leo Site Map button (there's one on the bottom or side of every page). It will lead you the "Master Site Map".*

A distinct pirate-faced link was introduced. The page explained that this link would lead you the search for this treasure. The link accompanied the text.

The "Explore the Course" page provided five links, including three links describing essential course information and two links to selected geological and Urban College science websites. These external websites were not directly related to course work,

The first link on this page, "Course Outlines and Goals" brought-up a very brief overview of the course:

- *COMPLETELY IN-CLASS INVESTIGATION:*
  THE NATURE OF MINERALS
- *COMPLETELY ON-LINE INVESTIGATION:*
  FINDING LEO'S TREASURE TROVE
- *PARTIALLY IN-CLASS, PARTIALLY ON-LINE INVESTIGATION:*

  THE GEOLOGY OF THE NYC AREA

In addition, the following list of goals of the investigations was provided:

- *TO LEARN ABOUT THE MATERIALS OF THE EARTH*
- *TO UNRAVEL THE MYSTERIES IMPRISONED IN ROCKS*

- *TO GAIN SKILL IN READING MAPS*
- *TO UNDERSTAND NEW YORK'S NATURAL ENVIRONMENT*
- *TO THINK ABOUT THE NATURE OF SCIENTIFIC BELIEF*

There were three links at the bottom of the page. The first, largest and most highlighted link took students to the "How to Use the GEO 101 Web Site" page. Below that were two simple text links in purple, underlined letters. The first of these took students to the "Explore the Course" page. Below that was a simple text link to the "GEO 101 Homepage".

The second link on the "Explore the Course" page was the "Course Calendar" which provided a table of lab activities tied to calendar dates (see Table 3.1 below). It outlined what sessions were required in-class meetings, which days had optional in-class meetings, and which weeks were fully on-line. It also reminded students to bring particular print-outs on certain dates.

The third link on the "Explore the Course" page led to a description of the course's "Grading Policy". This page listed the specific breakdown and value of assessment in the course, a list of material for which students would be responsible on the final lab exam, and a list of potential extra credit activities.

II. Maps and "Leo's Treasure Trove"

This module formed the heart of the online activities during Spring 2000. The general format of this module was that of a story-lined conversation between two cartoon characters: Lou, a tough guy with a Bogie-like image (complete with fedora), and Lulu, apparently a woman of intrigue with a classic wide-legged comic-book stance. In the module's general story line Lou has found a yellow, tattered map and a pair of poetic pointers that promise to lead to the buried treasure of Leo the pirate. Unfortunately, Lou lacks any understanding of maps and how to read them. Lulu conveniently comes to his rescue by explaining the basics of topographic maps and how to interpret them.

TIME:1 to 2:50 PM	Room 200
DATES	**ACTIVITY**
1. Monday, February 7	1. Minerals (required in-class)
2. Monday, February 21	2. Minerals (required in-class)
3. Monday, March 6	3. No Class (Do 'Leo's Treasure Trove' on-line investigation)
4. Monday, March 20	4. Maps Review (optional in-class Q and A session)*
5. Monday, April 3	5. Geology of New York City (required in-class)**
6. Monday, May 1	6. Geology of New York City Review (optional in-class)*
7. Monday, May 15	7. Final Exam (required in-class)
	*Bring print-outs you wish to review.
	**You must bring NYC print-outs to lab.

Table 3.1. GEO 101 course calendar for Spring 2000 as presented online.

Students were required to learn about the basic features of topographic maps. Finding the treasure was optional. However, students were informed on the "Grading Policy" webpage that the final lab exam would contain an extra-credit question based on additional information that was provided in the treasure hunt.

The link structure within this module is very complex (see Fig. 3.1). From the initial page where Lou and Lulu are introduced, the students had 3 possible links to follow: 1) the standard text link back to the "GEO 101 Homepage" that was found at the bottom of every page; 2) a highlighted link labelled "Let's Go" on a pirate-faced button that began the search for Leo's treasure; and 3) a large link-button labelled "Leo Site Map". This last link, which was present at the bottom of most pages in the map module, took students to an interactive site map (Fig. 3.2) that detailed a possible (and implicitly recommended) pathway through the maps module. It also allowed students to link to the various sub-modules by clicking on each of the labels on the Site Map.

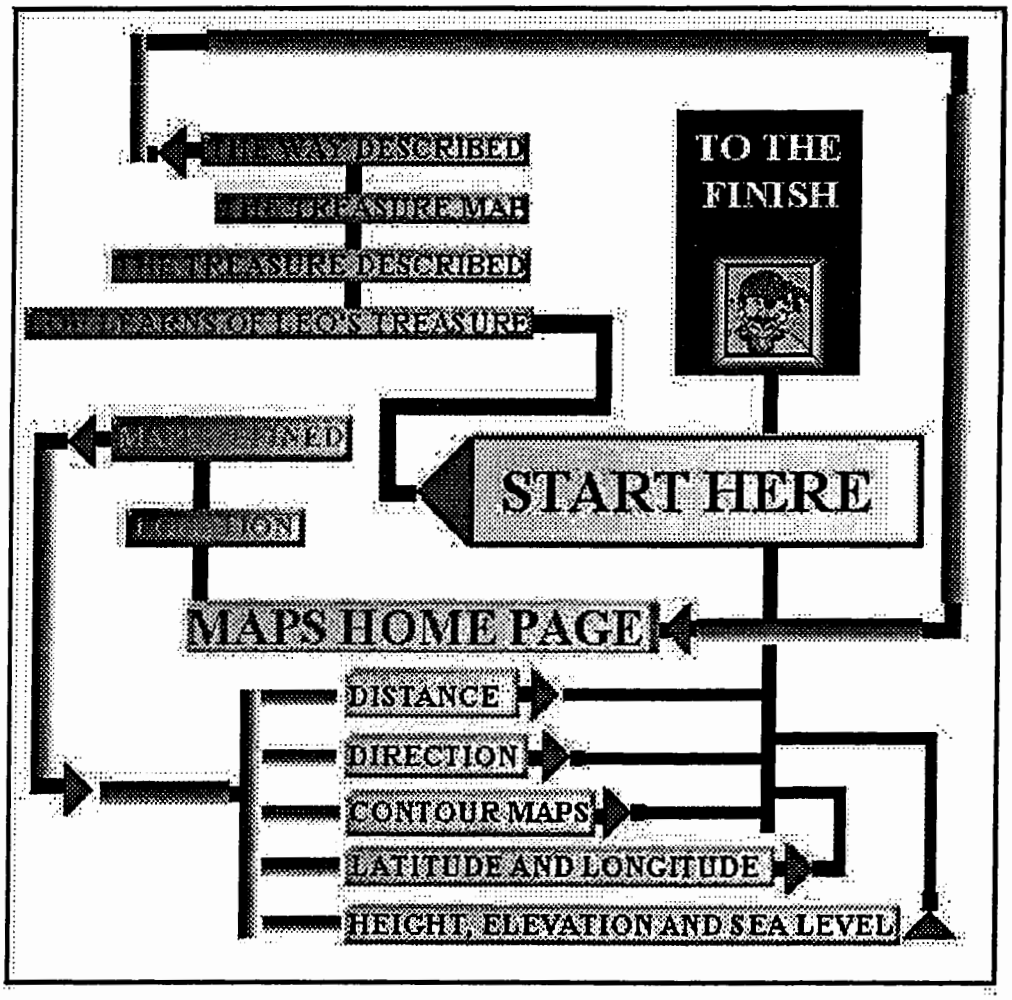


Figure 3.2. The Maps Site Map

Clicking on the "Let's Go" choice took students to an exchange between Lou and Lulu in which the treasure map and the cryptic clues were introduced. Two separate links, one a highlighted text link in Lulu's dialogue saying "Let me see!", and a pirate-faced link labelled "The Treasure Described" would load an image of a yellowed parchment on which was written a five stanza poem describing the way to the treasure. Below this were two links, again a highlighted text link in Lulu's dialogue and a pirate-faced link labelled "The Old Map" that took students to an image of a simple treasure map with several obvious topographic features (Fig. 3.3). Below the figure of the treasure map were two links (text and button) that led to another yellowed piece of parchment, this one with a three stanza poem with a cryptic description of the way to the treasure (Fig. 3.3). When

Lou asked what it all means, Lulu replied "Ya gotta learn to read maps", leading to a link labelled "Maps".

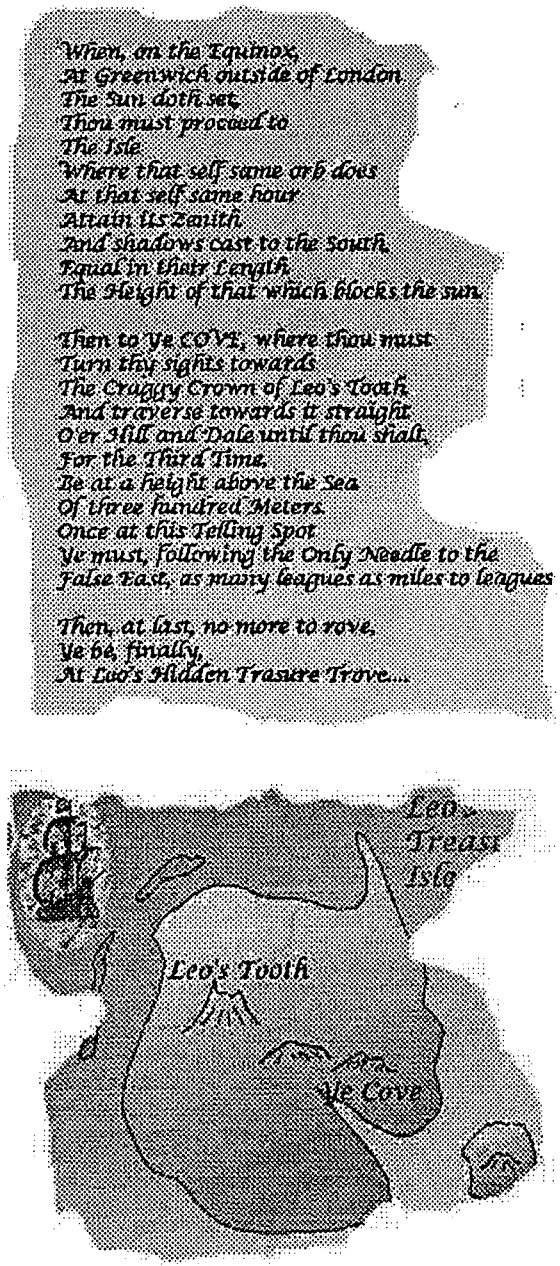


Figure 3.3. "The Way Described" and the accompanying treasure map.

Below each of these three map/parchment pages were a set of three links, the "Leo Site Map" link, the usual "GEO 101 Homepage" link, and an additional link labelled "Maps Homepage". Clicking on either the "Maps Homepage" link (a link found at the bottom of

every page in the maps module), or the "Maps" link in Lulu's last utterance took you to the "Maps Homepage" which contained approximately two screens of scrollable text/graphics and was the jumping-off point for the entire maps content lesson. It included a hierarchical subject list (Fig. 3.4), each entry of which was a link. Beside this list was a reminder that the site could also be navigated by means of the interactive "Site Map". This reminder was also a link to the "Site Map". A pirate-faced link to the treasure hunt was located at the bottom of the page.

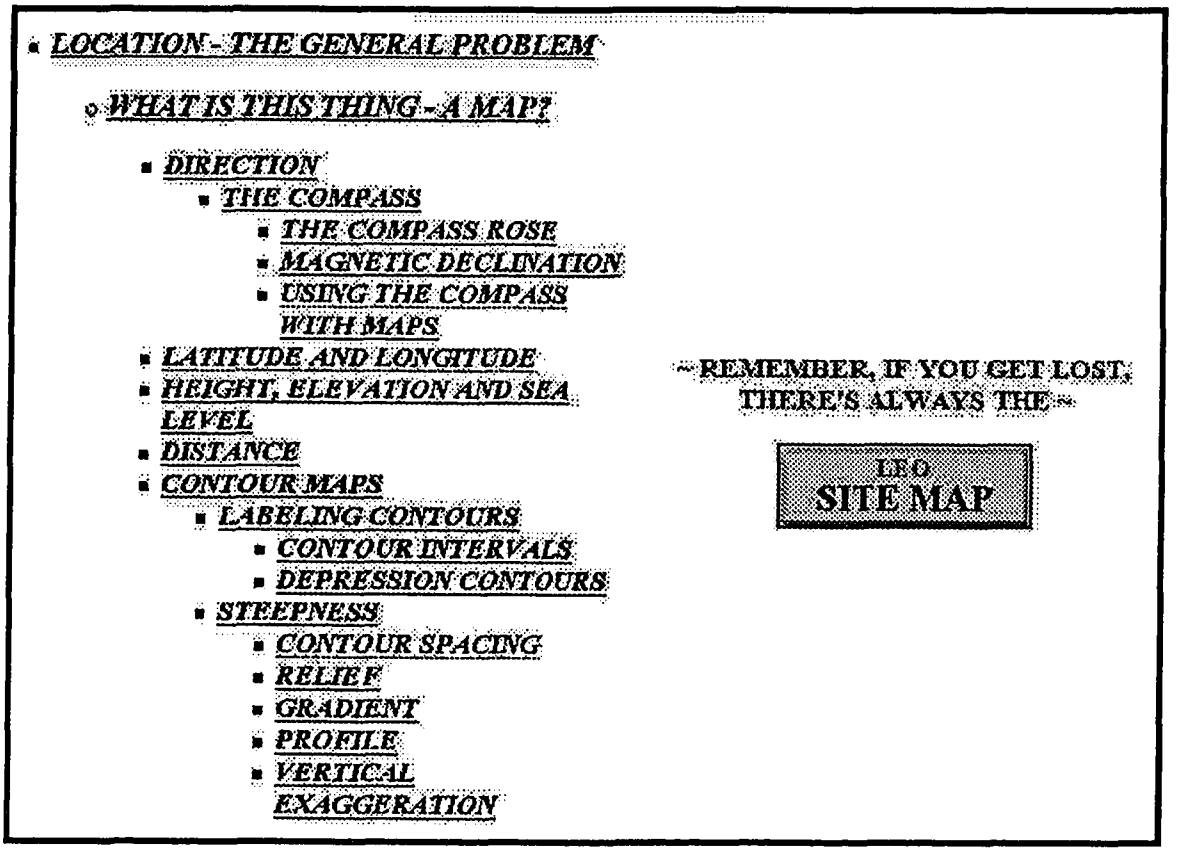


Figure 3.4. Navigation segment of the Maps Homepage

The structure and layout of each of the expository pages within the maps module were similar. (See Fig. 3.5 for a typical page.) The structure was that of a conversation between Lou and Lulu focused on a particular topic. A small picture of Lou or Lulu lay beside each character's utterances. Each piece of the dialogue was within quotation marks. The text occupied the full width of the page. Each new piece of dialogue was

found beneath the previous one on the page, with a minimum of one blank line between them.

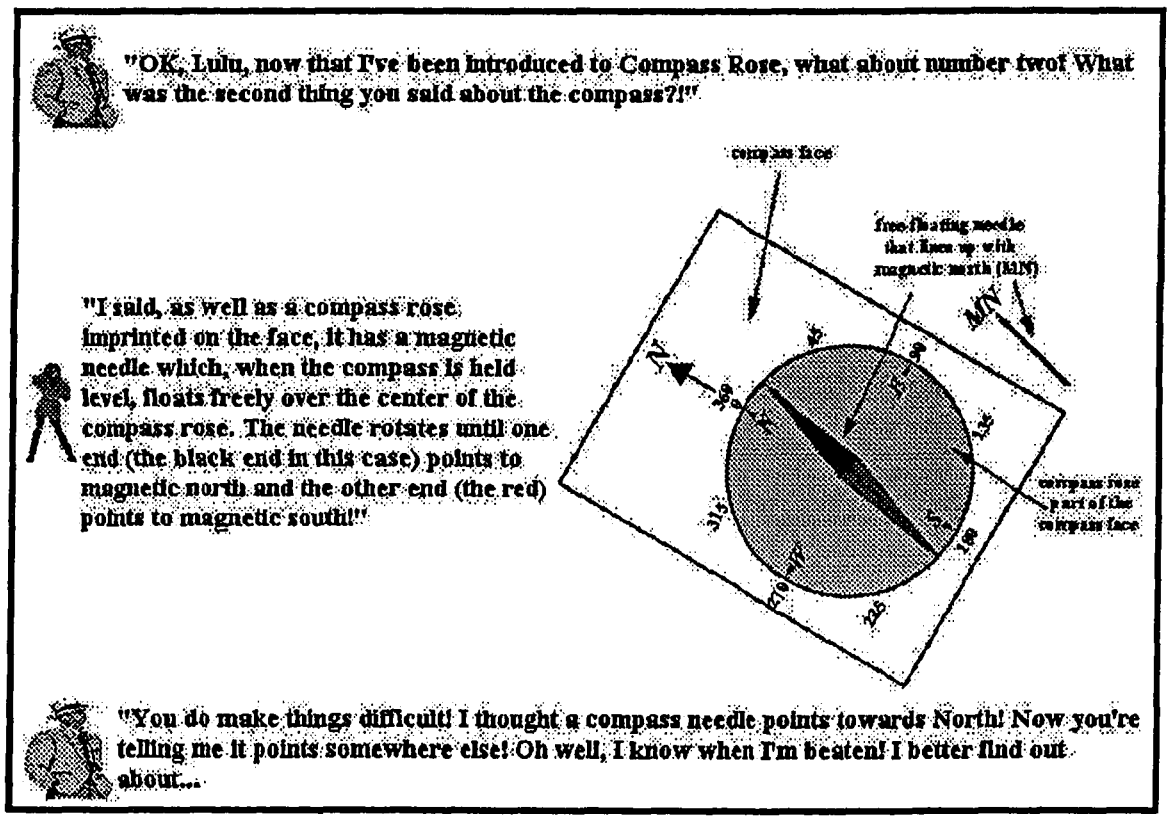


Figure 3.5. Example of content exposition through dialogue between Lou and Lulu.

Abundant, relatively simple figures and maps were used throughout to illustrate the points being discussed. Sequences of figures with incremental changes were used to illustrate procedures such as drawing a profile from a topographic map. Each of these figures was positioned beside the block of dialogue in which the illustrated concept was mentioned (Fig. 3.5). In this way, it was made clear to which piece of text the figure was associated, although the text did not usually refer to the figures specifically.

Each page consisted of a white background with most text in black, bold, 14 point, Times Roman font. Major headings and subheadings were printed in larger characters. The text commonly contained links. Each of these text links was made apparent by using capital letters, underlining and a bright color. In most cases the linked text was red, but in a few cases the linked text was blue. Key words and key sentences were highlighted using

bright colored text, this varied between red and blue. In some cases the highlighted text was capitalized, whereas in other situations the text was lower case.

A total of 19 quizzes were included in the maps module. These are listed in Table 3.2. There were three distinct styles of quiz, each of which provided instant feedback to students. Multiple choice quizzes were composed of a series of questions each of which was followed by the answer and 3 distracters. Clicking on the box beside the answer brought up two alert boxes that said "Right On! Congratulations" and "Try Another! Go On To Greater Victory". Clicking on a box beside any of the distracters brought up a sequence of two other alert boxes: "Sorry! Wrong!" and "Try Again!". Fill-in-the-blank quizzes involved inputting a short, usually numeric, answer to a question into a response box. Beside the response box was a box labelled "Correct?". Clicking on this box returned a response of either "Yes, correct!" or "Sorry! Not correct!". Students could continue to input answers until the correct answer was determined. Worksheet quizzes involved students writing answers on paper, usually more complex responses and/or constructions. The correct answers could then be found on another page through a link below the quiz.

Somewhat ironically, the structure of the treasure hunt was simple relative to the maps module, being essentially a linear progression. Through a sequence of six screens Lou and Lulu interpreted the clues in the poems. In the process the student was introduced to additional material regarding latitude and longitude through the familiar dialogue format. Students were asked to apply what they had learned during the maps module in order to determine the latitude and longitude of the island on which the treasure was buried. Then students were asked to determine the directions that Lou needed to travel (both in azimuth and compass-quadrant bearing) from the landing cove to the treasure, as well as the distance that had to be travelled. The answers were input in the familiar Fill-In-The-Blank format. It was not necessary for the students to input the correct answer, or any answer at all, in order to advance to the next screen.

SECTION	SPECIFIC TOPIC	QUIZ STYLE	HOW MANY QUESTIONS?
Distance	Interpreting Scales	MC	6
Compass Rose	Degrees in Circles	FITB	2
Compass Rose	Azimuth and Compass Quadrant Conversion	MC	12
Compass & Maps	Determining Direction from Maps	FITB	15
Compass & Maps	Finding Your Way with Maps	FITB	6
Magnetic North	Magnetic Declination Change with Time	FITB	10
Magnetic North	Decimal to Degree/Minute/Second Conversion	FITB	4
Magnetic North	Rounding Numbers	FITB	6
Labelling Contours	Contour Labelling	FITB	5
Lebelling Contours	Spot Elevations	FITB	8
Labelling Contours	Rule of V's	FITB	4
Depression Contours	Labelling Depression Contours I	FITB	6
Depression Contours	Labelling Depression Contours II	FITB	4
Vertical Exaggeration	Calculation of Vertical Exaggeration	FITB	3
Gradient	Gradient	FITB	6
Relief	A Problem in Relief	Worksheet	12
Latitude-Longitude	Finding Latitude-Longitude on a Globe	FITB	8
Angular Measurement	Degrees and Minutes	MC	8
Angular Measurement	Degrees, Minutes and Seconds	MC	3

Table 3.2: Summary of Quizzes in Spring 2000 Maps Module. MC=Mutltiple Choice, FITB = Fill-In-The-Blanks.

III. Geology of New York City

The Geology of New York City was a very simple module that essentially transposed the pre-existing in-class exercise to the internet environment. It consisted of one main page with links to seven secondary pages that contained maps and accompanying assignments. The students were required to print out each of these secondary pages and bring them to the in-class meeting. The first two links led to unlabelled maps of the geographic subdivisions of New York City and the New York City Region respectively. Students were asked to label the geographic subdivisions. This required either prior knowledge or external research because the answers were not available on the website. The next two links led to topographic maps of Brooklyn-Queens and Manhattan-Bronx, respectively. These two pages required students to apply the concepts of vertical exaggeration, contour interpretation and azimuth and compass-quadrant bearing. No answers or corrections were supplied online.

The final three links led to the bulk of the exercises. In these exercises students were required to examine, describe and name the geological materials (rocks and sediments) that comprise Brooklyn-Queens, the Palisades and Manhattan-Bronx. Students printed these worksheets from the webpage but the work had to be done in class because they had to examine rock and sediment samples. After noting the physical characteristics of these materials, students were required to hypothesize about how these materials controlled the topographic patterns of the New York City region. Students had the option of completing the hypothesis portion of the assignment on their own or to attend an optional second in-class session if they desired additional help.

2. PERSONAL EXPERIENCES WITH THE SPRING 2000 WEBSITE

My initial impression as I began to navigate through the website was that the link structure was overly complex and too repetitious. This was apparent from the very beginning when I first explored "How to Use the GEO 101 Web Site" and "Explore the Course". Rather than finding a linear flow through these pages, I found a set of circular link structures such that I found myself arriving at the same page from different

directions. This was frustrating. Often I found myself repeatedly using the browser's "back" button because I did not want to follow the apparent path I had chosen. The main reason for my reluctance to explore the path was a feeling that I was getting off-track.

In my main phase of exploration through the maps module it took a while for me to learn to recognize and predict the links. Certainly the text links to the "GEO 101 Homepage" and the "Maps Homepage", as well as the button link to the "Site Map" located at the bottom of the pages were obvious. However, I commonly missed links that lay within the text of Lou and Lulu's dialogue. I believe this was partly due to the fact that the same color highlighting for links was also used for simply highlighting important words or phrases. Conversely, I often attempted to click on text words that were merely meant to highlight key words. What consistently identified a link was underlining, but this was not as eye-catching as the color variation.

Another reason that I believe I missed links within dialogue text was that I was drawn primarily to the figures. My instinct was to click on the small images, expecting them to lead to larger images. For example, on the first page where Lou discovers the map and the two poetic clues, there are thumbnails of these three objects. I immediately attempted to click on these images. When it became apparent that the images did not provide links, only then did I search for text links.

In reference to Lou and Lulu, I must admit that they had a negative impact on my perception of the website. It seemed to me that there was too much banter and in response I tended to skim through the text looking for the critical data. Also, I wondered how students would respond to these "action-comic" figures. Would it seem somewhat demeaning to the students?

Within the body of the maps module, the repetition of linkage became extreme. This is clearly evident in the complexity of the linkage flowchart (Fig. 3.1) with its many crossing tie-lines. The "Maps Homepage" included a hierarchical list of subjects, each entry of which linked to the corresponding webpage. Such a central link is very useful, but on the same page was a link to the "Site Map" which linked to 14 main topic pages. Then two pages ahead in the linear progression of the module, the "What Is This Thing – A Map?" page linked to 10 main topic pages. Each of these link lists duplicated some, but

not all, of the other two. Finally, at the end of each main topic (e.g., Direction) there were links to each of the other main topics.

The repetition of links caused me to lose the intended flow of the website. In fact, I stopped thinking of it as having a natural flow. The navigation strategy that I eventually adopted was to rely on the "Site Map", however, this method only developed after a number of unintentional circular meanderings through the module.

Although I think I did encounter each of the expository pages in my early phases of exploration, I realized later while constructing the flowchart that I had missed 3 of the quizzes. I cannot explain exactly why I bypassed these pages but it seems likely that the links were simply lost in the background. There were too many links, too many ways to get from one page to another, and it was too easy to miss a particular link, especially if a text link wasembedded in the dialogue.

3. ADJUNCT EXPERIENCES WITH THE SPRING 2000 WEBSITE

In discussing the maps module the adjunct first noted his support for the choice of subject matter for online presentation it terms of being essentially a study of non-tactile, 2-dimensional materials:

> *"...mapping, it is a little different in the fact that you are looking at a flat surface when you are looking at a map to begin with. So you are taking away that hands-on type of loss."*

He felt that the material was straightforward, and laid out in an easy to follow, step-by step format. However, he did highlight what he considered to be a potential impediment to much of the ESL student population of Urban College, that is, the use of pseudo-Old English and complex verse in the treasure hunt clues.

The adjunct expressed concern over the complexity of the linkage structure of the website but liked the flow-chart style "Leo's Site Map" for navigation:

> *"as far as just the general web setup, I think the simpler you can make it, the easier it is going to be for the students to follow through with it. So*

usually you have less amount of links that go to different directions. I think it would be simpler to go through."

"Leo's site maps that actually gives you a nice flow chart of the whole area. I think that visually it is pretty good so that you can actually head to any part of the lab."

In terms of the use of Lou and Lulu to guide students through the material the adjunct was ambivalent.

"Now as far as the way he had the lab set up with Lou and Lulu kind a guiding me through these figures. I think there are pros and cons to that. Remember, coming from someone with a science background who I guess, now I consider myself as older, having cartoon characters guiding through situations for me personally, I found it a little frustrating. But as far as students, especially newer college students, I can see how... And students who don't have an interest in the subject, how that meant benefit them. Somebody without that really isn't going into the science and that has that as their direction. So there are certain aspects of that that I found was a little drag. Having to go through conversations rather than step by step dry type of situation explaining how things go. Usually I don't like that, but for this lab is seemed that it kind a dragged through."

"I had my wife take a peek at this, at the labs as well, and she doesn't have a geology background at all... So I had her take a peek at it and she actually liked the cartoon characters. She thought it was real funny and it helped her – made it easier actually going through the lab a little bit."

"Having it explained by cartoon characters, it might work out well. I have no idea how this would work -- how they would attach themselves to this."

4. STUDENT EXPERIENCES WITH THE SPRING 2000 WEBSITE

Although this was a hybrid course, the main objective was to examine the interaction with the online components of the course. Accordingly the investigation focused solely on the maps and geology of New York City modules. Students were asked to rate the five sub-modules of maps (distance, direction, contour maps, latitude-longitude and the treasure trail) based on a scale from 1 (outstanding) to 5 (poor). Twelve students out of a class of 20 completed the survey, including seven students who were subsequently interviewed. Satisfaction was moderate with an average score of 2.4 for the entire maps module. Individual evaluations ranged from 1.7 to 4.1. Barbara was the only participant to rate the maps module as unsatisfactory (i.e., >3). Distance was the sub-module rated the highest (2.2) with the remaining sub-modules all receiving similar scores of 2.4 to 2.5.

NAME	AGE	SEX	GEO LAB SCORE	CUMM GPA	YEAR	MAJOR
Anne	32	F	28	2.88	Senior	Humanities
Barbara	24	F	37	2.19		Phys Ed
Clare	20	F	50	2.86	Junior	Business
Donna	22	F	58	2.63	Senior	Humanities
Emily	25	F	74	3.11	Senior	Business
Faye	30	F	100	3.92	Junior	Phys Ed
Gail	22	F	37	3.30	Senior	Social Science

Table 3.3: Demographic data of volunteer students in Spring 2000.

Seven students, all women, volunteered to participate fully in the study in Spring 2000. Their participation involved 2 questionnaires and a 30-minute interview. Five students were seniors and two were juniors. Volunteers ranged in age from 20 to 32. A summary of the demographics of these 7 students is provided below in Table 3.3. Two of the students, Emily and Gail had both taken an online biology course previously. All volunteers described their comfort with computers and the internet as very high, except for Anne who described herself as being fairly comfortable with computers in her pre-

course questionnaire response. It is interesting to note, however, that a rather different attitude was expressed by Anne in the post-course interview:

> *"This year is the first time that I have ever had a computer -- I purchased a computer -- so I am still somewhat intimidated by them."*

While watching students navigate the site and listening to their comments regarding their online experiences, it became clear that whereas they might feel generally comfortable on the internet, most do not possess more than the basic skills of working within a web navigator. For example, Barbara complained about having to work through 5 pages in which the treasure hunt was introduced before reaching the maps homepage where she could begin her work. She neither noticed that the first page of the maps module contained a link to the maps "Site Map", from which she could have linked to any portion of the module, nor did she think to set the "Maps Homepage" as a favorite on her web browser. Faye was the only student interviewed who simplified her task by setting favorites, both to the "Maps Homepage" and to her end points so that she could quickly continue in her next online session. All interviewed students accessed the site from home computers, so all had the opportunity to customize their browsers.

Although students were generally critical of the course after its completion, there were few complaints regarding purely technical aspects. The expected issue of loading time for graphics on low-speed connections was mentioned only by Barbara. A more troublesome issue raised by her, however, was that despite the college's support and encouragement for the development of online courses, the library maintained a 30-minute limit for computer use by students. Thus the college facilities could not be used effectively by students for extensive online course work. This came as a surprise to Prof. Brook who had assumed that those students who experienced technical limitations on their home systems could simply work at the college. Another technical issue, this one raised by Gail was that the maps and figures that they were required to print for assignments in the Geology of New York City were in color. She did not own a color printer and as a result had difficulties reading data from some of the maps.

The most common reason given for registering in the online lab section of GEO 101 was that it best fit the student's schedule and in the cases of Donna and Gail, it was the only

section open at the time they registered. Clare enrolled in the class because she liked to work independently. Barbara and Gail stated in their questionnaire that they wanted to try something a little different and that the idea of an online course was interesting. However, it should be noted that in the post-course interview Gail stated,

> *"I do not like virtual labs. I had a virtual bio lab last semester and I didn't like it either. I don't think anything replaces a lecture."*

During the term the class experienced a hybrid course. One module (minerals) was entirely in-class. One module (maps) was entirely online, although with optional review sessions. One module (geology of New York City) was a combination on in-class and online requirements. Accordingly, there was a strong presence of the instructor throughout the course, and yet a communication barrier existed regarding online activities. Over the term Prof. Brook received only ten emails from students regarding the course: five messages notified Prof. Brook of errors in his website (three of these messages were from Faye) for which the senders were each awarded five points extra credit; three messages involved student absences; one message was a request for help understanding basic course expectations and procedures; one message from Gail stated her state of confusion regarding maps and her anxiety regarding the lab exam. Barbara said that she sent several emails to Prof. Brook and received no replies. This is odd because Prof. Brook was very conscientious about replying to student emails. He had no recollection of these messages and they do not appear in his email log. It must, therefore, be assumed that Barbara had an incorrect address for Prof. Brook and did not use the email link on his homepage.

Each of the seven interviewees noted that they checked "Late-Breaking News" each time they logged on to the site, and that the messages posted there clarified many of their uncertainties regarding course logistics. However, the only venue in which content questions were addressed was in the classroom or in Prof. Brook's office immediately after class. Gail, Donna and Emily all approached Prof. Brook in this setting. Certainly, this standard form of student-instructor communication was valuable to and sufficient for Emily who expressed the following opinions:

"When he went over it and I was able to interrupt him and say, 'Okay, can you explain this a little more'. That was helpful."

"But other than that, I didn't really need to contact him."

This certainly did not mean that the course content was clear to everyone else in the class. Repeatedly, students stated that in hindsight they should have asked more questions, particularly about the maps material. Examples of this include Donna's statement

"I should have asked more questions with the formulas and all that, but I figured that I would teach myself."

Another example of this attitude was Faye's response to my query as to whether she had sought out Prof. Brook to ask him a question:

"No, even though they were burning in my mind. I should have actually."

Why the lack of questions, particularly questions through email? Certainly part of the problem is that students were unable to articulate their misunderstanding. As Gail put it,

"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'."

This is a problem that can arise in any learning environment, but perhaps there were additional problems directly linked to the online nature of the maps module. Perhaps, like Barbara, many students did not have Prof. Brook's email address and did not think to find it online. In this first term of running an online course, Prof. Brook did not require students to contact him by email prior to registering in the class, nor did he ever compile a complete student email list. Therefore, it is possible that some students did not have email accounts and so could not contact the instructor in this fashion. Perhaps it was also due to the asynchronous nature of communication during online investigations. This is certainly evident in the two following statements of frustration,

"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." (Gail)

"If I have questions I like to be able to ask right then and there." (Anne)

Students commonly expressed confusion regarding the interpretation of topographic maps. This is not surprising considering that maps are graphical abstractions of the real world that involve multiple concepts including such mathematical concepts as graphing and ratios. Certainly, such frustration is not unique to students working on the internet, but should such a problem arise while doing a typical in-class investigation the student can immediately turn to a peer or the instructor for help. They can also verify their answers with classmates and thereby feel more secure about their understanding of the assigned task. Although they had the quizzes, these acted only as a check to see if they were correct. If the wrong answer was entered, there were no prompts or hints. A student could only re-read the text and try again. Furthermore, the problematic concept may have been on a previous page to which the student may not have been able to retrace their way. This sort of frustration was expressed both by Anne and Barbara.

> *"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 do that." (Anne)*

> *"There was really no way of looking at your answers to find out if you were putting down the right answer until you come to the class." (Barbara)*

For these students taking their first, or at most, second on-line course it was a new learning environment for which they had not adapted appropriate skills. For Prof. Brook this was his first attempt at offering an online course and he had not yet fully adapted to this new teaching environment. Accordingly it is not surprising that students made numerous statements that reflected a desire for more classical educational experiences in the class. They commonly expressed a desire for a more familiar, immediate and controlled form of communication. In fact, this desire was expressed by six of the interviewed students. The common sentiment was that the internet was good for assignments but that face-to-face encounters were preferred for learning new material.

> *"I was too intimidated by it to begin with. I would have been better off with a professor explaining it so that if I did have any questions I could sit*

and talk to them about it and not feel so insulted by seeing little Carmen Sandiego characters." (Anne)

"[I would have liked] More in class. Like having a lab section in class that dealt with 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?" So maybe explain how to really look at a map, instead of having to going on line for it!... Yeah I like the concept that mostly the labs is on your own. I mean, you could do it at the time you needed to do it because it didn't interfere with anyone's schedule. But I needed a little more guidance, than just go on the internet, do what you had to do." (Barbara)

"I found it very interesting and very informative. But the map section, I believe it shouldn't have been entirely all virtual. I think there should have been one lab meeting with the maps because I think they were kind of confusing. But overall it was definitely a learning experience." (Donna)

"Overall it was pretty interesting. I am glad that we had both, that we were still able to come into the classroom, because there was things that I sort of had trouble with online. He was able to sort of help out in class." (Emily)

"More teacher–student interaction. I don't think it is good just with the web. I think it is good to do homework on the web. That's probably the best way to go." (Faye)

"And if I would have been asked "Do you still want to meet with teacher or do you want to do it on your own" I would have definitely said, "I don't care if it's every week. I would like to come to the teacher." (Gail)

Note that even Clare who stated, "*I don't like going to class. I find it annoying*", expressed a desire for more contact from, and communication with, the instructor, if only virtually:

"I would have students have like a progress report — like writing a report to let the professor know what progress they made and what they are doing. Just let them know what point they are up to. What have they done? What they understand? What they don't understand? What needs to be covered when we have class time?"

A critical part of the interview process was an opportunity for the student to navigate through the website with the general instruction to "show me some things that you liked and didn't like about the website". This 10-15 minute tour allowed me to witness their familiarity with the site, their navigation skills, and served as a reminder to the student of past experiences online. Observing their navigation it was apparent that for some of the students, even at the end of the course, they were still lost within the site. In the case of Anne, even the most basic navigation was difficult.

"The maps... Where are the maps? I don't even know how to get to the maps."

Link structure was a significant issue for the students. Simple, circular or multiple links such as on "The Treasure Described" page described previously, although a minor point, seemed to be a common annoyance, and one that was specifically pointed out by Barbara, Clare and Donna. Whereas they eagerly demonstrated this issue to me, none of them thought to address this annoyance to Prof. Brook.

More problematic was the complex link structure within the maps module, a problem of which Prof. Brook was aware as demonstrated by his onsite reference to "the maze of links". While surfing deep into the site during the interview, if asked to go somewhere else in particular, most were unable to find the requested page without my assistance. This issue of becoming lost was expressed commonly. For Faye and Clare, this complexity was something they faced and felt that they learned to overcome, whereas for Barbara and Gail the link structure led to obvious frustration throughout the term.

"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. So I would put a little short cut on my desktop or something like that so that I could click right there." (Faye)

"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." (Clare)

"See from that past screen I did not know where to begin, so I just started from Leo's Treasure Hunt, then I'd go back to the map. So that is how I would find where I am supposed to be. It was just a lot of information, with a lot of different links, so you would end up getting lost and having to go back, and then find out where you were supposed to start." (Barbara)

"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." (Gail)

It should be noted, however, that even successful students such as Faye stumbled upon pages during the interview that they had never seen before. For Faye it was the page describing rounding-off of numbers. By the end of navigation session with me Barbara realized that actually she had missed several key pages including the "Label the Contour" page.

"I had a little difficulty finding the sites. I think a lot of difficulty. I missed a bunch of them."

Prof. Brook's intention was to allow students convenient access to the complete set of sub-modules. Accordingly, he placed a link to the Maps Homepage at the bottom of almost every page, as well as a link to the graphically presented link map of the Site Map. Interestingly, Faye was the only student to use the Site Map to navigate through the website during her interview.

The central design element of the maps module, that is the expository dialogue between Lou and Lulu, received mixed response from students in the Spring 2000 term. When designed by Prof. Brook, the dialogue format was intended to breakaway from the electronic-textbook model, and also to attempt to simulate the dialogue-based learning

that would occur within a classroom. The "Search for Leo's Treasure" provided the reason behind Lou's interest in learning about maps: Lou had to learn to interpret a topographic map in order to find the treasure. However, the treasure hunt sub-module was an optional exercise. Of the interviewed students only Donna completed the treasure hunt.

The decision to make the treasure hunt an optional exercise for extra credit appeared to have been made after the development of most of the maps module. This is evident from the fact that on the "GEO 101 Homepage" there is a link entitled "Start the Search for Leo's Treasure Trove". There is no reference to maps on the homepage. This issue frustrated a number of students. Barbara, Clare, Donna and Emily each commented on their confusion when they first began exploring the site. The following comment from Emily suggests that this problem was common throughout much of the class:

> *"I know in class, a few people mentioned a thing about having trouble finding the general information about the maps. I mean it wasn't hard to find, but for some reason it wasn't on the initial screen that we went into."*

Regarding student attitudes toward the cartoon dialogue, there was no clear trend. Anne exhibited very strong responses against the character-based format. In fact her initial comments describing her impressions of the course were of the "somewhat insulting" nature of "a Carmen Sandiego-type treasure hunt".

> *"I am joking about it but it does do something to someone, when they are like, you are talking to me as if I am a child at the same time... I know that in geology I am like a child, but nobody wants to be insulted in that sense." (Anne)*

Her descriptions of her interaction with the website showed that the Lou and Lulu dialogue, and the treasure hunt format was a deterrent to proceeding through the site and therefore to her learning process:

> *"As soon as I saw these little cartoon characters, it was like, 'NEXT'."*

At the opposite end of the spectrum was Donna's experience who very much enjoyed the comic-like style, and for whom the treasure hunt theme was a motivation to move through the material:

> *"I started looking at the Leo's Treasure Trove, which I thought was kind of fun with Lulu and Leo. I just kept linking. I was more interested in finding the treasure than I was actually reading about it. I would print out the clues, the yellow pieces of paper, where he would make these poems. And I would just read through them to see if I would get a clue. And I would look through them. That was fun. I liked that part. And then I went through it and when you go though it, you learn about the maps."*

Comments from Barbara and Emily both demonstrate a more moderate view of the delivery approach. In essence they liked the dialogue delivery, but would have liked a more straight-forward, less time-consuming exposition of the necessary content. This attitude is well summarized in the following statement from Emily:

> *"I liked the little skits. They kind of helped to explain it. I mean sometimes I kind of wished, 'All right, where do I find the actual information?' But it was helpful. It made it easy to read."*

From Table 3.3 it is evident that there was a significant variation in student success. The class mean for the term was 53, indicating a general problem with learning in the class. It is likely that the problems in communication, structure and style that have been discussed previously contributed significantly to the overall low results. But why did several students still perform well? Interestingly, the interview group included the class' highest scoring student (Faye) as well as the 3 of the 5 lowest scoring students (Anne, Barbara and Gail), allowing some insight into the this question.

There was little variation between Gail and Anne in their demographic data (Table 3.3). Some difference is success could be attributed to their general attitudes toward the material and its perceived relevance. Faye enjoyed the outdoors and even expressed some interest and knowledge about geology. Anne was very much a creature of the city for

whom geology was quite alien. This is demonstrated in a comment she made regarding her lab exam:

> *"He asked a question about if you were lost, how are you going to use a compass? I am like, 'I haven't been to Staten Island yet.'"*

I think this certainly contributed to the variation in the success of these two students, but basic work habits and attitudes toward schoolwork appear to have more critical factors in their results. Anne repeatedly commented on her lack of discipline and a lack of patience. This coupled with the relatively weak, out-of-class communication between students and the instructor, and therefore, a lack of motivation/push from the instructor, resulted in last-minute work and skipped content. This was summed up in Anne's concluding remark:

> *"It was way too easy not to do it, way too easy... Because I know that I am a horrible procrastinator, and I have no self-discipline, I should have not have taken a virtual course because I knew that if I had to rely on myself completely, I wouldn't do it"*

Such a sentiment is mirrored in another' low-achieving student's responses. Gail also remarked repeatedly about a lack of patience while working through the website. One such instance was:

> *"Latitude and longitude. I haven't been on here. I just saw it and I didn't bother to do it. I am not a lazy student at all. It's just that this is really irritating me."*

On the other hand, Faye described herself as being more disciplined than most and has a very strong drive to succeed. In describing her experiences on the lab exam Faye said:

> *"I am a very grade-oriented person. But it is not just the grade, it's that I hate to feel like I don't know what I am doing on the test. It is my worst fear to not know the answer and not even be able to figure it out."*

Rather than seeing the free nature of the work schedule as a hurdle to success, Faye described the flexibility of work-schedule as a real benefit that allowed her do work through the material when she was "*interested in doing it*".

4. DISCUSSION

Several problems were evident from study of the GEO 101 website in spring 2000 and required addressing: 1) insufficient communication, both student-instructor and student-student; 2) a confusing structure in which students were far too likely to become lost; 3) an overly "chatty" format which most students considered to be time-wasting; 4) insufficient milestones to maintain students progress during self-directed study. Surprisingly, technical issues did not seem to be a significant issue.

These points were discussed with Prof. Brook on several occasions throughout June. This involved brief informal discussions, a series of telephone and email messages and extensive one-on-one discussions of the results while examining the site itself. In addition, transcripts of the interviews (without names) were given to Prof. Brook after grades had been submitted.

It is important to remember that the development of this website was part of a larger process involving multiple people, in particular, Prof. Brook, his mentor and myself. Independent ideas were developed by each of these individuals and communication of these ideas was continuous. However, it was Prof. Brook's decision as to what ideas were adopted and how improvements would be implemented. Below, in his own words, is Prof. Brook's recollection of the changes he made to his GEO 101 website between its first offering in February 2000 and its second offering in September 2000. However, the itemized changes were reordered and placed under captions to help reorganize his ideas with respect to the key issues identified above. Note that the vast majority of modifications made for Fall 2000 addressed the two main issues of insufficient communication and internal complexity.

> *Earlier on I had found that I couldn't appreciate (or even understand) many of [my mentor's] suggestions until I had consciously or inadvertently ignored them*

and suffered the consequences. It seemed (unsurprisingly, I'm sure) that I had to learn from my own mistakes. Wayne now joined [my mentor] in making useful suggestions that I incorporated into the second draft of the course, offered in the Fall semester, 2000:

Communication Changes

1. *Requiring students to email me as part of the registration process*
2. *Sending emails to students to remind them of upcoming events and responsibilities*
3. *Requiring the students to submit five sets of lab exercises during the course of the term*
4. *Alerting students individually to mistakes they made in the lab exercises and inviting them to meet with me in my office or ask for help via email*
5. *Creating a collaborative homework exercise that required students to work together both in-class and via email, thus trying to decrease the isolation that totally on-line course work engenders.*

Structural/Linkage Changes

6. *Creating a simple, vertical website structure*
7. *Minimizing lateral links*
8. *Making use of 'back' links*
9. *Making use of 'new' windows*
10. *Avoiding multiple links to the same page*
11. *Placing on-line the completed mineral identification module*
12. *Keeping the pages clean and simple, avoiding excessive changes in font size and color; restricting text width to half the page*

Pedagogical Changes

13. *Introducing each topic in class*
14. *Letting students 'discover' information and relationships, rather than 'telling them'*
15. *Creating individualized exercises for each student so that the answers can't be obtained simply by copying another's work*

CHAPTER 4: FALL 2000 STUDY

1. WEBPAGE DESCRIPTION

Unlike the previous term, all students seeking permission to enroll in the virtual section of GEO 101 were required to email Prof. Brook based on instructions on a form distributed from the Geology Department office. Thus Prof. Brook ensured that all students enrolled in the class had access to an internet account and were able to contact the instructor through it. It also allowed Prof. Brook to compile an email address book for the class. Students were informed of the homepage URL both on paper and by email, and were reminded of the address when they met in class for the first lab. The second lab was conducted online, although students had the option to meet with Prof. Brook during the regularly scheduled lab time for an optional review session.

I. Introduction, Background and Initial Instructions

The GEO 101 Homepage for Fall 2000 presented its links in a table format rather than the simple list of Spring 2000. The table was consisted of two columns under the headings "Information" and "Investigations" (Fig. 4.1). A similar set of information links were presented (Explore the Course, Tips for Your On-Line Work, Late-Breaking News) although in reverse order to the way they were presented in Spring 2000. Under "Explore the Course" students could link to three pages that provided basic information about the course: Course Outline and Goals, Course Calendar, Grading Policy. These were essentially the same as those presented in Spring 2000 with the exception that scenic geology-related images decorated the right-hand side of the pages. The course calendar as presented on the website is illustrated in Table 4.1.

"Late-Breaking News" was reworked to some extent. The sequence of postings was reversed from that of Spring 2000, with postings now listed sequentially by date in ascending order (i.e., the most recent postings was located at the bottom of the list). The page also made use of button-links similar to those used throughout the website rather than the text-links used in Spring 2000.

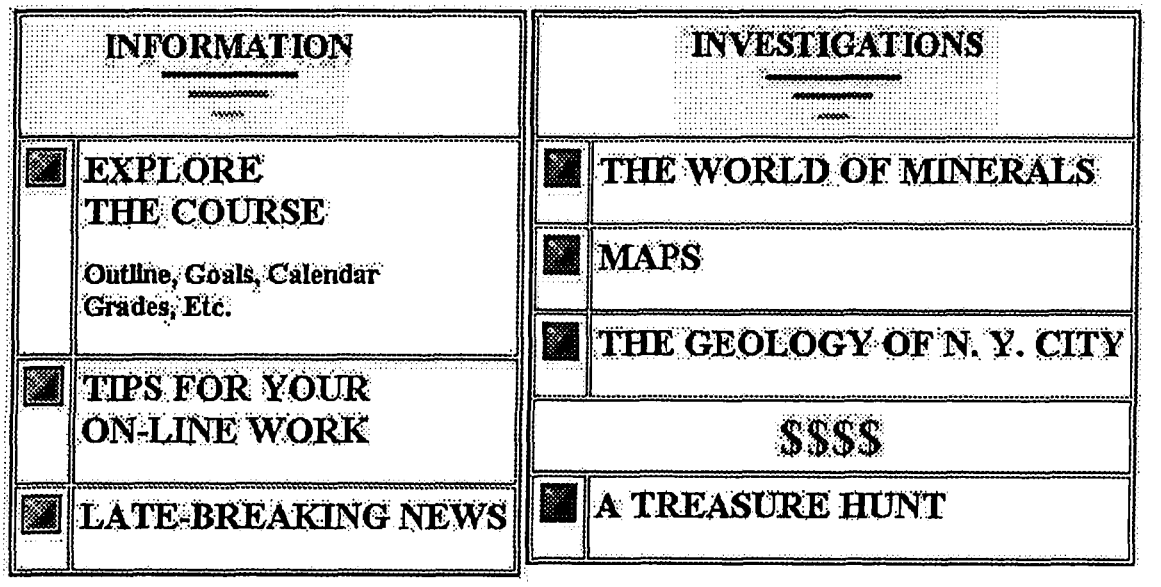


Figure 4.1. The Fall 2000 GEO 101 Homepage

Prof. Brook used the "Late-Breaking News" primarily to provide students with detailed instructions regarding what was expected for assignment submissions, when submissions were expected, information/hand-outs required, and the detailing of procedures necessary to complete the exercises. This venue also was used to provide students with feedback on past exercises. For example, students were asked to write a short description of the topography of a region based on a topographic map. Prof. Brook did not feel the responses were adequate, and so he posted anonymous student responses and a "complete" description so that they could compare their work both with that of their peers and that expected by their instructor. He also provided a step-by-step methodology for preparing a landform description.

The "Investigations" column consisted of four headings. "The World of Minerals", "Maps", "The Geology of N.Y. City" were listed together, each with a green link button. Below these titles, and separated by a row of dollar signs, lay "A Treasure Hunt" with an associated purple link button.

TIME: 1 to 2:50 AM	ROOM: 200
DATES	**ACTIVITY**
1. Tuesday, September 12	1. Minerals (required in-class)
2. Tuesday, September 26 Preliminary Mineral Report Due.	2. Minerals (optional review in-class)*
3. Tuesday, October 10 Final Mineral Report Due.	3. Maps (required in-class)
4. Tuesday, October 24 First Map Exercise Due.	4. Maps* (optional in-class Q and A session)*
5. Tuesday, November 7 Second Map Exercise Due.	5. Geology of New York City (required in-class)**
6. Tuesday, November 28 First New York City Exercise Due.	6. Geology of New York City (optional in-class review)* **
7. Tuesday, December 12	7. Final Exam (required in-class)
*Bring print-outs you wish to review. **You must bring NYC print-outs to lab.	

Table 4.1. Schedule for virtual section of GEO 101, Fall 2000

II. The World of Minerals

Minerals was the first topic of investigation in the course. An online investigation of minerals was developed during the Spring 2000 term for implementation in Fall 2000. In fact it was appended to the website late in the Spring 2000 term but students were not directed to this site, nor were they required to use it in anyway. Thus the first true implementation of this module was in the second term of the study. The module was a continuation of an investigation that was initiated in-class with real samples. It was intended that this online module continue to build skills in data collection and interpretation rather than to train students to recognize a specific suite of minerals.

In the first lab meeting students were introduced to, and applied, the basic tests used to characterize minerals: hardness, colour, streak, breakage, density, as well as a number of miscellaneous properties. These were the same properties that the students would investigate online in the weeks following.

The structure of the "World of Minerals" module is illustrated in figure 4.2. The "World of Minerals Homepage", where they began their investigation, presented the following bulleted list of 5 links:

- *The Print Shop: Materials to print before beginning your investigation*

  This linked to a page from which one could link to en printable forms: eight property-based classification charts, and two forms on which to tabulate the results of their investigations

- *What is a Mineral?*

  This linked to a page on which Lou and Lulu introduced the definition of a mineral. Although the images of Lou and Lulu and their conversation style were the same as those employed in the maps module in the previous term, the layout was considerably different. Whereas previously their discussions were presented in a simple vertical structure, on this page the format was much more similar to that of a comic-book; the page was subdivided into a number of discrete boxes with each box containing one piece of the dialogue or a supporting figure (Fig. 4.3). The length of text lines was controlled by the width of the table's cells rather than the width of the page as it was in the maps module in both terms. From here students could link directly to the Mineral Investigations.

- *Mineral Investigations – Introduction & Resource Table*

  This link, which was highlighted relative to the other four links on the Minerals Homepage by the use of red text rather than black text, led to the heart of the maps module. This will be described in detail below.

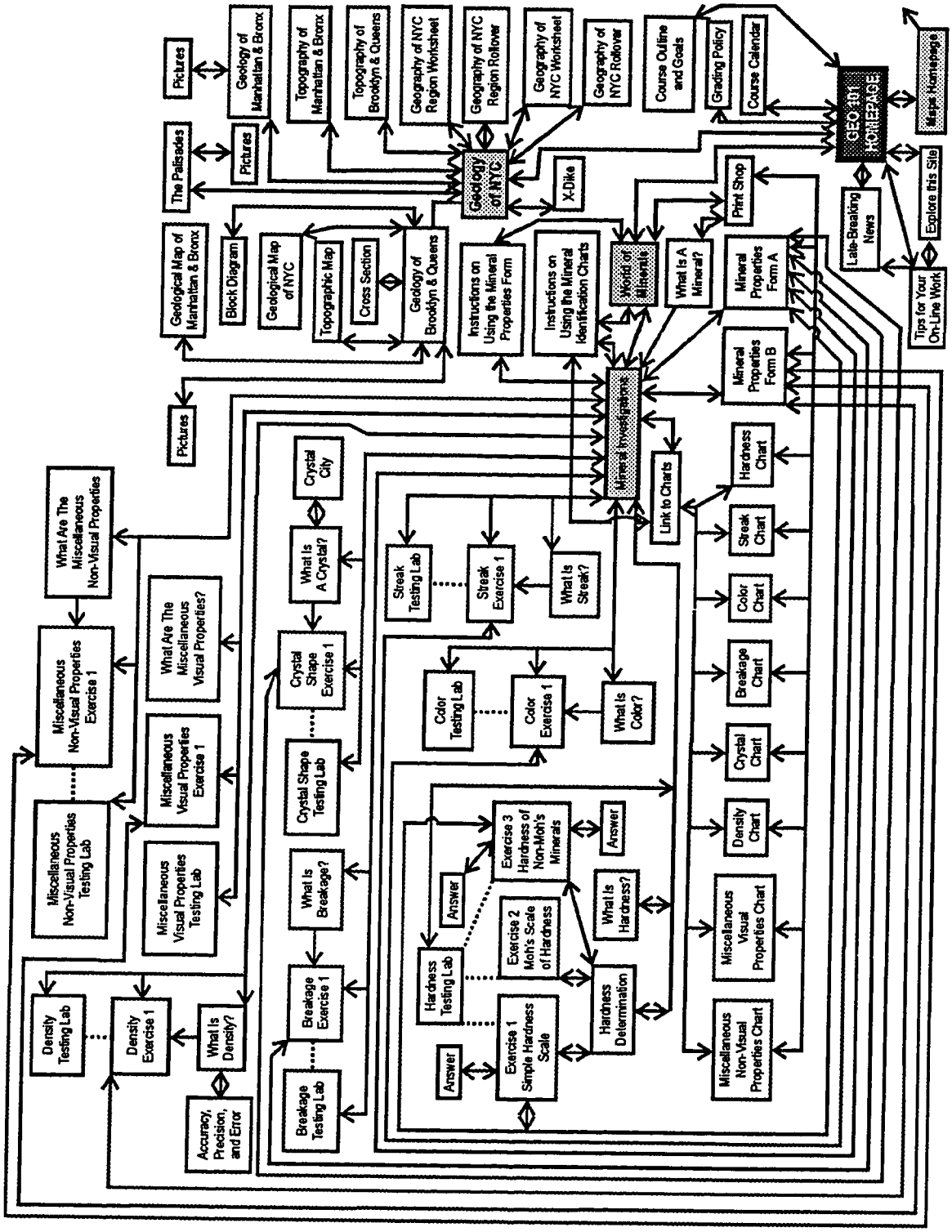


Figure 4.2. Linkage flowchart of the GEO 101 website as offered in Fall 2000. Maps module is shown separately in figure 4.8. Note that dashed link lines represent pages that open as separate windows.

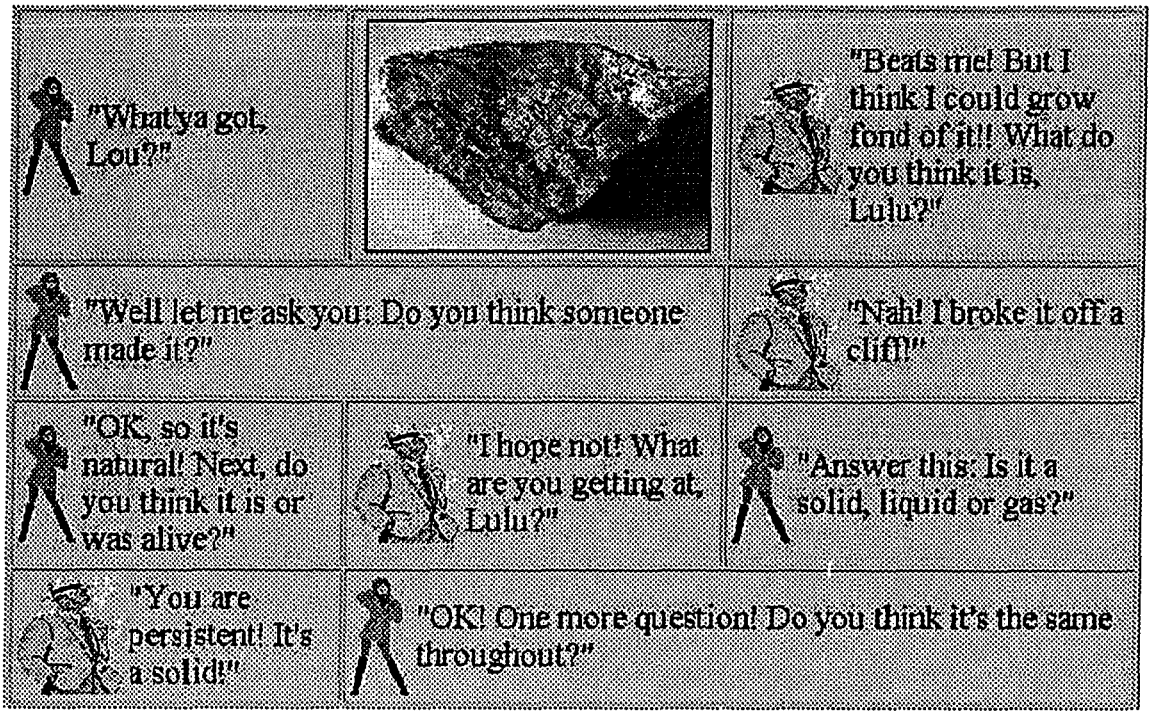


Figure 4.3. Portion of the "What Is a Mineral?" page illustrating the comic-book style layout of Lou and Lulu's expository dialogue.

- *Instructions on How to Use the Mineral Properties Form*

  This link led to a page that described in detail the use of the forms in which students were required to tabulate and submit their data during the investigation. It involved a series of bulleted instructions on the left side and supporting illustrations of the use of the form on the right-hand side. From here students could link directly to the Mineral Investigations as well as to the Mineral Identification Charts.

- *Instructions on How to Use the Mineral Identification Charts*

  This link led to a page that described how to read and interpret the 8 tables that students were required to use in order to determine the identity of their assigned unknown minerals based on the properties data that they had collected. Like the instructions for the Properties Form, this page involved a series of bulleted instructions on the left side and supporting illustrations on the right-hand side. From

here students could link directly to the Mineral Investigations as well as to the Mineral Identification Charts.

The Mineral Investigations page is laid out in a table/columns format with text instructions on the left-hand side, and the link table on the right. This is the page from which students linked to all of the mineral investigation activities. Accordingly, Prof. Brook included an additional set of links to each of the forms, charts and instruction pages.

The minerals module is centered on one main exercise. The corresponding description and instructions presented on the website are included below. On the website, the text was colour-coded. Most of the text was black. Blue text is presented as bold text below. Red text is presented as underlined text below.

> *PURPOSE OF THE INVESTIGATIONS: You have been hired by the Know-Whin Investment Corporation to determine the value of a mineral deposit located on a piece of land they are considering buying. The Corporation has supplied you with mineral samples their agents have collected from the land. The samples are identified only by numbers. You may have several samples with the same number. Samples with the same number are the same mineral, even though they may vary in their appearance and properties. Your task is to determine the mineral names of the samples.*
>
> *METHOD OF INVESTIGATION: You will identify and name the samples by determining their properties. The* ***Properties of Minerals Resource Table*** *shown on the right will enable you determine up to eight properties of the samples. For each property, the Table provides you with three links. The links give you access to:*
>
> 1. *<u>"What is...?"</u> - an explanation of the property.*
> 2. *<u>Exercises</u> - that include instructions on how to use the property Testing Lab.*

3. *The Testing Lab - a 'virtual' scientific lab that allows you to investigate that property of your samples.*

For each property, follow the three links provided. Make sure to read the explanation and instructions carefully before visiting the Testing Lab.

RECORDING YOUR RESULTS: You will determine up to eight key properties of each mineral by visiting each of the eight Testing Labs. For any of your mineral samples whose numbers are listed in that Testing Lab, perform the indicated tests.

Record the results of the tests on a printout of the Mineral Properties Form. *DID YOU FORGET TO PRINT OUT THE FORM? If you did, parts A and B of the Form may be accessed by clicking on the two blue buttons to the right. Print out the two parts of the Form before starting your investigation.*

For instructions on how to use the Form, click on the yellow button to the right.

IDENTIFYING YOUR MINERALS: When you have performed the tests and recorded the results, you will determine the mineral names of your samples. This will be done by comparing the properties of your samples to the properties of minerals listed on the ***Mineral Identification Charts.*** *There are eight Charts corresponding to the eight properties in the Mineral Properties Resource Table. DID YOU FORGET TO PRINT OUT THE CHARTS? To access the Charts, click on the green button to the right. Print out the eight Charts!*

For instructions on how to use the ***Mineral Identification Charts,*** *click on the yellow button to the right.*

SUBMITTING YOUR REPORT: Your report will be a letter addressed to the Know-Whin Corporation. In the letter, list the sample numbers and the mineral names you have decided upon. Indicate clearly the tests you have

performed for each and the evidence used to identify the sample. If you cannot decide between two or more mineral names for a sample, list the possible mineral names and the evidence for each name. Indicate clearly why the choice could not be narrowed down to one mineral name. Submit the letter together with Parts A and B of your Mineral Properties Form to your instructor on or before the time and date indicated on your assignment sheet.

COLLABORATION: You are encouraged to collaborate with other students both in testing your samples, deciding on names, and preparing your report. Each student, however, must submit their own report.

Beside these instructions was the "Properties of Minerals Resource Table". This was a link table allowing students to explore 8 categories of mineral properties: hardness, colour, streak, breakage, crystals, density, miscellaneous visual properties, and miscellaneous non-visual properties. Each of these 8 table cells contained 3 links:

- *What is...?*

  These links provided explanations and descriptions of the property in question (e.g., What is Hardness?) my means of a Lou and Lulu comic strip with the same format as that of the "What is a Mineral?" page described above.

- *[Property] Exercise 1*

  These pages provide detailed instructions on how to perform the required tests in the Testing Lab. Numbered instructions are provided in the left-hand column. Cartoons illustrating the testing activity are provided in the right-hand column. An example of a portion of one of these instruction pages (for streak) is illustrated in figure 4.4.

- *[Property] Testing Lab*

  These pages are the locations of the actual activities in which the students engaged. In each case the exercises were designed to be interactive and modelled on the actual hands-on processes that they performed in class during the previous lab session. Each of these 8 activities will be described in detail, however, each of the pages are similar

in form. Each consists of a 3-column table. The left and right columns contain lists of unknowns, standards, or both, from which each test sample can be selected. The center column consists of graphic windows in which images of the selected unknowns and/or standards appear after being selected by the student.

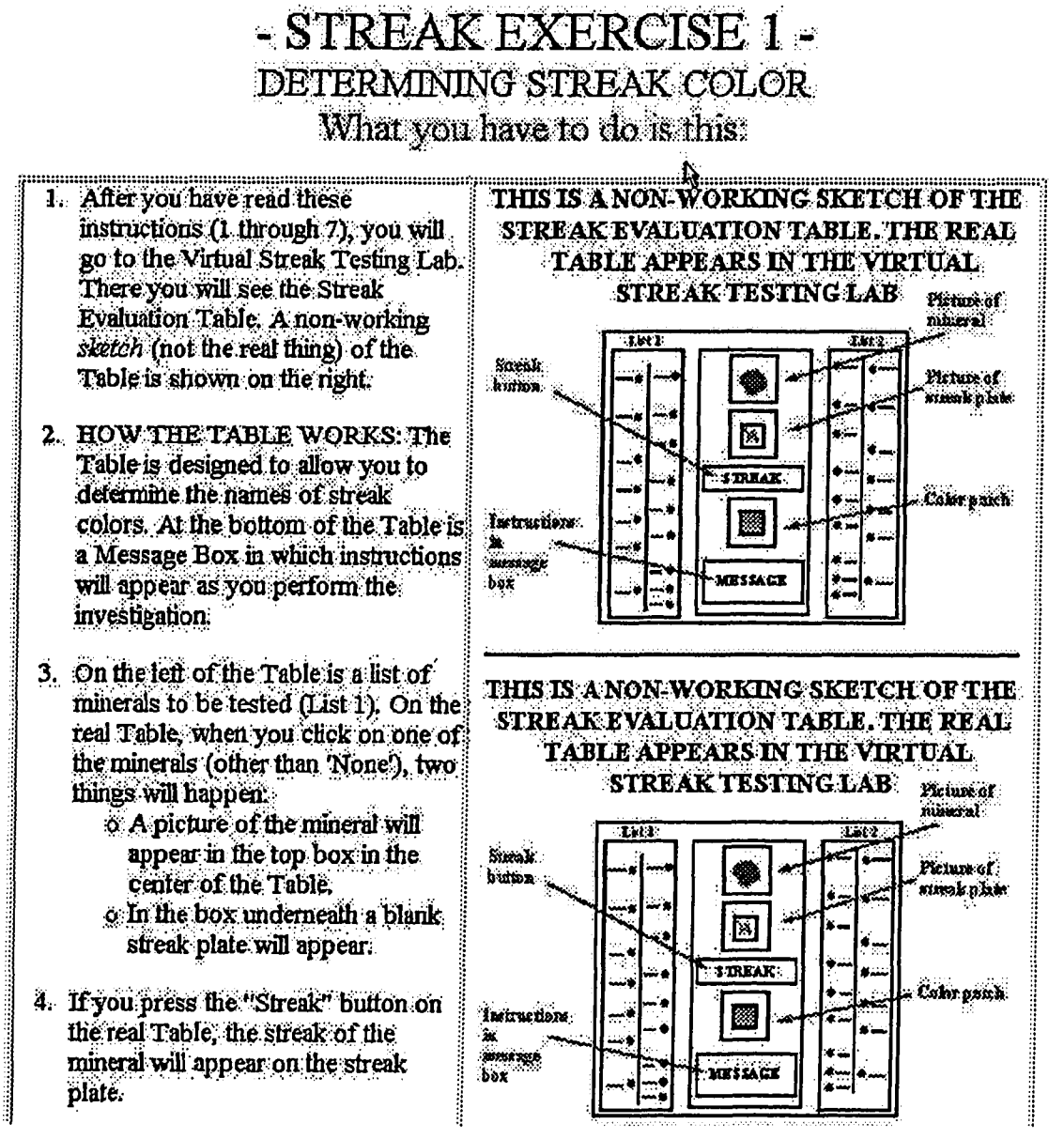


Figure 4.4. Instructions for using the Streak Testing Lab.

The hardness testing exercise consisted of 3 parts. Initially the students were asked to determine the general hardness of a set of unknown minerals (a unique list for each student). Students would click on a sample number from the left-hand column and a picture of the unknown mineral would appear in a box in the central column (see figure 4.4). Next the student would click on one of the testing tools listed in the right-hand column, either a fingernail or steel. An image would then appear in the box beside the mineral picture. Below these pictures is a button labelled "SCRATCH". When this button is pressed the two images appear again but in this set of pictures, the softer sample displays a prominent scratch. For example, if students select Mineral Specimen #5 (which is biotite) and Steel and "scratch" them, then the biotite is displayed with a large white scratch. This activity mimics the activity that the students did in class and allows students to rate the hardness of a mineral into three categories: soft (scratched by fingernail), intermediate (scratches fingernail but scratched by steel) and hard (scratches steel). The online exercise then goes beyond the class experience by requiring students to scratch minerals against other minerals to determine their relative hardness (Fig. 4.5). In this way students are required to determine by iterative experimentation the sequence of 10 minerals in the standard Moh's Scale of Hardness.

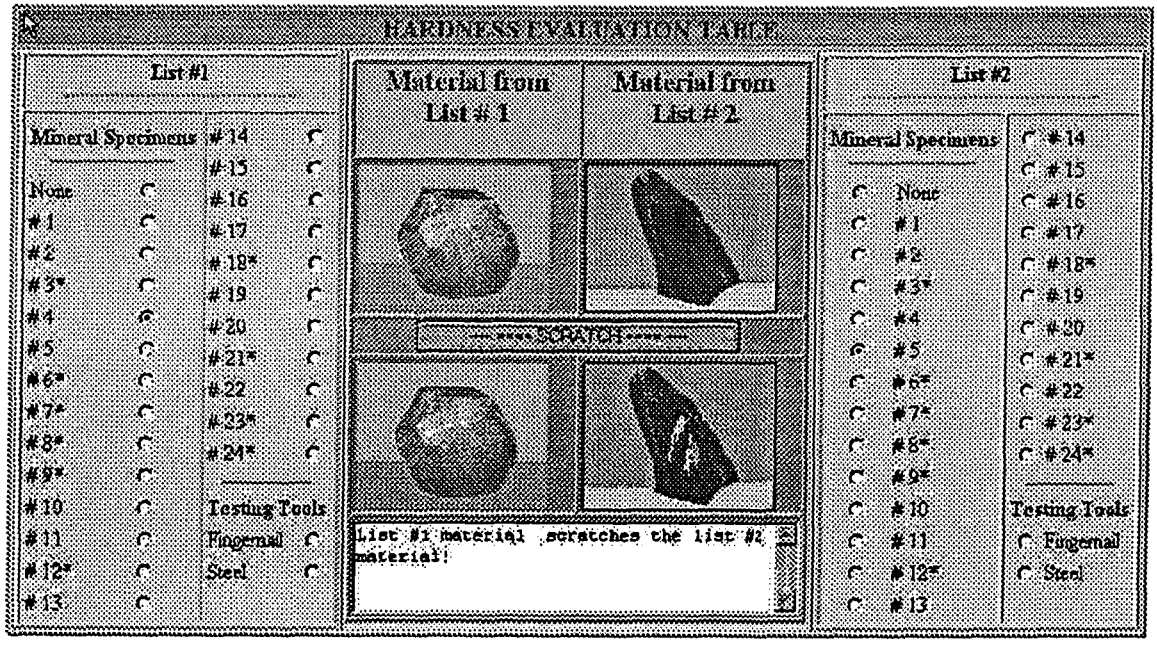


Figure 4.5. The Hardness Evaluation Table

The color testing and crystal testing activities both worked in similar ways. Students were asked to determine the color/crystal shape of an assigned group of unknown minerals by comparing it with a set of standards. Students would select a particular specimen number and thereby bring up its image. Next the student would roll the mouse over the list of standards until they found the best match, which they recorded on their data sheets. For color this meant that students had to select between various shades (e.g., sample 2 [hornblende] is best described as greenish black rather than brown-black or black). The streak testing presented a similar setup where students had to determine the best match between the sample color and the standards. However, in this case, students had to click the "Make a Streak" button after selecting their specimen. Then an image of a porcelain plate across which the sample had been streaked appeared. Students had used similar streak plates in class. It was the color of the streak on the virtual porcelain plate that had to be compared with the standards.

In the breakage test, students selected a specimen from the list in the left-hand column. Once the image appeared, students could click on the "Break the Mineral" button which would cause a new image to appear next to the specimen's picture. This new picture showed many fragments of the same mineral after being broken. The student then had to select the best-fit shape from a set of seven images listed in the right-hand column.

The virtual density test was somewhat different in its format because it was based on measurement rather than comparison. The table on this page consisted of only two distinct columns. The left-hand column contained the list of samples to be tested and the remainder of the table consisted of graphics boxes (Fig. 4.6). On the right was a cartoon illustrating a sample on a string help over a graduated cylinder partially filled with water. When a student clicked on the "Immerse the Mineral" button, a cartoon of the sample immersed in the water in the graduated cylinder appeared on the right. The water level on both graduated cylinders was marked. An instruction window also opened. This explained how to determine the sample volume from the figures. When the student clicked on the "Weigh the Sample" button, a cartoon of a triple-beam balance appeared below with the weight indicated to a 10^{th} of a gram. Again an instruction window appeared explaining how to use the date to determine the sample's density. Students had

used the immersion method and triple-beam balances to determine mineral density of actual samples in the previous in-class session.

In the "Miscellaneous Visual Properties Testing" page, graphics boxes were surrounded by sets of terms under the titles "Luster", "Passage of Light", "Layering", "Crystal Groups", "Single Crystals", and "Other". Clicking on one of the terms, such as "vitreous" under the heading of Luster, would bring up images of up to three numbered specimens that exhibited the property. The fourth box displayed a definition of the term.

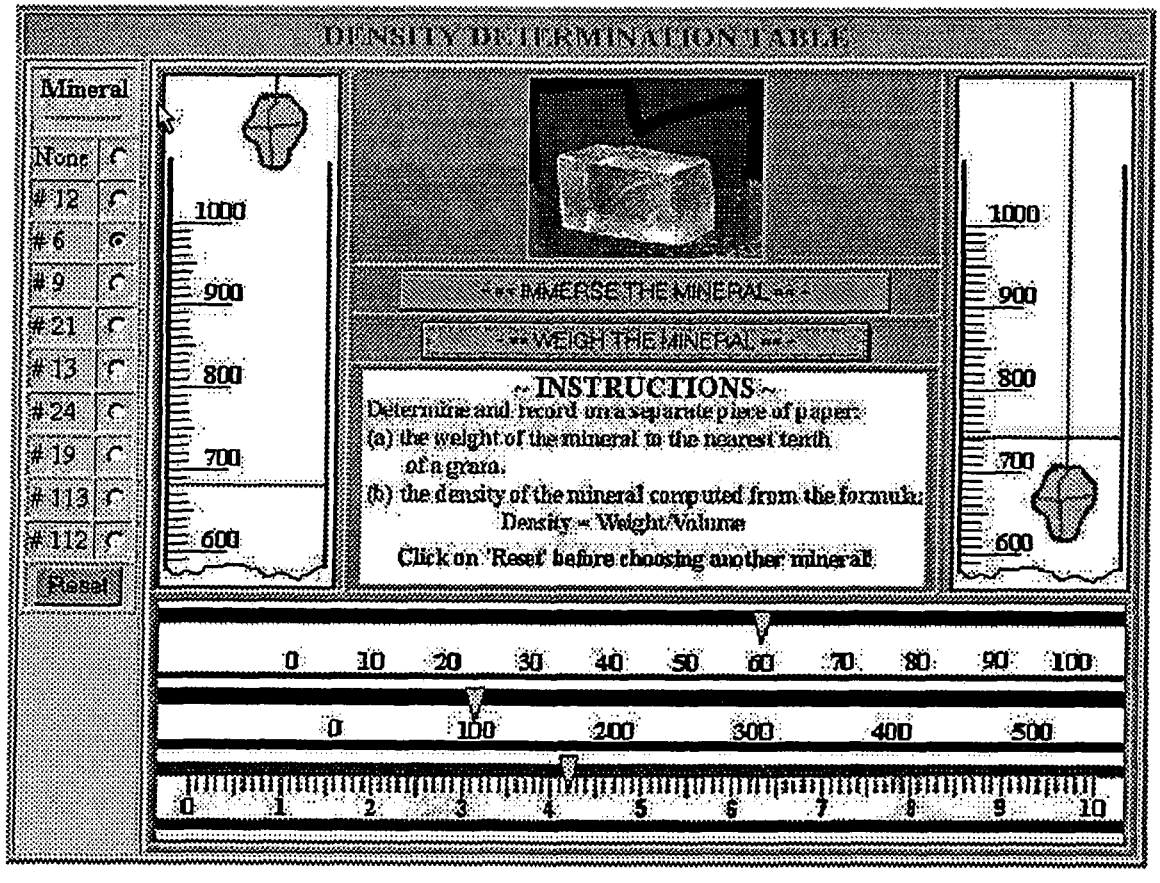


Figure 4.6. Example of the Density Determination Table

The "Miscellaneous Non-Visual Properties testing" page presented examples of sample numbers under the headings "Taste", "Smell", "Sound", "Magnetism", "Reaction to Acid", and "Elasticity". Selecting a mineral sample brought up its image. Clicking on the "Results" button brought up a statement of results and an explanation. For example,

clicking on sample #15 under the heading "Magnetism" caused an image of a black, massive mineral to appear. Clicking on the "Results" button caused a similar image to appear, but now with a magnet attached. Below that was the explanation "This mineral is strongly attracted by a magnet".

Each testing page was graphics-intensive and so could take considerable time to load through dial-up connections. To avoid unnecessary download time, Prof. Brook designed the links to the testing pages so that they would pop-up in separate windows, a link structure not used previously in his webpages. His intention was that students load the page, use it, then minimize the window rather than linking back to previous pages. Thus if students needed to return to a particular testing screen during a single session, they would have needed only to maximize the page and thereby avoiding an additional download of the graphics.

II. Maps

The "Maps Homepage" consisted of a simple table of links located beside the "Maps Homepage" banner. The table is illustrated on figure 4.7. The overall structure of the maps module is illustrated in figure 4.8.

Clicking on "Begin Here" loads a page entitled "Where Am I?" on which we find a portion of the map of New York's subway system followed by a dialogue between Lou and Lulu in which they define a map and discuss its uses. The only links on the page are text-links at the bottom of the page to either the Maps Homepage or the "GEO 101" Homepage. The final line in the characters' dialogue provided students with further instructions: "The first thing to learn is how to measure *distance* on a map!! **Go to Maps Home Page and click on the 'Distance Menu'!'** Thus the basic link structure, which was repeated throughout the module, is a set linear progressions from the Maps Homepage, each of which returns to the Maps Homepage at the end.

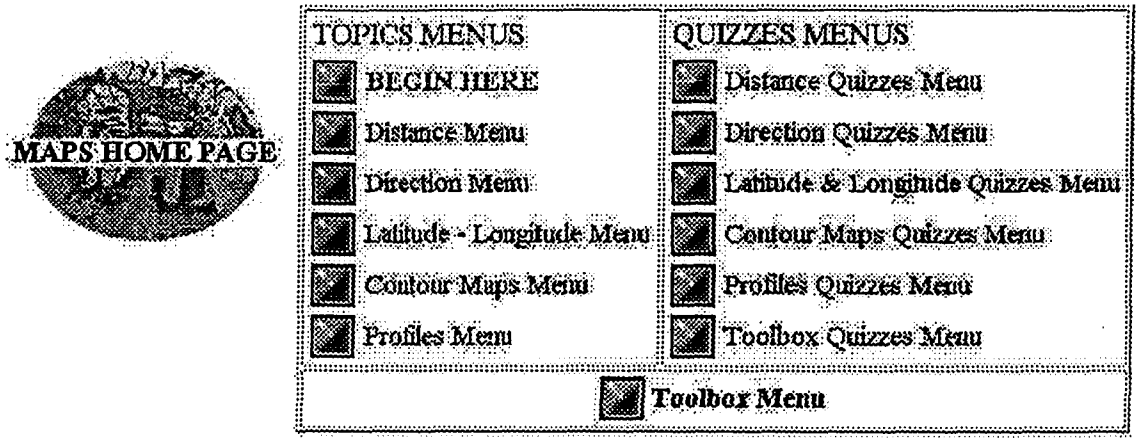


Figure 4.7. Maps Homepage, Fall 2000

The Distance Menu consisted of a table of two links: "Scale – Introduction" and "Using Scales". Similarly, the Direction Menu, and each of the other maps menu pages, contained a simple table of links. Each link took the students to a new page dealing with a related sub-topic.

The content and format of the expository pages of the maps module were similar to those initially presented in the Spring 2000 version. That is, the required content was conveyed to the students through an ongoing dialogue between Lou and Lulu. The dialogue was again accompanied by small cartoon images of the characters beside reach of their statements. The statements flowed down the page rather than being organized in the comic-book format used in the Minerals module.

The most striking difference between this version of the maps module and the previous version is the omission of all reference to a treasure hunt or Leo's treasure map within the maps module itself. The link structure was also markedly different. The link structure for the maps Fall 2000 module is illustrated in flowchart form in figure 4.8.

The quizzes remained the same between spring and fall 2000, however, the links to quizzes were also modified in this version of the website. Within the expository pages, links to quizzes were marked by a gap in the text and 2 solid lines between which were

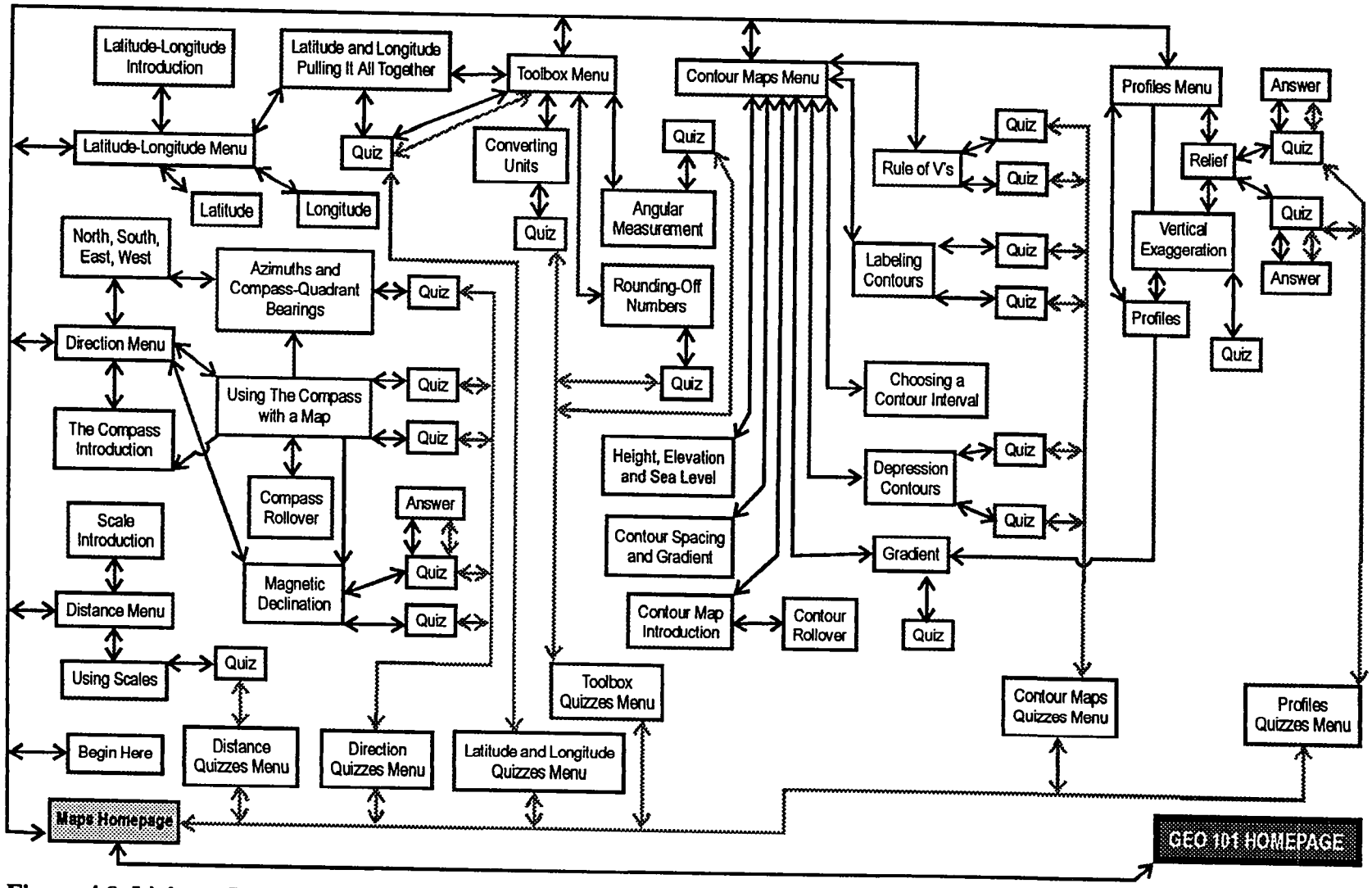


Figure 4.8. Linkage flowchart for the map module offered in Fall 2000. Note that the two shades of linkage arrows are mutually exclusive pathways. One can follow either grey or black but not switch back and forth except at the Maps Homepage.

link buttons labelled "LINK TO QUIZ". Quizzes were also directly linkable from the Maps Homepage.

III. The Geology of New York City

The Geology of New York City module was unchanged in most aspects from the Spring 2000 version. Aside from the changing of print-out maps from color to black-and-white, the only substantial change to the Geology of New York City module was the addition of three rollovers that aided in the understanding of the local geography. Students were directed to these three rollovers by commands from Lulu, each of which was followed by a large, red link button.

The first two rollovers were very similar. The first illustrated the geography of New York City. This rollover presented an unlabelled map of New York City that corresponded to the base map in the students' assignment. By moving the mouse over each of the 14 buttons on the side of the map, the 14 different geographic regions were highlighted and labelled sequentially. The second rollover illustrated the geography of the New York City region using the same format.

The third rollover concerned the "X-dike". Through a series of ten frames Lou and Lulu discuss possible hypotheses to explain the origin of two granitic dikes that cross in an outcrop in Central Park to form an X. The characters propose two different hypotheses and evaluate the relative validity of the two scenarios. The hypotheses are illustrated in a graphics frame that changes with the dialogue. This page was designed to introduce the concept of geological hypotheses to explain landforms and features. This concept is revisited at the end of the Geology of New York City assignment.

IV. A Treasure Hunt

The Search for Leo's treasure that formed the theme for the Spring 2000 maps module was presented as a separate, optional module in the revised version of the website. Although there was no mention of the optional nature of the module within the module

itself, this policy was explained under the description of extra credit on the "Grading Policy" page:

> *Engaging in The Treasure Hunt is optional, but the additional skills attained will give you a better chance to earn extra credit on the final exam. These skills include:*
>
> - *Determining location with a contour map, chronometer and sextant.*
> - *Understanding the relationship between time and longitude.*

The content of the Treasure Trail module is an amalgamation of the first five pages from the Spring 2000 maps module (introduction to the treasure map and poetic clues) as well as the distinct treasure hunt pages. Unlike the maps module, quizzes are embedded within the expository text rather than lying on distinct pages. These quizzes consisted of one or two fill-in-the-blank questions.

The module had a linear flow except that the Treasure Trail Homepage featured two link tables. One allowed you to link to any of the content pages directly from the homepage. The second table would allow students to jump to the small quizzes that were embedded in the various expository pages. All text links that had been embedded in Lou and Lulu's dialogue in the Spring 2000 version had been removed. At the bottom of each page there were always three links, a pirate-faced button that would link to the next page, and in the footer there were always links to both the Treasure Trail Homepage and the "GEO 101" Homepage.

2. PERSONAL EXPERIENCES WITH THE FALL 2000 WEBSITE

The minerals module was a major addition to the second implemented version of the GEO 101 website. It presented a series of interactive exercises that well mimicked the real hands-on experience of testing mineral properties. I was impressed with the layout and thought that students would enjoy using this module. The one concern raised both by myself and Prof. Brook was that the graphic-intensive testing modules would create problems for the students without high-speed internet connections.

I felt far more comfortable in navigating through the revised maps module. It felt streamlined. There were no unnecessary pages slowing my progress. I felt comfortable with the structure and never felt lost. I also was confident that I had not missed any pages along the way.

Another strong impression that I had while examining the revised maps module was that some pages had a much neater appearance. I had the impression that the formatting had been improved. Upon careful comparison of the two versions of the maps module it was evident that the only substantial change in formatting had been a change in font. The original module had used bold text throughout Lou and Lulu's dialogue, whereas several pages in the revised version had used the equivalent normal font (Times Roman).

3. ADJUNCT EXPERIENCES WITH THE FALL 2000 WEBSITE

The adjunct's response to the Spring 2000 offering was generally positive. Certainly he viewed it as a great improvement over the previous term's course, particularly in terms of structure and layout:

> *"The organization here, it seems to be a lot better. As far as the first page you have a lot more of the material linked to it. You don't have to go to another link to get to another link, to find out what they are trying to get to."*

In the same line of thought, he liked the concept of the "Print Shop" in the minerals module because it made the task of accessing required forms so much simpler.

Overall, his response to the minerals module was positive in terms of both layout and pedagogical approach as an interactive activity. However, he still had reservations.

> *"I think the scratch test -- the hardness test -- was interesting, the way it was set up. The explanation was first, and then the exercise itself was, as far as online, I can't see any other way to really do it. As I like the fact that it was... I would have had a hard time figuring an interactive way of*

setting it up. And the way that he has it set up, I think was pretty good job. Actually figuring out... Actually having to click on things and showing the different hardness, actually showing the scratch, that is, I think, was pretty interesting."

"Is it better than actually doing a hands-on? I don't know."

In later discussion it was apparent that the adjunct viewed the minerals module from a classical in-class viewpoint, that is, teaching the students to identify a specific set of minerals. However, the objective of the module was not mineral identification as an end in itself but rather as a means to exploring the concepts of data collection and classification.

4. STUDENT EXPERIENCES WITH THE FALL 2000 WEBSITE

In Fall 2000, twenty-one students initially registered in the virtual lab section. Fifteen students completed the lab course. The mean grade for the 15 remaining students was 67%. Over the term, four questionnaires were distributed to voluntary participants in the class. Fourteen students completed the pre-course survey. Results from this survey indicated that the majority of students considered themselves to be very comfortable with computers and the internet (9 out of 14). Only one student, Ed, expressed some limited concern regarding computers: "*I'm not very knowledgeable about computers but can find my way around things*". However, this student, along with 7 others, had previously completed an online course. As it was in the previous term, only one student indicated that she customized her web-browser to set the GEO 101 Homepage as a favorite. This would suggest that although students are comfortable with the internet, they are not necessarily proficient.

Reasons stated for enrolling in this online lab course were: curiosity about the online education experience (6), preference for the more flexible schedule (3), it would result in less time in class (3), it was the best fit to their schedule (3), and they had a good experience in a previous online course (1). Note that some of the students stated two motivating reasons.

At the end of each of the three required modules, the volunteer students were asked to complete questionnaires concerning their experiences online. Eleven students completed the minerals module survey. Only five students returned questionnaires for the maps and geology of New York City modules. The first question on each questionnaire asked students to rate aspects of the modules based on a scale from 1 (outstanding) to 5 (poor). The responses to these responses are summarized in Table 4.2.

	Minerals (n=11)	Maps (n=5)	Geology of NYC (n=5)
Clarity of Module's Text	2.1	2.4	2.4
Ease of Navigation	2.0	2.4	2.2
Clarity of Module's Diagrams	1.9	1.8	2.2
Personal Understanding	2.4	2.6	2.8
Overall Average	*2.1*	*2.3*	*2.5*

Table 4.2. Average ratings of modules based on a 1 (outstanding) to 5 (poor) scale.

Seven students agreed to be interviewed for approximately half an hour within a week of completing their lab exam in GEO 101. The general demographic date for these students is listed in Table 4.3.

NAME	AGE	SEX	GEO LAB SCORE	CUMM GPA	YEAR	MAJOR
Abby	23	F	57	2.46	Senior	Communications
Bette	23	F	71	2.35	Junior	Business
Carl	21	M	103	3.89	Junior	Computer
Deb	20	F	78	3.81	Senior	Social Science
Ed	23	M	74	2.99	Senior	Communications
Fred	25	M	87	2.40	Senior	Business
Gordon	22	M	80	3.15		Math

Table 4.3: Demographic data of volunteer students in Fall 2000.

As was indicated by both the survey and interview results, students generally rated the minerals module highest. The online module was a continuation of the data collection that they first did in class with real samples. It applied the same tests but in a virtual setting.

> *"...it was graphic and you were able to interact with it. You know it was as if you were actually scratching a mineral and comparing it to other minerals." (Fred)*

One aspect that students commented on commonly was that the mineral properties were clearer online when compared to the classroom. Color, density and crystal shape were mentioned in particular. This was voiced both by the Fall 2000 class and the Spring 2000 class. The Spring 2000 students were not required to use the investigation but it was put online midway through the term and some students chose to examine it as a personal review.

> *"The minerals were clear to look at... Sometime when you're in class... I don't know they just look worn out. I hate to say it like that. The numbers sometimes were smudged. You don't get a chance to look at it for as long as you want because you have to share it with other people. So I like the fact that I had it all to myself." (Anne, Spring 2000)*

The overwhelming criticism of the minerals module was the time required to load the investigations. Six of the seven interviewed students considered the loading time to be an issue, with both Abby and Carl reporting a 30-minute loading time for the 44 items in the hardness investigation page. All of the interviewed students worked from home computers that were one to three years old and had slow, dial-in connections. The loading speed was more problematic on pages that used roll-overs. This included the color testing page in the minerals module and the geography and x-dike pages in the geology of New York City. Carl complained that when he used Internet Explorer (version 5), if he moved the mouse during the period in which the graphics were loading, then he would be alerted of a JavaScript error and need to reload the page. A similar complaint was made by another student on the minerals-module questionnaire.

The maps module was generally considered to be the most difficult, although there was no clear focus in their difficulties. Latitude-longitude, azimuth/compass-quadrant bearing, and contour maps were each described as being poorly understood by different students, and that the homework assignments were not clear extensions of the online material. For example, in regards to the contour maps component Fred stated:

> *"I went to see him and he cleared everything up but I am not sure if the website informed me enough about contours. I mean it talked about V-lines in streams and stuff like that, but I don't know if it was the website because there was some complicated contours and the website was no good help. It just taught the basics but that was pretty much it."*

The general exposition of the theory behind maps appears to have been sufficient. What seems to have been inadequate was the demonstration of applications of the information so that students could perform the practical tasks presented to them on their assignments and exams. In class, such demonstrations typically would have been done by the professor on the blackboard. Online, Prof. Brook attempted to accomplish this through the dialogue of Lou and Lulu but these explanations tended to be extended over several screens. Furthermore, they were located on different pages than the related quiz questions. Regardless, this seemed to be effective for Bette but she did have suggestions for improvement:

> *"Lou and Lulu actually go through a problem, you know, like a step-by-step, like one of the problems, so that when you came up to the quiz it would be like you are almost in class. You are on the web and you saw someone actually do a problem before you actually take the quiz."*

> *"I believe that maybe there should have been more like the illustration. Like have Lou and Lulu actually go through a problem, you know, like a step-by-step, like one of the problems, so that when you came up to the quiz it would be like you are almost in class. You are on the web and you saw someone actually do a problem before you actually take the quiz."*

When Gordon navigated to the quiz on azimuth and compass-quadrant bearing during his interview, he made a similar suggestion:

> *"Probably if we can see the solved problem -- an example next to it. Because every time I have to scroll over back 3 screens in order to go to the solved problem and compare each problem."*

Students such as Deb, who considered the course to be a last hoop through which the college forced her to jump, were still somewhat annoyed by the extended narrative form of explanation. All she wanted to do was finish her assignments as fast as possible with the least amount of work. To Deb, anything that extended the required work, regardless of whether it could make the experience more entertaining, was unacceptable

> *"And here you have to go through stories and nit-pick to find what was... I felt like that something was explained in three pages when it would have been explained in three concise sentences. A lot of times I didn't do all the work."*

> *"And these little stories, Lulu and some guy. Like you needed this information, but it was given in story form. I felt like it should have been a dry explanation of facts you need, and then that could be extra thing if someone wants to go through it slowly and in a fun way. But I didn't feel like going through all the extra conversation. My time is valuable. I didn't fell like going and reading through a story. And then sometimes there was important information and sometimes there wasn't so much important information. I didn't want to have to read. I just wanted the information to be there."*

> *"That's what made it interesting, with all the characters, but I found it tedious."*

Most other students received the dialogue between Lou and Lulu throughout the maps section favorably. However, a desire to decrease the banter was common. Abby, Bette, Carl and Ed each stated in their interviews, without solicitation, that the comic style improved their experience and aided their learning in the maps module. Although Ed

described his priority as "*just to get my labs done on time*", he articulated his experience with Lou and Lulu's dialogue in the following fashion:

> *"[Lou] was asking questions. Like basically he was the dumb one, like me. Like you know, it was entertaining a little. Like her giving all the answers and him being the naive one asking all the questions that basically I was asking. Okay, that's fair. That's fair. So it was an effective way to give out the information instead of just listing all the information like a book. I liked that they sort of did a role play."*

Students enjoyed the concept of learning about their local environment in the geology of New York City module, and considered many aspects of it to be practical.

> *"Yes. Now this site I liked a lot. [Rollover of the geography of New York City] There are a lot of things to do. Like a lot of kids they are doing geography in school. This is very good. What's this area? And find out what is this area is different from what is this and what is that or labeling New York City. Many people don't know the name of this river yet they pass it everyday. Some people don't believe that Brooklyn and Queens is part of Long Island so I thought this was useful" (Bette)*

However, students sensed the fact that other than the roll-overs at the beginning of the module, the New York City material was essentially an in-class exercise that was copied to the net. Ed was confused as to which aspects of the exercises were for home and which were for the classroom. Similarly, he was confused as which pages had to be printed at home, and then brought to class. In terms of the "classroom-like" style, Bette noted:

> *"Well actually where you have to measure the vertical exaggeration and this A to B on Brooklyn and Queens because you can look at it on the web site but you can't actually do anything because you need to print them out in order to tell what is what. It is more like to show you what's going on with the colors and all that, but there's more like you have to do it in class. In the 3rd part where they ask for a profile of Brooklyn and Queens –that can be on there because of the color. That question is all right but*

measuring the vertical exaggeration is more like a question you would give a student in class."

Based on the interviews, students in the Fall 2000 class felt quite comfortable with internet learning in this hybrid course. They trusted that in most cases the essential information was provided on the webpage and it was their task to find it.

"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." (Bette)

"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." (Carl)

'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." (Fred)

If understanding eluded them then they felt confident that Prof. Brook, or in rarer cases, a fellow student would be available to help them. Both Deb and Gordon worked through assignments with the help of a fellow student. In both cases the initial connection had been established in a previous course. In Gordon's case however, his bond with a fellow student in his class formed the nucleus for his working group.

In the first class meeting, Prof. Brook had students break into groups of four, introduce themselves, exchange email addresses and work collaboratively in class. These groups worked together in each classroom session. The intention was that this would break the ice and encourage students to contact each other for help, thus reducing the sense of isolation. This was also encouraged by assigning a group map exercise in which each student was required to email his/her group mates their results in order to complete the final question. Only Gordon's group appears to have achieved this state of cooperation and communication.

"We exchanged emails and we emailed each other. Yes they emailed me, helping problems, asking what kinds of questions we had to do, what kind of problems we had to do and so on." (Gordon)

"I haven't emailed them either. Nah, just on a project that we did—that we had to do together. That was it." (Fred)

"I didn't really communicate with other students except when we were working in the class on the rocks and stuff." (Ed)

There was considerable communication between the students and Prof. Brook throughout the term. No one expressed reluctance to approach Prof. Brook, either in person or by email. In interviews, several students remarked on the abundant email from Prof. Brook which included notifications of marks and class reminders. A total of 62 student emails reached Prof. Brook over the term, mostly asking about procedures (20), arranging meetings (11) or submitting assignments (11).

The Late-Breaking News page was the other means of communication between instructor and student. The response to this communications forum was quite negative. Although each student stated that they checked Late-Breaking News at least once per week, Carl, Ed and Deb each said that they would want to see this forum removed or changed considerably. Deb felt that news about assignments should have been incorporated into the assignments themselves, rather than on a different page. Carl objected to the mixing of general announcements and assignment announcements within the same venue. He would have preferred to have had a distinct page for assignment news. Ed simply wanted to have the order of postings reversed so that the most recent announcements would appear at the top of the list, and therefore, not require the student to scroll to the end in order to check for new postings. Essentially, they were seeking a more ordered framework for communication. In this vein, Deb mentioned her preference for the experience that she had in a previous online course. This virtual political science course was offered through the Blackboard platform. This platform limits the instructor's choices in web design but provides well-designed communications modules, including a sidebar with a clear subdivision of announcements, course documents and assignments. Deb's words:

"There's a frame on the side, apart from the frame you are working in, there is another frame on the side that has everything—the schedule of classes, when everything is due... The whole site is linked together very nicely. Very easy to navigate. With this site I felt like I had to always keep looking for what there was. I didn't like using the site much."

No major concerns regarding linkage and structure were raised. Two students noted that the new window links in the minerals module caused some confusion. While navigating the site during his interview Ed became frustrated that he could not find his way to the material on azimuth. However, this confusion was likely due to him being unable to remember that azimuth was covered in the directions unit, rather than an ability to navigate in general.

4. DISCUSSION

In general students were content with the course as it was offered in Fall 2000. There was no sense of alienation of the students from the course or the instructor, although there remained a communication barrier between the students themselves. This is an issue that requires further attention and creativity.

It was evident from comments associated with "Late-Breaking News" that communication is still a key issue that causes concern for students. Small impediments to communication, or small miscommunications, can lead to significant frustration. On a positive note, the extra work required for communication with the instructor and/or peers contributed to making students more independent in their learning.

Another reason that students took more control of their learning and felt more confident in their online experiences was the simplified link structure. Students knew where the material was and how to explore their way through it. Furthermore if students explored ahead they were confident that they could find their way back.

The minerals module was definitely more positively received than the other two modules. Minerals are not usually popular in classroom-based labs so the success was probably in

the delivery rather than the content. The minerals module involved interactive rather than static activities, the objectives were well-defined, reading was limited, and the module made effective use of the medium. All of these probably combined to the success of the module. However, its strengths are also directly related to its greatest weakness – the module's high volume of graphics. The challenge in further content development is to expand on the strengths demonstrated by the minerals module while finding a way of reducing download times.

After discussions based on the data collected during the term, Prof. Brook chose to focus on two major changes at the end of the term. In Prof. Brook's words:

> *(a) I rationalized and condensed the Maps lab. I concentrated on scale, direction, and contours-profiles-gradient-vertical exaggeration. I placed latitude and longitude, magnetic declination, decimal-degree conversions, rounding off numbers, and the Treasure Hunt into the Toolbox - as resources and extra credit topics. In short, I wanted to sharpen the focus and decrease the length of the Maps lab. This also facilitated simplifying the link structure.*
>
> *(b) I replaced the conventional Geology of NYC with the Landforms of NYC. My aim was to make the lab interactive, end the reliance on in-class viewing of rocks (for which there had been no theoretical preparation) and stress the development and testing of hypotheses.*

CHAPTER 5: SPRING 2001 STUDY

1. WEBPAGE DESCRIPTION

I. Introduction, Background and Initial Instructions

The homepage for GEO 101 remained similar in style from the previous term: two columns of links labelled "Information" and "Investigations" (Fig. 5.1). "Explore the Course" remained unchanged. However, "Tips for Online Work" was rewritten to provide the student with advice for avoiding technical problems and navigational mishaps as well as minimizing time wastage. The page stated the optimum screen resolution, the preferred browsers, suggested "bookmarking" the homepage in their home browser, described the basic linkage structure of the site, and introduced the use of the CD provided to each student. CD instructions were also presented under its own Homepage link, and even given extra prominence by the use of a double-sized link button (Fig. 5.1).

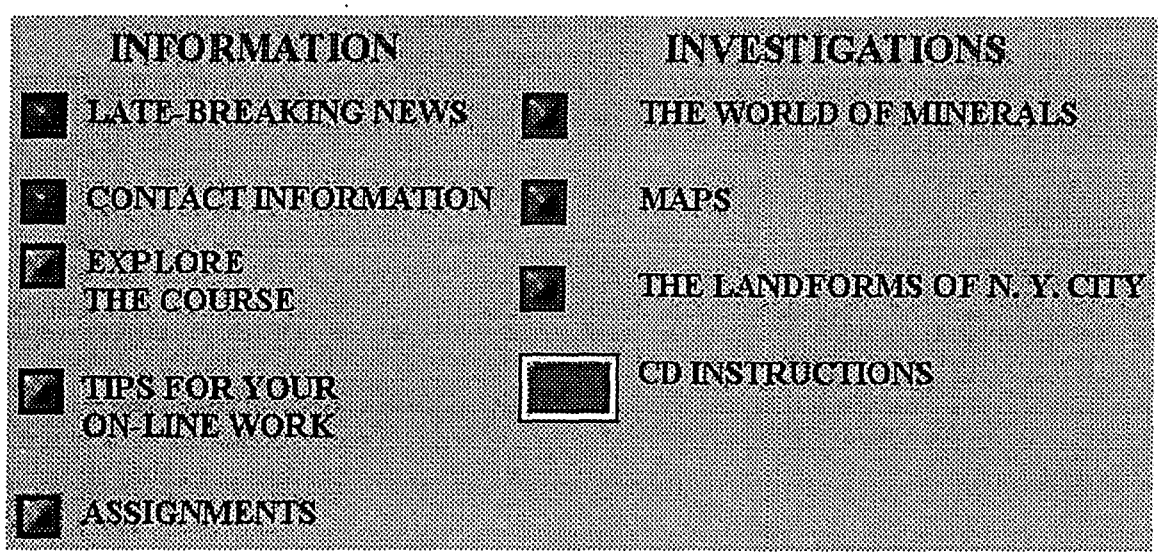


Figure 5.1. The GEO 101 Homepage, Spring 2001.

The addition of a CD containing all of the graphics-heavy pages on the website was a new addition to this term's course offering. Each student was given a personal copy of the CD on the first classroom session. It was Prof. Brook's hope that the issue of excessive download times for graphic-laden pages could be avoided by having students load these pages directly from their personal CD drive. Only selected pages were

included. Students were made aware of which pages were stored on the CD by the inclusion of a yellow box labelled "CD" beside the associated page links. The CD symbol was not a link to the CD. Students were required to find and open the page themselves if they chose to use the CD.

An "Assignments" button was added to the Homepage. This link led students to a list of the five assignments in the lab course, along with their due dates. Each of these entries linked to a complete description of the assignment, the due date, solutions to example problems, and personalized assignments for each students based on their ID number that was printed on their copy of the CD. In the previous term, all of this information was posted on "Late-Breaking News" rather than on its own page.

"Late-Breaking News" was moved to the top of the information column on the Homepage. It was otherwise similar in form to the initial layout of the previous term's offering. Although the page existed, Prof. Brook did not post any new messages throughout the term. Instead he chose to send emails that described any updates, additions, deadlines or assignments. Over the term Prof. Brook sent a total of 19 group emails in addition to the 106 replies to student email. The address list was compiled from all of the requests for enrollment that Prof. Brook received. It was mandatory for all students wishing to enroll in the virtual GEO 101 to email their request directly to Prof. Brook, thereby assuring that each student had an email account prior to enrolling.

The final addition to information links on the Homepage was "Contact Information" which listed Prof. Brook's address, phone number, email and office hours.

II. Investigations

"The World of Minerals" remained unchanged from the previous term and so will not be described here (see Chapter 4). The "Maps" module remained essentially the same in its structure but the required content was reduced. "Latitude and Longitude", "Magnetic Declination", "Using the Compass with a Map", "Height, Elevation and Sea Level" and "The Treasure Trail" were all transferred to the "Toolbox". This location was designed to

hold optional material and general background resources. The required content involving direction was further reduced by the transfer of the direction system of compass-quadrant bearing to the Toolbox. Thus in Spring 2001, students were only responsible for one navigation system – azimuth. All of these materials in the "Toolbox", to which students could link from the "Maps Homepage", were available for students to explore. The reward for this optional exploration was the promise of a bonus question on the final lab exam that would involve these topics. The description of this extra credit (up to 10% for the bonus question based on the extra maps content and up to 5% for the question based on the Treasure Trail) was provided in "Grading Policy", under "Explore the Course".

By far the greatest change to the site was the complete redesign of the New York City-based module, now renamed "The Landforms of N.Y. City". A linkage flowchart of this module is illustrated in figure 5.2. As stated on the website, "*This lab module investigates the general question: What is the nature of 'proof' in geology? It does so by examining how answers are generated to a specific geologic problem: How did the landforms of the New York City region originate?*" Specifically, these landforms include the parallel ridges and valleys of Manhattan, New Jersey and the Bronx, the irregular hills of northern Brooklyn and Queens, and the flat lowlands of southern Brooklyn and Queens.

The main body of the module was structured in terms of the scientific method: data acquisition followed by hypothesis testing and finally conclusions. Data acquisition is a broad description. On the website, it begins with the basic element of determining the geographic place-names of the New York metropolitan region. Rather than simply illustrating a labelled map, the site required students to identify individual sites (e.g., Manhattan, New Jersey, Hudson River) as they were sequentially highlighted in a simple animation controlled by students "mousing-over" a set of link buttons (i.e., a rollover) (Fig. 5.3).

The use of JavaScript-based rollovers, was extensive in this module. They formed the focus of the study of the topography on New York City in which students measured elevations at a set of numbered sites. Mousing-over each site brought up a bar graph from which students had to read and record the elevation. Data was recorded on specific sheets that students printed directly from the website. Similarly, students were introduced to the

rock types that occur in the New York City region by rolling over a list of rock names. When the student moused-over the word "gneiss", for example, two images of gneiss appeared: a hand-sample photo and a sketch of a microscope slide illustrating the interlocking mineral texture. Beside the images, a list of minerals present appeared.

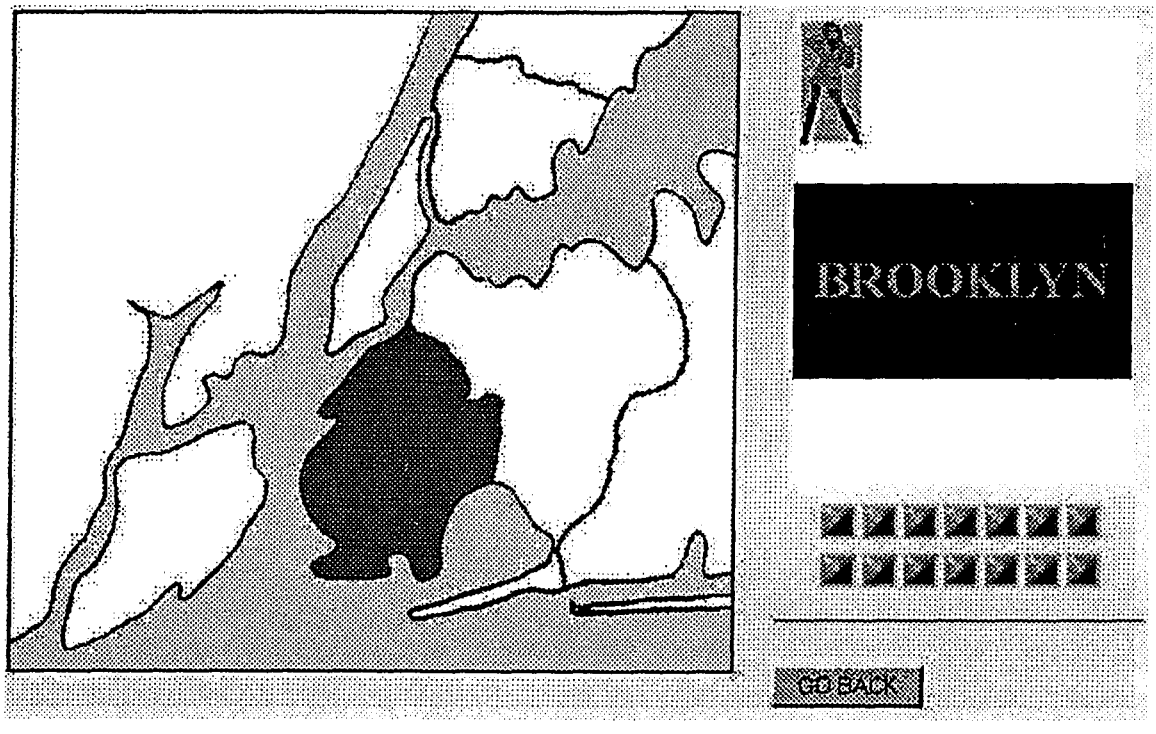


Figure 5.3. Example of the geography of New York City rollover. Mousing-over each of the buttons would highlight and label a different geographic feature

This mineral/rock data was then augmented with the determination of modal mineralogy of each of the six rocks and two sediments present in the region. This was determined through a simplified model of each rock as a 10x10 grid of "minerals" (Fig. 5.4). Students were required to count the number of each of the different coloured "minerals" in a highly simplified simulation of the common geological technique of point counting. Once the modal percentages were determined, students could enter them into an accompanying answer-checking table to verify their results. After entering an answer, a student could click on a radio button labelled "Correct?" to return either the response "Yes. Correct!" or "Sorry! Not correct!"

The data from the modal mineralogy exercise was applied in the subsequent exercise in which students had to determine a "hardness value" for each rock and sediment type. This involved returning to a mineral hardness testing exercise similar to the one that they had previously done in their mineral investigation. However, in this version mineral names were provided instead of numbers of unknown samples. Thus students could determine, for example, that quartz scratched a steel nail and would therefore be classified as "hard". This data was then used to develop the "hardness value" of each rock which was a numeric measure of how resistant each rock is to abrasion. To complete the calculations, hard, intermediate and soft minerals were given a "numerical equivalent" of 7, 3 and 1, respectively. An example of a hardness value calculation, and the form provided for students, is illustrated in figure 5.5. For each of the eight materials (diabase, gneiss, marble, sandstone, schist, shale, hill sediment and plain sediment) students could verify their answers for hardness value in an answer-checking table that was similar in form to that provided for the modal mineralogy investigation.

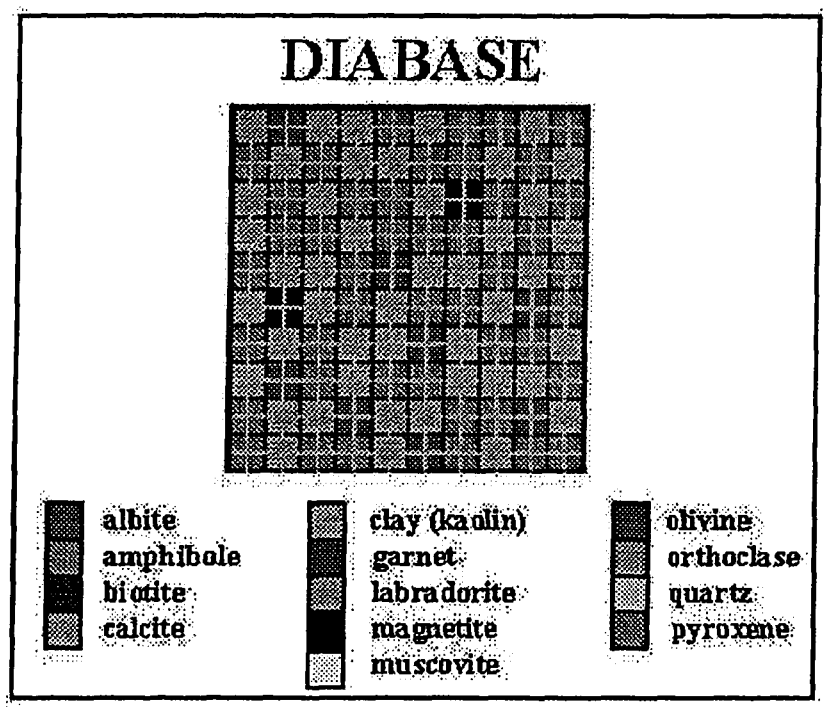


Figure 5.4. Example of a model rock used in the simulation of determining modal mineralogy through point counting.

Next students were introduced to the concept of dissolution of minerals and rocks through a rollover that illustrated the differential weathering of halite, calcite and gypsum by dissolution. Calcite is the only highly soluble mineral contained within the rocks and sediments of the New York City area. Accordingly, students were directed to quantify the inertness of the same eight materials from the region by the calculation of an "inertness value" which was based primarily on the calcite content of each material. An example of an inertness value calculation, and the form provided for students, is illustrated in figure 5.6. Again, an answer-checking table was provided.

Student Name: Class: Date:

HARDNESS VALUE CALCULATION TABLE

NAME OF ROCK OR SEDIMENT: SCHIST

Names of Constituent Minerals	Mineral Percent (%M)	Mineral Hardness (S, I, H)	Numerical Equivalent (NE)	(%M x NE)
albite	10	H	7	70
amphibole	5	H	7	35
biotite	20	I	3	60
calcite				
clay (kaolin)				
garnet	4	H	7	28
labradorite	10	H	7	70
magnetite	1	H	7	7
muscovite	25	S	1	25
olivine				
orthoclase				
quartz	25	H	7	175
pyroxene				
			TOTAL	470
			HARDNESS VALUE (HV) = TOTAL/100 →	4.70

Figure 5.5. Example of the calculation of Hardness Value

The next phase in the investigation of the weathering properties of New York City materials was the study of cohesion between grains. The stronger the cohesion, the more likely a material will resist breaking. A rollover introduced the concept of cohesion. It schematically represented increasingly heavy weights being placed on rocks with interlocking grains (i.e., crystalline rocks), rocks with cemented grains (i.e., clastic

sedimentary rocks) and unconsolidated materials (i.e., sediments). Crystalline rocks were shown to be able to support more weight than clastic rocks, which were able to support more weight than unconsolidated materials. Students were then required to quantify the cohesion of their eight materials through the calculation of a set of "cohesion values" (Fig. 5.7). They could verify their answers with an answer-checking table.

Student Name: Class: Date:

INERTNESS VALUE CALCULATION TABLE

	Rock or Sediment	Dia-base	Gneiss	Marble	Sand-stone	Schist	Shale	L.I. hill sediment	L.I. plain sediment
	Feature								
(a)	% calcite*	0							
(b)	% other minerals*	100							
(c)	Total (a) + (b)	100							
(d)	3 x (a)	0							
(e)	7 x (b)	700							
(f)	sum of (d) + (e)	700							
(g)	(f)/100 = INERTNESS VALUE	7.00							

* Obtain these percentages from your 'Mineral Composition Tabulation Sheet'.

Figure 5.6. Example of the calculation of Inertness Value

The site then led students through a procedure of integrating all three measures of resistance to erosion through the creation of an "Erosion-Resistance Index" (Fig. 5.8). This allowed a rapid and easy comparison of the erosive nature of each of the eight New York City materials. An answer-checking table was provided.

Student Name: Class: Date:

COHESION VALUE CALCULATION TABLE

ROCK OR SEDIMENT	Dia-base	Gneiss	Marble	Sand-stone	Schist	Shale	L.I. hill sediment	L.I. plain sediment
Particle relationship and cohesion strength								
Interlocking (high strength)	✓							
Cemented (int. strength)								
Unattached (low strength)								
Numerical Equivalent of cohesion strength	7.00							
COHESION VALUE	7.00							

Numerical Equivalents of Cohesion Strength (N.E.)
H = 7.00 I = 3.00 L = 0.00
COHESION VALUE = N.E.

Figure 5.7. Example of the calculation of Cohesion Value

Student Name: Class: Date:

EROSION-RESISTANCE INDEX CALCULATION TABLE

	(a) Hardness Value	(b) Inertness Value	(c) Cohesion Value	(d) Product (a) x (b) x (c)	(e) E-R INDEX*
MATERIAL					
DIABASE	7.00	7.00	7.00	343.00	343
GNEISS					
MARBLE					
SANDSTONE					
SCHIST					
SHALE					
L.I. HILL SEDIMENT					
L.I. PLAIN SEDIMENT					
SANDSTONE & SHALE**					

* The Erosion-Resistance Index = (d) rounded off to the nearest whole number.
**Assume equal parts sandstone and shale; average the E-R index for sandstone and shale.

Figure 5.8. Example of the calculation of the Erosion Resistance Index

The final data-collection sub-module introduced the concept of geological maps. This unit was based heavily on rollovers. Initially, two rollover animations introduced the thought process involved in constructing a geological map with a logical pattern that is consistent with a limited data set based on a scattering of isolated outcrops. The four activities that followed allowed students to apply these concepts and thereby develop their skills in map making. The approach taken was to present a set of complex rollovers in which images of different materials appear, along with their names, as the student rolls the cursor over the map surface. In this way the student defined the borders of the different units and drew the contacts on a base map that was supplied in the module. In a second practice exercise students again rolled the cursor over the map surface, but in this case, images only appeared when they rolled over the scattered "outcrops" which comprised less than 10% of the map area. Some outcrops contained more than one geological unit. In this exercise students were required to infer the contacts between units based on a limited data set. Answer keys were provided for both practice exercises.

The next two exercises were realistic applications based on the actual geology of New York City. Students first revisited the map of Manhattan on which they had already determined the topography. This exercise was much like their first practice activity: as they moved the cursor over the map, an image of the underlying rock appeared on the side. Thus students could define the exact position of contacts between rock units and draw them on a base map printout. The final exercise was a study of the surficial geology of New York City. Students were required to construct a reasonable map of the surficial deposits of this region based on a set of "outcrops" which were presented as a scattering of pink areas across the region (Fig. 5.9). This exercise was similar to their second practice exercise.

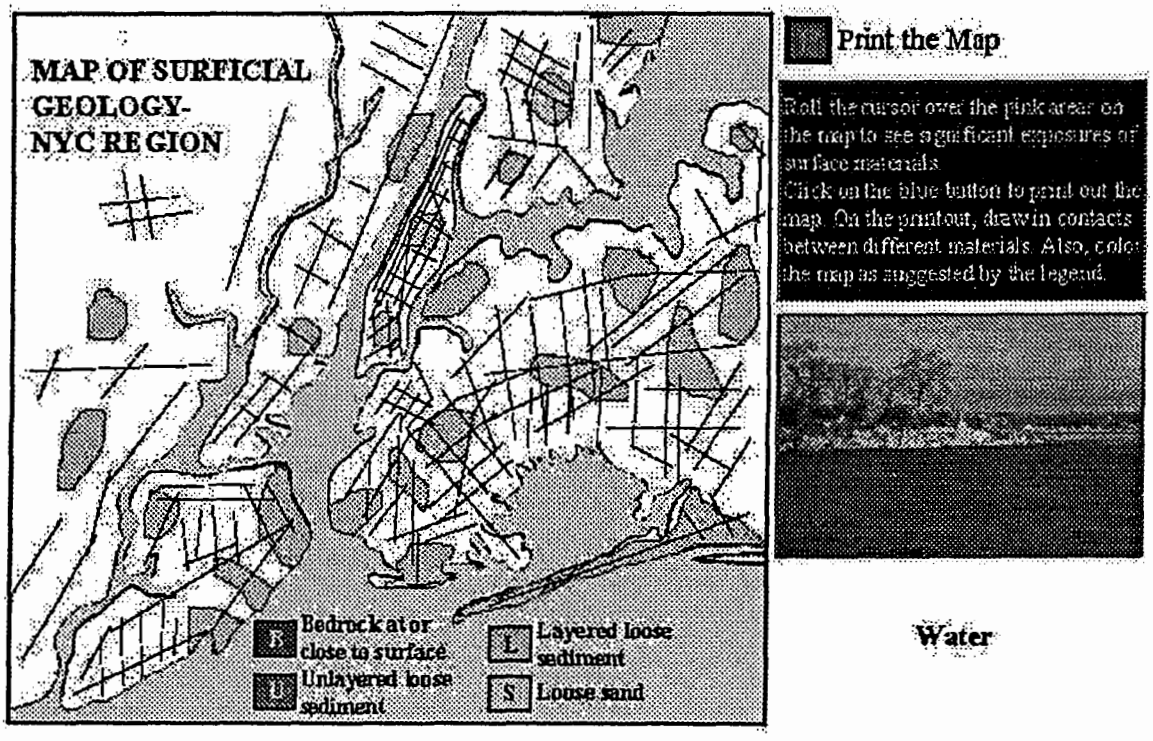


Figure. 5.9. The surficial geology map exercise.

The second phase of the module involved applying the topographic and geologic data collected by the students to testing three hypotheses for the formation of New York City's landforms: 1) differential erosion (i.e., regions underlain by resistant materials lie at higher elevation); 2) differential deposition (i.e., higher regions simply had more material deposited); and 3) uplift and depression (i.e., highs and lows are formed by the warping and fracturing of the crust). These three processes were introduced in brief rollover animation sequences. Then each of these hypotheses was tested by the students.

Differential erosion was examined first, and was highly guided. The problem was stated as:

> *THE HYPOTHESIS: The hills and valleys of the NY City Area formed due to the more rapid wearing away of areas underlain by non-resistant materials and less rapid wearing away of areas underlain by resistant materials.*
>
> *THE PREDICTION: Areas that have higher elevations are underlain by more resistant materials than adjacent areas with lower elevations.*

THE TEST: Seeing whether the prediction is fulfilled in areas where bedrock is *at or close to the surface.*

Student Name: Class: Date:

CORRELATION OF EROSION-RESISTANCE VARIATION WITH ELEVATION DIFFERENCE

(a) *Paired Stations	(b) Greater Elevation	(c) Lesser Elevation	(d) (b) - (c)	(e) E-R for (b)	(f) E-R for (c)	(g) (e) - (f)	(h) both +
2 - 1							
3 - 4							
5 - 6							
7 - 6							
9 - 8	210	40	170	230	63	167	✓
12 - 13	130	30	100	323	63	260	✓
14 - 13	70	30	40	323	63	260	✓
15 - 17	80	30	50	230	63	167	✓
19 - 22							
24 - 22							
27 - 29							
11 - 10							
25 - 23							
26 - 28							
16 - 17	70	30	40	323	63	260	✓
21 - 17	60	30	30	323	63	260	✓
20 - 17	60	30	30	323	63	260	✓
18 - 23							

*NOTE: For each pair of stations, the station with the higher elevation has been listed first.

% with ✓

DEGREE OF SUPPORT

Figure 5.10. Data collection and analysis chart for differential erosion hypothesis.

Detailed instructions were provided as to how to collect and analyze the data. The general methodology laid out for the student was a comparison of elevation and the erosion-resistance index of the underlying material. This was done through the use of tables such as the one illustrated in figure 5.10. At the end of their comparison of elevation and resistance to erosion, students stated how strongly the data supported or contradicted the hypothesis, and explained their conclusion. This procedure was performed twice, once for the Manhattan/Bronx/New Jersey region where bedrock is at or near the surface, and once for the Brooklyn/Queens region where bedrock is deeply buried by sediment.

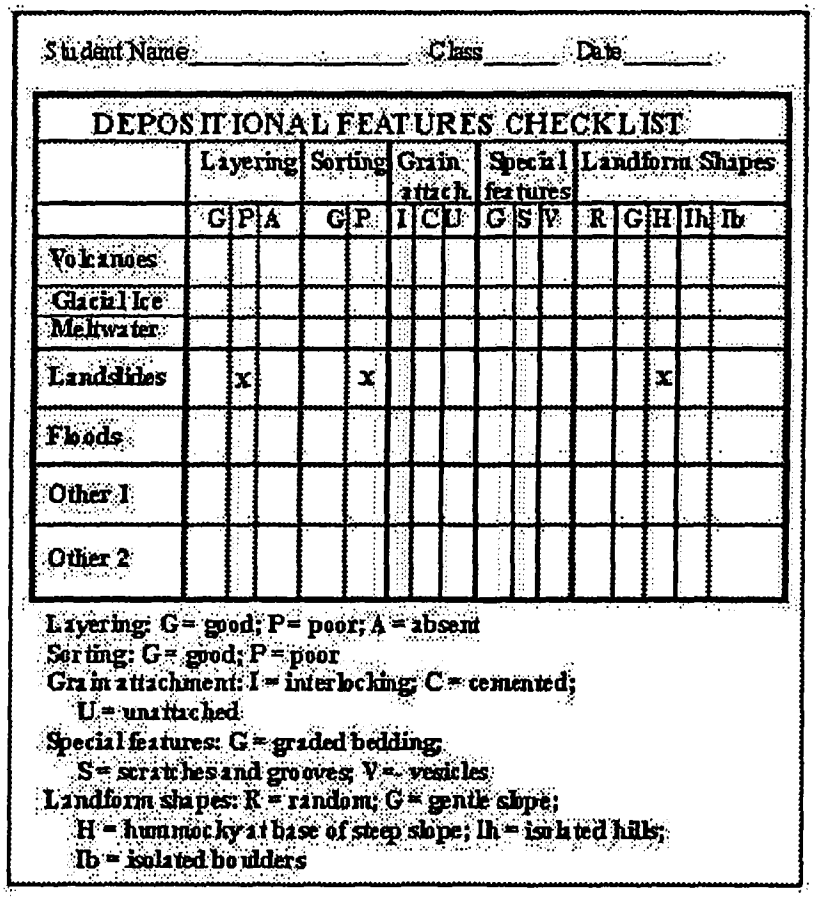
Differential deposition was studied next and the investigation was presented to the students as:

> *THE HYPOTHESIS: The variations in elevation of the land surface in the NYC Region are the result of depositional processes dumping more material in one place than another.*
> *THE PREDICTION: Features indicative of depositional processes will be found.*
> *THE TEST: Seeing whether the prediction is fulfilled.*

In this investigation four different means of deposition were presented to students through a series of rollovers. The physical characteristics of volcanic beds, glacial sediments, flood deposits and landslide deposits were described therein and students were required to record these characteristics within a structured table (Fig. 5.11). These data were then compared with a similar student-constructed table that summarized the physical characteristics of three areas: northern Brooklyn/Queens, southern Brooklyn/Queens and Manhattan/Bronx (Fig. 5.12). The instructions to the students were:

> *Compare the 'NYC Features Checklist' with the 'Depositional Features Checklist'. Do any of the three distinctive landform regions (Northern Brooklyn & Queens; Southern Brooklyn & Queens; Manhattan & adjacent Bronx, NJ) display features identical or partly identical to the features indicative of particular depositional processes? Which regions? Which processes? Has the hypothesis of differential deposition been supported? How strongly?*

For the final hypothesis examined, that the landforms of New York City were formed by the uplift and depression of the crust, students were required to devise the test that would invalidate or corroborate the hypothesis. They were provided with geological cross-sections of New Jersey/Manhattan and Brooklyn, as well as with a link back to the rollovers that described and illustrated folding and faulting.



Student Name _____ Class _____ Date _____

DEPOSITIONAL FEATURES CHECKLIST

	Layering			Sorting		Grain attach.			Special features			Landform Shapes				
	G	P	A	G	P	I	C	U	G	S	V	R	G	H	lh	lb
Volcanoes																
Glacial Ice																
Meltwater																
Landslides		x			x									x		
Floods																
Other 1																
Other 2																

Layering: G = good; P = poor; A = absent
Sorting: G = good; P = poor
Grain attachment: I = interlocking; C = cemented;
U = unattached
Special features: G = graded bedding;
S = scratches and grooves; V = vesicles
Landform shapes: R = random; G = gentle slope;
H = hummocky at base of steep slope; lh = isolated hills;
lb = isolated boulders

Figure 5.11. Example of data collection checklist for depositional features.

The final pages of the "Landforms of New York City" module summarized the questions that were investigated:

> *This lab module has investigated a specific geologic problem: How did the landforms of the New York City region originate? The problem was broken down into more detailed questions:*
>
> - *How did the long, narrow, parallel hills and valleys of Manhattan, the Bronx, and adjacent New Jersey originate?*
> - *How did the belt of randomly shaped hills and valleys of northern Brooklyn and Queens originate?*
> - *How did the gently sloping, flat plain of southern Brooklyn and Queens originate?*

- *Large, isolated boulders are scattered across the landscape of all areas of the NY City region except the flat plain of southern Brooklyn and Queens. The bedrock from which they have been broken off lies many miles or tens of miles to the north or northwest. How did the boulders get to their present locations?*
- *Why is the surface of the bedrock exposed in Manhattan, the Bronx, and adjacent New Jersey characterized by numerous parallel scratches and grooves?*

Student Name_____ Class_____ Date_____

NYC REGION FEATURES CHECKLIST

	Layering			Sorting		Grain attach.			Special features			Landform Shapes				
	G	P	A	G	P	I	C	U	G	S	V	R	G	H	Ih	Ib
Northern Brooklyn & Queens																
Southern Brooklyn & Queens																
Manhattan & adjacent Bronx, NJ			X		X			X								

Layering: G = good; P = poor; A = absent
Sorting: G = good; P = poor
Grain attachment: I = interlocking; C = cemented; U = unattached
Special features: G = graded bedding; S = scratches and grooves; V = vesicles
Landform shapes: R = random; G = gentle slope; H = hummocky at base of hills; Ih = isolated hills; Ib = isolated boulders

Figure 5.12. Example of data collection checklist for New York City features.

The final page also discussed the nature of "proof" in geology with the use of a rollover. First introduced in the previous term, this rollover discussed in an animated sequence how an x-shaped pair of pegmatite dykes in Central Park may have formed. The cartoon

characters Lou and Lulu discussed two different hypotheses and concluded that the simplest explanation, that a younger dyke cut a pre-existing dyke, was most likely. This was followed by a final rollover that provided an animation of the glaciation and related sediment deposition in the Long Island area, and explained how this single geological event could explain most of the geological features of the New York City region.

2. PERSONAL EXPERIENCES WITH THE SPRING 2001 WEBSITE

From the outset it was obvious that students were going to have to work long and hard to complete the Landforms of New York City module. There were many tables to complete and a great deal of data to collect. However, the instructions appeared clear and the link structure was very easy to navigate. The concepts were complex but the design of the module was essentially linear (Fig. 5.12). The module appeared to be an online implementation of guided discovery with increasing student independence as the module progressed. I enjoyed the module and I felt that students would probably respond favorably, although be offput by the amount of work required.

There was no answer checking of the final conclusions and due to the complexity of the ideas and their possible interpretations it was likely that students would commonly deviate from the "expected" response. However, Prof. Brook rewarded students for any creative and logically consistent answers. He used a final in-class session to gather their ideas and discuss the glacial theory in more detail as the excepted, although not necessarily totally correct, explanation for the landforms of New York City.

3. ADJUNCT EXPERIENCES WITH THE SPRING 2001 WEBSITE

The adjunct was again asked to look over the webpage, work through the material and discuss his impressions of the site. He still showed skepticism in regard to the value and effectiveness of offering a lab course on line. He saw the site as a course removed from Prof. Brook, rather than as an extension of him, or a projection of him, his personality and his teaching style to a new medium:

"...that's where the thing is a little bit weird, putting a lab totally on the web. The labs usually, you think, are usually more hands-on, and it is really hard to do hands-on work on the web. So as far as that goes, the totality of it goes, another weakness that I see from the web-based labs are when you're doing the web-based labs you are taking away the instructor basically from the course and you're putting a website in place of the instructor. The students are interacting with that instead of the instructor. So if you asked a student what's one of the most important things as far as taking course goes, they're gonna tell you it's the instructor. That's the thing that makes a big difference in the course. When you are taking a course with a really good instructor it can make even a really tough course, you know, enjoyable. And if you have a terrible instructor, of course, it can make the easiest course horrible, and I think everyone has had that experience. Some now you are replacing it... You are replacing that aspect of it with the web page."

The minerals and maps modules, having been examined in previous terms by the adjunct, were skimmed over and he concentrated his critique on the revamped "Landforms of New York City" module. Although he recognized the considerable time and work that had gone into the construction of the site, the adjunct was generally critical of the product. He commented on the great length of the instructions and expository text and recommended a rethinking and reduction of the text:

"He gives these general instructions pages which are extremely detailed. He makes sure that they know exactly... I think that when he went through constructing this he was thinking about questions that they would come up with, or problems. You want to make sure that every single step of every single part of... When it's a web page the more concise that you can make it, I think, the better off you are. And it's going to be very difficult to answer every single questions that the students are going to have. So there's a balance that's going on as far the amount of material, and how

detailed you want me to be to make it concise and more readable throughout, and for them to make proper progress."

In reading through the text of this latest module, including brief sections using the Lou and Lulu dialogue format, he again reconsidered his opinion of the utility and effect of this expository technique:

"I know the first time I talked about the lab, that for some... I thought that the cartoon character aspect of it would've been a bit demeaning to people who are in [Urban College] but when I went through this [module] I actually... I was little relieved to get out to the other aspect of lab and go for [the Lou and Lulu section] because it was much easier reading it."

Aspects in the landforms unit that the adjunct considered to be positive in terms of student learning was the reintroduction of mineral hardness that they learned at the beginning the course and reapply it to the understanding of landforms. He also considered certain rollovers such as the one that showed the changes in ice patterns, sedimentation and landforms over time on Long Island to be very instructive. He did, however, wonder if it would have been better presented as an animation rather than an interactive rollover.

4. STUDENT EXPERIENCES WITH THE SPRING 2001WEBSITE

In Spring 2001, twenty students initially registered in the virtual lab section. Nineteen students completed the lab course. The mean grade for the remaining students was 76%. Based on the complexity of in-class student discussion, the complexity of questions raised in class, and submitted assignments, it was the opinion both of myself and Prof. Brook that this class was above average, and indeed had several students with very high intelligence. Certainly this class was, on average, brighter than those in either the Spring 2000 or Fall 2000 classes.

Over the term, 4 questionnaires were distributed to voluntary participants in the class. Fifteen students completed the pre-course survey. Results from this survey indicated that

the majority of students considered themselves to be very comfortable with computers and the internet (10 out of 14), however, 4 of the students expressed a lack of understanding in the way computers work and an inability to deal with technical problems when they arise. Six of the fifteen students who responded had previously completed another online course.

As with the fall 2000 offering, the most common reason stated for registering in this online course was curiosity about the online education experience (five responses). A lack of other choices and best fit for students' schedules were also common reasons (four responses each). Preference for independent work, reducing time on campus and positive experiences with other online courses were noted as reasons for registering by two students each.

Information regarding the computer equipment used by students was obtained during the post-course interview of 12 students. Demographic data for these twelve students is provided in table 5.1. All but one student had a home computer. All home computers were PC's, had been purchased within four years (all but two within two years) and all but two home computers equipped with Pentium microprocessors of some kind. Most students had a 56K modem, dial-up connection, although two students had cable internet connections. Only three of the interviewed students stated that they used college computers, two used the college facilities predominantly.

At the end of each of the 3 required modules, the volunteer students were asked to complete questionnaires concerning their experiences online. Twelve students completed the minerals module survey. Thirteen students returned questionnaires for the maps module and 11 for the Landforms of New York City module. The first question on each questionnaire asked students to rate aspects of the modules based on a scale from 1 (outstanding) to 5 (poor). The responses to these responses are summarized in table 5.2.

NAME	AGE	SEX	GEO LAB SCORE	CUMM GPA	YEAR	MAJOR
Alice	21	F	63	1.82	Sophomore	Arts
Bridget	24	F	93	3.24	Senior	Computer
Carla	40+	F	86	3.21	Junior	Arts
Doris	30	F	56	2.41	Junior	Humanities
Erica	23	F	100	3.89	Junior	Arts
Fabian	23	M	83	2.87	Junior	Sciences
Greg	20	M	73	3.86	Junior	Social Science
Harriet	35	F	88	3.32	Senior	Sciences
Ian	23	M	90	2.22	Junior	Computer
Janet	32	F	100	3.86	Senior	Arts
Keith	25	M	69	1.94	Freshman	Social Science
Laura	21	F	100	3.79	Junior	Social Science

Table 5.1: Demographic data of volunteer students in Spring 2001.

The minerals module was generally well received by the students in this class, with 9 of the 12 interviewed students stating that this unit was their favorite. The main reasons given by those who enjoyed the module were that it was easy and fun:

> *"I thought for a subject that I totally don't think I should learn, I enjoyed doing the work because it was kind of like a game." Erica*

> *"I liked the minerals. I thought they were fun. I mean I thought it was kind of amusing to track them down. I felt like 'Where in the World Is Carmen San Diego' or something. It was kind of amusing." Carla*

When further questioned about whether the module was an educational experience or merely a game Carla replied, "*I remembered how to do it so I guess I learned it*".

	Minerals (n=12)	Maps (n=13)	Landforms of NYC (n=11)
Clarity of Module's Text	**2.3**	**2.3**	**2.1**
Ease of Navigation	**2.4**	**2.8**	**2.1**
Clarity of Module's Diagrams	**2.3**	**2.6**	**2.1**
Personal Understanding	**2.5**	**2.7**	**2.4**
Overall Average	***2.4***	***2.6***	***2.2***

Table 5.2: Average ratings of modules based on a 1 (outstanding) to 5 (poor) scale.

Negative comments about the minerals unit generally fell into two categories: 1) unclear instructions; and 2) a preference for the hands-on experience. Prof. Brook provided lengthy instructions on how to navigate through and use the online property-testing lab. A couple of students became lost in these lengthy instructions. Students also felt that there was ambiguity in the instructions for the assignment itself, such as the number of samples required and the format of the written report.

Students were required to complete an in-class examination of minerals two weeks prior to undertaking the online minerals investigation. In comparing the two experiences Janet, Ian, Fabian and Doris each found the in-class experience to be more satisfying:

> *"I felt that it was almost too easy. This portion of the lab made me feel as if I really needed to have more hands-on experience to appreciate things." Janet*

> *"It is kind of a childish way of putting it but I saw some things that I had never seen before, so I liked to hold them in my hand, to feel it and smell them, then run some tests that are very, very simple." Fabian*

> *'I think it's hard to look at pictures and try to imagine a real rock—how this looks and if it has some flashes or not. How you can scratch with a nail or metal things. It's hard to imagine.' Ian*

In the mineral property investigation a link structure was employed that opened each testing activity in a new window. This structure led to minor confusion and irritation with two students. The main problem cited was confusion due to having too many windows open at once when they would forget to close the windows when finished. Keith also mentioned the predictable problem of accidentally closing the main page instead of one of the pop-up windows, requiring him to reload the webpage and restart the assignment.

In both post-module questionnaires and post-course interviews, students generally provided only brief commentary regarding their experiences with the maps module, even when prompted. The one aspect that was unanimously appreciated was the set of self-administered quizzes found at the end of each sub-module. These, along with the detailed step-by-step examples, provided gave students a feeling of confidence that they understood the material that they had just covered. As in previous terms, the sub-units with which students had the greatest difficulty were scale, gradient, and vertical exaggeration; these were the three topics that required calculations of some kind.

> *"I think it was too mathematical, a lot of it. I mean giving it in inches and having you convert it to feet, and then to miles. It just, you know, it seemed unnecessary." Carla*

> *"I thought it should have stated the formulas more clearly. I was confused by how they arrived at the answers." Carla*

> *"Vertical exaggeration and gradient, I didn't like those two because... I could not get it. Like there is too much stuff to do, so many steps for each one. I just didn't... Even on the test I did some, but how could I finish? I just didn't know how to finish so I just gave it to him." Bridget*

Students continued to see such activities as requiring memorization of formulas and procedures rather than of understanding a concept. For example rather than seeing gradient as simply an application of the basic concept of slope, with which they were all familiar, most students put effort into memorizing a formula (gradient = vertical distance / horizontal distance).

Additional criticisms included the large volume of reading necessary and confusion due to tangential links (i.e., having to link to an additional page/concept in the middle of reading through another). This particular issue was described at length by Janet:

> *"But 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."*

One minor error caused considerable frustration for students. Students were asked to print out a topographic map with a ratio scale and create a profile with no vertical exaggeration. Students began emailing Prof. Brook because many of them could not understand why their answers did not match those posted by the professor. The reason was that although the ratio scale remained constant for everyone, each student's printer produced a map of a slightly different size. Although it was a minor error that was easily rectified by using a graphical scale, considerable time and effort were unnecessarily applied to the problem by the students.

Despite the common acknowledgment that the subject matter was interesting and relevant, students were most critical of the "Landforms of New York City" module. This newly implemented module was ambitious both in terms of its extensive use of complex JavaScript rollover graphics and its pedagogical approach of guided inquiry. Large interactive graphics such as the geological maps of New York and elevation maps of New York were slow to load on dial-up connections and did not work properly with Netscape Navigator or some versions of AOL. Students who used these browsers would get blank images or software crashes.

Each student was provided with a CD containing all of the graphically intensive pages so that students could avoid excessive download times. Five of the 12 students interviewed used the CD at least once during the course, particularly for the mineral properties investigation as well as the geological and geographical maps in the landforms unit. Carla copied the contents of the CD to the hard-drive of her home computer and worked

extensively from these saved files to avoid tying up her home phone line while working on her assignments. Those who did not use the CD, including Erica and Alice who were the two students with cable modems, stated that download speeds were not as issue for them. However, Laura indicated that many students probably did not use the CD because they were unclear as to how it worked:

> *"I found [the CD] helpful, but I know a lot of the kids told me, 'I don't know how to use this CD. I don't know how to use it'." Laura*

This would be consistent with the fact that although Harriet, Doris and Greg stated in interview that they did not use the CD because their computer was fast enough, later in the interview they complained about the time required to download the rollovers in the landforms lab. Laura was the only student to describe the rollovers as not being very helpful. Both the step-by-step nature of the rollovers, and their novelty seem to have been a positive experience for most students:

> *"I liked the rollover chart. That was interesting. You could actually physically see everything work. Time lapse, the process that would have happened, and the captions under it would explain everything, what happens." Keith*

> *"[The rollovers] are so cute, and actually you can see what is going on as you are reading what is going on, which is good." Bridget*

It was Prof. Brook's intention that the students be guided through the active collection of geological and geographical data to be applied to the testing of hypotheses for landform development. As the lab progressed students were given less and less guidance. However, responses from students indicate that these objectives were not met. Students did not feel actively involved, nor understand the meaning of the data:

> *"It was like a dry explanation, no games. Nothing for me to do. There was not an active participation in what was going on. It was a more dry way of writing things." Erica*

"I mean it just seemed like a lot of pages of just moving numbers back without really knowing or seeing anything. You were just taking numbers subtracting them and moving them. So this page, you really didn't see what you were doing." Carla

The map module that was completed prior to this unit contained over a dozen quizzes, as well as answer checks for assignments. When students encountered assignments in the landforms module with its open-ended answers students felt very unsure of themselves, their answers and their understanding of the concepts:

"I liked the landforms but actually there wasn't very much feedback." Carla

"Again there were no quizzes so you couldn't know if you were doing well or not. So it was kind of up in the air when I had to make a report. There are many things I was not too sure about. I didn't know if I wanted to give my answer at all." Erica

"And the other problem with landforms was also I didn't feel I knew what I was supposed to get at the end. You were handing something in and you were not really sure if that was what the end result was supposed to be." Janet

Janet suggested that some of the ambiguity could be alleviated with more concrete examples. For example, in addition to the generalized explanation that was provided on how to construct a geological map from incomplete outcrop data, a specific, related example be given that was similar in form to the assigned maps. Specifically she suggested a detailed tutorial-style construction of a geological map of upstate New York be provided before students attempt their own map of Manhattan. Carla and Erica both recommended the inclusion of quizzes in the landforms module.

By far the most troubling component of the "Landforms of New York City" for students was the final question when students were asked to devise a test for whether or not the landforms of New York were created through tectonic forces of folding and faulting (uplift and depression). They were given geological cross-sections of the city and brief

introductions to the geometry of folding and faulting through rollover graphics. Most students were unprepared to answer this question and felt adrift:

> *"He asked at the end of the lab 'look at the landforms of NYC and the layering and this and that and decide what kind of compression was involved'. I have no clue. I just made something up. I have no clue what it was about. I was told 'You have to try to figure it out' but I had no clue what I was trying to figure it out based on. And I didn't use layering or anything in my analysis that's for sure." Laura*

> *"Landforms of the New York City area, testing the hypothesis of uplift and depression, I have the whole thing printed out and still didn't know what to do. I think that the landforms should be done over. I just didn't get it. I understand uplift. I understand the concept in general but it doesn't help... I didn't grasp the essence of it. I understood the concept but not the essence. I didn't see how it helped me interpret anything." Harriet*

As a whole the course rated poorly in terms of student satisfaction with only eight out of eighteen students stating that they would take another online non-majors course when asked on a college-implemented post-course questionnaire. Similarly only 8 out of 18 students stated that they would recommend this course to a friend. The predominant reason for student dissatisfaction was workload. When asked what was the one least helpful aspect of the course and what they would recommend to improve the course, 11 out of 18 students stated that the course load was excessive and needed to be reduced.

> *"I liked it. I learned a lot. But it was too time-consuming. I thought the idea was to spend less time in the lab and save time but I find that navigating it and understanding exactly what the what was being asked of me took a lot of time." Harriet*

> *"This was just too much work and it took us too long. It really was a very impressive site. Everything was very clear. It looks like someone really put a lot of time into it. It was absolutely the best web course I took in [Urban College]." Erica*

"This class was a lot of work and I strongly feel that it was worth it as I learned some new stuff, but I also felt that I was doing two different classes" Anonymous

In a regular GEO 101 lab, students would meet in the classroom 7 times for 2 hours each. Assignments are typically due at the end of the class. Students in this partially virtual GEO 101 described work schedules that were considerably more intense:

"I would spend 3 or 4 hours and finally have a grasp. I would be able to grasp what was been asked of us, and understand everything and maybe in 2 hours be done in two extra hours. It was a lot of work. It was a lot of work." Bridget

"I don't want to sound like I want to make it easier but it's too long. Like I said, I've never been used to doing 2 1/2 to 3 hour labs before. Most of the labs that I've done in my life have been in class, physical labs, and they're like 1 hour 20 minutes and out." Greg

"I thought that it was a great deal of work. A lot of work. Sometimes it took several days to complete the project which had I taken the labs here I would of been done in an hour and a half, or whatever, and that would've been it." Janet

"I felt like I was putting in twice as much work as people who were taking a regular lab. We had to come in 3 times for the 2 hours anyway, and he still plans to do lab on our own time. So we would come in for 2 hours for a lab, then for at least 2 or 3 hours at home and we were putting in 5 hours for this class easy." Laura

"Just give the whole class through the computer, don't go into the class at all. Or just give it in the lab. We work double. We come to the class and then we come back to the computer and it takes a long time. It takes a lot of time." Doris

Although students were unanimous in their desire for a reduction in the overall workload, they were divided on whether they would have preferred a lesser or greater proportion of the work to be done online. There was general agreement that an initial meeting was necessary to introduce the site, describe how it worked, and discuss what was expected:

> *"For me the in-class meetings were almost like 100% understanding. The first lab I looked at it and I don't know what to do, where to go, here or there? When I come to the lab the professor explain and then I understand where to go—click over here, go over there." Ian*

> *"I think there should be less in-class because all he did was show us something for perhaps 10 minutes but it did make a big difference when I went to do the lab." Janet*

> *"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." Greg*

In the final cut, students based the necessity of both the in-class and online sessions on whether it aided them in the completion of their assignments or allowed them to succeed on the final exam or saved them time in their online work.

> *"It helped for the assignments because basically he would discuss what was required. If a person didn't go to the sessions he would have to waste a lot more time trying to figure out what to do." Harriet*

> *"I think the map was the one where I actually learned something in -- the streams and how to read which direction you are looking at it from. Even though it was on the website later, it was something that I skipped. The second one I think I found useful before I looked at the website to see what the website had. But it was pretty redundant." Laura*

> *"Oh the maps definitely helped. It helped in every way, definitely. That is something they should keep especially with the contours and the profiles. But then again I am biased because I already had the lecture before doing*

the assignment. It helped me. I just didn't go and try and do the assignment first, and then not be able to do it. But the class definitely helped because when I came here I was able to see. I was able to understand right away. I didn't have to work so hard to understand what was going on because I knew what was needed." Bridget

During classroom meetings student questions most commonly were directed toward procedural and logistic issues. However, several of the brighter and more involved students (Janet, Harriet, Erica, Bridget) would ask for further examples, quiz the professor about particular cases and exceptions, and ask for clarification.

"[The webpages] don't give different scenarios. Like sometimes you could have a contour and then you could have a depression contour, and then a contour, and then a point in the middle. He went through everything. You were in class. You could ask all kinds of scenarios, and he would answer the question. There is that communication there. But if you went online you would see maybe 5 scenarios and that's it. So you could get to the exam and see something else and not know how to do it." Bridget

Prof. Brook made himself available for office hours each week during the time block that would correspond to the normal lab session. Over the term he had 18 student visits and three phone calls regarding the virtual GEO 101. However, the bulk of the communication outside of classroom was through email with 106 emails received from students. Thirty-three of emails dealt with specific questions about assignments, both clarifying instructions and checking answers. The next most common reason that students emailed Prof. Brook was to book an appointment (16 emails). In addition, Prof Brook sent out 19 class-wide emails alerting students to upcoming deadlines and/or corrections to the website, as well as posting assignment grades. In previous terms this class-wide communication had been done through "Late-Breaking News".

Students relied heavily on email communication with Prof. Brook when problems arose. When students reached a portion of the website that they did not understand most continued to work independently to solve the problem by rereading the material or moving on and returning to the problem material later. If the material remained

incomprehensible, then students would pause their work and email Prof. Brook for help. All 12 students interviewed remarked on the promptness and usefulness of the professor's replies, always the same day and usually within a few hours. When asked to compare the degree of student-teacher communication in the virtual GEO 101 with in-class science lab courses that they had taken the interviewed students unanimously agreed that they had an equal or greater degree of contact and communication with Prof. Brook.

> *"The chemistry and physics was in class and again I wouldn't see the professor alone. I would ask a question in class. So in a way my connection with [Professor Brook] was better, more like one-on-one connection, rather than in class with like 20 students or whatever." Erica*

> *"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." Doris*

The increased communication and connection with Prof. Brook may have been, in part, due to the fact that most students were previously unexposed to geology and suddenly were confronted with relatively complex lessons in the science:

> *"Geology is something which I never studied. So I actually needed to communicate with [Prof. Brook] a lot more because in [introductory biology] whatever happened, happened. You know, I could follow it. I didn't need to ask as many questions. It wasn't anything new." Laura*

"Because this was so in a depth, I guess I had ask him more in depth questions. We had to go over it and sit and go over them. I spent more time with him than the others." Janet

Another reason that there was greater student-teacher communication in this online class was due to the fact that few students communicated with each other to solve problems and help each other. Despite Prof. Brook's efforts to foster inter-student communication by requiring in-class groups to exchange email addresses and even requiring groups to share answers to complete one assignment, few students worked together outside of class. Out of the group interviewed, only Alice and Ian worked together outside of class. This cooperation began when Ian contacted his fellow in-class group member Alice by means of the email addresses that they had exchanged in class. Doris also tried to begin communication with other students through email. She emailed classmates several times and received only one response after two or three days. Accordingly, she chose to focus her communication on the professor because it was more efficient and reliable.

Based on a previous experience in an online course, Erica suggested that Prof. Brook adopt the use of an online bulletin board to increase communication. In an online biology course she had been able to consult a bulletin board for student questions. If another student had already asked a similar question, then she could see the professor's response and immediately get back to work. Thus students would not have to pause their online work waiting for an email response from the instructor.

Through JavaScript-based quizzes and answer-checking pages students had another form of communication and reassurance that required no extra work on the part of either the instructor or other students. Students certainly valued their ability to verify their answers for mineral hardness and the various data charts in the landforms module:

"I liked the idea of having your answers right there. You can check your material to see if you did it right. That I liked. It's not fair when you get them back, and it's wrong, wrong, wrong. And I spent all this time doing everything and then it's wrong. At least now you can check it and figure what you did wrong." Keith

Every student interviewed said that they attempted most of the quizzes in the maps module even though no mark value was attached to them. Several students commented on their desire to have feedback on their understanding of the concepts in the landforms module through the use of quizzes, as was presented in the maps module. Erica, for example, stated:

> *"I liked the fact that like you explain something and then do the quiz. And you can see immediately if you understand or not. You can immediately make it like actual for you... If we could have like quizzes also in the landforms part or some sort of clarification. The second landforms was not clear how to do things."*

The quizzes, to which students could link directly from the maps homepage, also acted as a means by which students could study for the final exam. These quizzes, along with their corrected assignments were the basis for the study strategy for most of the class. Most students also skimmed over the website text and/or printed portions of the site. One student, Janet, systematically took notes throughout the course by copying key sentences from the website and pasting them into a word-processor document.

The exam was seen by all students as being overly long and difficult and held too much weight, being worth 75% of the lab grade. Aside from these important but easily fixable issues, many students were concerned that the exam experience did not accurately reflect their online experiences in the course. In particular, the mineral-testing portion of the lab involved real samples. The use of such samples led to ambiguities in their physical properties such as the exact color of the streak (and how an individual would describe it) or which object scratched which. Online there was no such ambiguity and so the testing and classification process was more straightforward in their assignment than on the exam.

> *"For minerals it could be this but it could be that. The way he presented it to us you needed to choose. He said make it this one or that one so I wanted to write an explanation of why I wasn't sure about it. It's that it's missing this or this is supposed to have a rotten egg smell, but I have a cold and can't smell anything." Laura*

Another reason that students may have found the exam a frustrating experience was that 15% of extra credit was presented on this exam which was based on optional material found in the "Toolbox" on the maps homepage. Essentially this was the material that was removed from the maps module this term, including latitude-longitude and the treasure hunt. Although Prof. Brook made reference to this extra credit both in class and under the grading policy under "Explore the Course", six out of the twelve students interviewed did not know that the treasure hunt and the other optional material existed. None of the six who knew about this material had read through the bulk of the text. The most common reason given for not looking over this extra-credit material was that the required workload was already too great.

One final aspect of the Spring 2001 website to be examined is the student reaction to the continued use of the cartoon characters Lou and Lulu. They remained a prominent feature of the maps module and were also had a minor presence in both the minerals and landforms units. Seven interviewed students responded very favorably to these characters, and felt that there use increased their enjoyment of the course:

> *"I felt that they were a little helpful because often he came up with questions that I would've come up with myself. So I think it was interesting but the bright colors helped I guess." Janet*
>
> *"Yes a little bit of humor put in always takes away from the seriousness and the repetitiveness of just detail and facts. It brightens it up and takes your mind off of it. Makes it easier to learn." Keith*
>
> *"It like kept you going. It's like a story so you want to know what's going on, what's next." Ian*

Fabian and Greg were essentially ambivalent to their use. Harriet, Bridget and Doris all reacted negatively to Lou and Lulu, although to different degrees. With Doris and Bridget it was a matter of the dialogue style slowing down the process of going through the site and completing the assignment:

> *"Oh my God, they got annoying after a while. They got annoying after a while. After I think 'oh, this is cute', but then when you are frustrated and*

your are having... I guess it is better than just reading through text so you know, yeah in a way it's... But after a while I just got angry. 'Oh my god, do I have to do this?' The work, just having to do so much work. I guess it's not so much Lou and Lulu. I guess it was just the fact that there was so much work to do and I had first to read this and then Lou and Lulu... It was just too much." Bridget

"Sometimes was very helpful. Sometimes was very annoying. Like in the beginning they give you instructions like they tell you what is a mineral, how to do your calculations correctly, what elevation, the gradient. This is very good. But sometimes Lou asks such stupid questions, like I don't know how to explain. Sometimes there was too much and more information than what you needed to do the exercise. That's what I feel. At some point it was too annoying. Too much information. More than what you need for the exercise." Doris

Harriet was the only one who was entirely negative about the characters. She describes her experience with Lou and Lulu in the following way:

"Oh I hate Lou and Lulu. I don't know what they're talking about sometimes... What on earth is this girl trying to say. After reading what Lou had to say I can't answer the questions. Eventually I got it, but it took like about two hours trying to figure out what it is. I think they were both weird. Perhaps because I am a senior and I am doing on this now, it almost seems too simple. I think for more mature people, running out of time, you don't want to hear what Lou has to say. It's too much detail. Lou could say these things a bit simpler."

5. DISCUSSION

Spring 2001 was the first time that Prof. Brook offered a course with all three modules developed for online study: the third offering of the maps module, the second offering of minerals, and the first offering of landforms of New York City.

The major issues raised by students in this class were workload and correlation of term work to the exam. Both of these issues, while important, are general course structure issues rather than being related directly to online delivery. The excessive workload appears to be due to the fact that although Prof. Brook has essentially developed a fully asynchronous course, he maintained a schedule more appropriate for a partially virtual course. If the problematic content areas such as vertical exaggeration were improved and clarified, in-class meetings could be reduced substantially, and this time could become office hours rather than in-class meetings.

The landforms module presented the greatest problems for students. As with any guided discovery lesson it must be fine-tuned to achieve the appropriate level of guidance. When delivered in the classroom, an instructor can adjust the delivery immediately based on direct questions from the class. In the case of this online delivery, the level of understanding was not evident until the assignment was finished, assignments submitted, and the conclusions discussed in class. Based on interview responses and submitted assignments it is apparent that considerable tuning is needed to make this module successful.

The class must have a better picture of the overall project at the beginning so that they can appreciate the data that they are required to collect. Also more direction is required for the analysis of the hypothesis of uplift and depression. The subtleties of this complex geological and geometrical question were lost on the class, even to the better students. Perhaps some of the confusion and anxiety could be alleviated by increasing the degree of student-student communication. If this assignment had been conducted in-class it undoubtedly would have involved working in groups in a collaborative fashion. The use of bulletin boards and group email should be adopted to foster communication in an asynchronous fashion.

CHAPTER 6: DISCUSSION

1. FACULTY TRAINING IN WEBPAGE DEVELOPMENT

Although the idea of creating an online course was first seriously planted in Prof. Brook's mind four years ago, the actual process of creating this online geology course began a year later in the fall of 1998. At the outset, Prof. Brook had little computer experience and absolutely no knowledge of HTML or JavaScript. Furthermore, despite both a professional interest and considerable experience in collaborative and inquiry-based education in the classroom, Prof. Brook had no experience with online pedagogical issues.

The initial program that began the learning process was a broad college-wide offering that enticed faculty with the promise of new computer equipment and internet connections. In exchange, faculty were expected to produce a partially virtual course. Technical support involved mostly classes in HTML as well as important computer applications. These courses were frustrating to Prof. Brook. He felt lost and so soon stopped attending the classes.

In 1999, I became involved in the same ongoing faculty training program. I began the program with approximately 20 other faculty members. On the first meeting the wide range of ability was painfully evident. At one extreme, the class included several members of the Computer and Information Systems department who were well versed in computer use and were very comfortable using these machines. At the other extreme, the class included several faculty members who could not do the most basic of tasks such as using a mouse, saving files, copying or pasting. Personally, although I had no knowledge of webpage scripting, I was very comfortable and proficient with computers and basic applications.

The course continued at a painfully slow pace for me and the other faculty who were computer proficient. The promise of breaking into smaller groups of similar interest and experience did not materialize, and neither did the promise of being paired with an experienced faculty tutor. Like Prof. Brook, I became frustrated and stopped attending classes.

Despite Prof. Brook's negative experience with this broad training program, he reservedly chose to become involved with a smaller, externally funded project with a similar objective – to train faculty to create web-delivered non-majors courses.

> *"I thought about it and at first was quite skeptical. I was not convinced that I could master the necessary computer techniques (I was at that time new to Windows, to using a mouse, to using a modern word processor), that I would receive meaningful help, or that the results of all the effort to create virtual modules would be other than trivial compared to time tested value of "real" teaching."*

From the beginning, Prof. Brook knew that this was going to be a very different experience from his earlier one. Prof. Brook was immediately placed into a small group with other science faculty who had little experience with web development. Thus he and his group members had commonality of both experience and content interest. Furthermore, the group's mentor, who was highly experienced in the development of educational web sites, also shared a science background.

Another beneficial aspect of the second program was that the group spent considerable time discussing the pedagogical aspects of web-based courses. As members became proficient with scripting, and were ready to try their hand at webpage creation, they were also more prepared to design the teaching aspect as well.

All members of the web-development project met monthly to discuss progress and problems, as well as keep the rest of the group up-to-date on individual's strategies.

> *"It was always interesting to learn what others were doing, and to engage in discussions of the merits of 'Technology Mediated Instruction' and 'Technology Mediated Exchange'. However, these largely show-and-tell meetings did not, due to the limited time available and the diverse directions in which participants were headed with their websites, have the same value as sessions with Faculty Mentors."*

In the fall of 1999, I was invited to attend several of these monthly meetings because of my interest in educational research and assessment. At the time I was skeptical of the

value of web-based education but found the sessions very interesting. Under the strong mentorship of the project leader the participants had started to produce some interesting sites, each one unique in its design. Furthermore, the sessions delved deeply into pedagogical considerations, an aspect that was completely lacking in my official college-sponsored training program in which I was participating concurrently.

One of the main reasons that Prof. Brook decided to join this second project was to work in conjunction with a departmental colleague who was also was joining the group. As their individual involvement progressed, their level of commitment began to vary, as did their design direction. Thus over time, Prof. Brook lost the peer collaboration he had initially sought.

It was on Prof. Brook's encouragement that I began to become involved in the monthly meetings and, eventually, the study of his site. Since the fall of 1999, we have often met to discuss both design and content issues. He used me often as a sounding board for his ideas. More recently, once I had learned basic HTML and JavaScript, he would discuss specifics of intended design issues in order to help him understand what was possible in terms of programming, and help him translate his ideas into concepts that the supporting programmer could understand. Prof. Brook commented often about the additional support and enjoyment that he obtained from discussions and collaborations both with his mentor and with me. With me, in particular, he could discuss discipline-specific content and pedagogy issues.

Prof. Brook has had a long-standing commitment to inquiry-based and collaborative learning. From the outset of his involvement in web-based education it has been his intention to maintain this quality in the new medium. Yet despite his experience in the classroom, it took considerable time and experience online before the website began to reflect his educational ideals. With the exception of the initial presentation of the geology of New York, Prof. Brook did not simply transfer lab room lessons to the web. And in the case of this exception, it was done with Prof. Brook understanding that it would be a temporary measure for one term until he finished redeveloping that module for web delivery. Nevertheless, his initial offering was still predominantly a set of static text and graphics pages. The most significant adaptations in that initial module were the dialogue

style of delivery and the use of online quizzes. In hindsight, the maps module now seems simple and flat to Prof. Brook, and he is currently designing interactive activities with multiple degrees of feedback from the computer to augment the current material.

The invention and design of interactive modules such as the minerals investigation, and computer-based inquiry such as that which debuted in the Spring 2001 "Landforms of New York City" took several years. Each iteration of the website brought new insight into the possibilities that the computer could present to future students in GEO 101. Certainly the current offering is as ephemeral as the previous ones. Increased interactivity in the maps module will be accompanied by refinements of the inquiry in "Landforms of New York City". Perhaps Prof. Brook will also attempt online collaborative learning.

During the past term, I had continued involvement with another member of this web-development group, a member of the English department, through shared classes in JavaScript. During informal conversation with her, she repeatedly stated her desire for a departmental colleague with whom she could discuss her website. She longed for the sort of professional, collaborative relationship that had developed between Prof. Brook and myself during the study of his site. She also stated her wish for detailed, ongoing assessment of her website similar to the project described here.

These experiences with faculty training initiatives and their participants suggest that the collaborative learning environment that benefits our classrooms (e.g., Bruffee, 1999) is vital to the success of faculty training. Critical aspects of the training experience include:

1) Small supportive peer groups with similar knowledge level and background. Ideally this should include colleagues sharing the same discipline.
2) A mentor who understands both technical and disciplinary issues.
3) A holistic educational approach, including both technical and pedagogical aspects.
4) A realistic time-frame, a minimum of two years, in which to develop the first run of the online course.
5) Meaningful, ongoing assessment of the website once it is offered.

2. STUDENT EXPERIENCES WITH THE COURSE

Over the 3-term study of the online version of GEO 101 student perceptions evolved as the site also evolved in response to their criticisms and Prof. Brook's further understanding of his student's experiences. Each term the ratio of virtual to in-class work increased. Also each term the overall student attitudes toward the course improved and the key criticisms changed.

Navigation and Link Structure

The first class had great difficulty navigating the site. Prof. Brook constructed a site that allowed students to jump back and forth readily from almost any point in the site. In designing the site in this potentially non-linear fashion Prof. Brook had intended to give each student more control over their own learning. Ideally each student could choose a path that best suited them, being easily able to link to related concepts to see the connections or review the necessary material.

The concept of a non-linear educational site exploiting complex navigational tools such as image maps and with 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. However, such non-linear navigation mechanisms created great confusion for students. In the first term many students accidentally missed entire topics during their navigation and had great difficulty returning to particular topics.

In subsequent terms a hierarchical, linear navigation design was implemented. Within each topic the site did not provide links other than to navigational homepages. When students finished a particular topic they returned to navigational homepages which were nothing more than tables of contents that linked to the various subject pages. A study sequence was implicit in the presented order of the links, however, students were free to choose a different sequence if they preferred.

Although students in the Spring 2001 offering were generally satisfied with the structure of the site minor problems in navigation still exist. The homepages in each module presented essentially a table of contents with generalized titles. This served the students well when initially navigating through the site. However, during review students had some problems finding specific subtopics. So whereas it appears essential to keep the link structure simple and essentially linear, a more complex navigation tool such as a site-specific search engine would facilitate review and student-directed navigation.

Communication

The perception of communication in the classroom changed considerably since the initial run of the virtual GEO 101. The amount of in-class contact decreased progressively from term to term and so did the desire for further classroom contact. In the first term students strongly expressed a desire for more in-class instruction from the instructor whereas in the subsequent terms most students wanted limited contact. The main reasons for wanting face-to-face contact were to quickly demonstrate the workings of the website and have the opportunity to discuss particularly problematic material.

Two factors likely account for the decreased need for face-to-face contact with the instructor. First, the navigational structure of the website was greatly simplified in the latter two terms. Students could easily navigate through the material without becoming lost or loosing their train of thought. Secondly, the degree of instructor-student online communication increased substantially each term. In the first term Prof. Brook received a total of 10 emails from students, only 2 of which involved questions about the course and its assignments. In the second term the total number of emails increased to 62, and 106 in the third term (Table 6.1).

Students were generally willing and able to work independently. The main impediment to doing so was not generally a misunderstanding of content but rather ambiguity of instructions. Students were satisfied with taking time to learn the material online but did not want to waste any time unnecessarily on the assignments. Such issues usually would not require lengthy exchanges and so email was an effective means of clarifying these

problems. Note that in the second and third terms 1/3 of emails involved questions directly related to the assignments. As web-based communication increased, the need for face-to-face communication decreased.

What factors caused the increase in student use of email as a communication medium? Probably the most significant factor was the required use of email from the very beginning of the course. Students in Fall 2000 and Spring 2001 were required to email their request for enrollment directly to the instructor whereas the Spring 2000 class submitted paper request forms to the secretary in the geology office. Also in the first term, online work did not begin until the third scheduled meeting whereas subsequent term's classes began their online work on their second scheduled class.

SUBJECT OF EMAILS	NUMBER OF EMAIL MESSAGES		
	Spring 2000	Fall 2000	Spring 2001
Assignment Questions	2	20	33
Content Questions		6	2
Logistical Questions			9
Lateness/Absence	3	9	8
Web Errors	5	2	8
Submission		11	6
Booking Meetings		11	16
Replies/Confirmations		5	8
Technical Problems			6
TOTAL	**10**	**62**	**106**

Table 6.1 Summary of emails received by the instructor from students

The increase in email use between the second and third terms is likely due to the instructor's increased use of email as a means of communicating with the class. In Fall 2000 Prof. Brook disseminated information such as corrections and assignments through the "Late Breaking News" page on the website. In Spring 2001 Prof. Brook continued to

post detailed assignment instructions on the website (under the new heading "Assignments") but also communicated all important information to the class through a total of 19 class-wide emails, including a welcoming message. By doing so Prof. Brook led by example and the students followed.

There was class consensus in the last term that Prof. Brook responded to emails very quickly. Early experience with this relatively efficient form of communication probably reinforced the use of email by students. Certainly students discovered that they could rely on a faster and more accurate response from their instructor than they could from their classmates.

By the end of the study students perceived their degree of communication with Prof. Brook, predominantly through email, to be equal to or better than the communication that they had experienced with other science lab instructors at the college. Certainly they felt that the communication was more personalized and that the instructor was more readily available.

In the classroom, students worked in groups and were encouraged to work together outside of class through the exchange of email addresses as well as the group assignment in which students needed to exchange their answers in order to complete the assignment. At least half of the class in the latter two terms experienced frustration with the online group assignment, due to a group member not completing their portion. Despite Prof. Brook's attempts, student-student communication remained minimal outside of the classroom. There was no strong desire in students to foster student-student communication, nor was there significant expectation that this should exist in the class. As a non-majors required course with students from all programs and all years enrolled, very few students knew anyone in the class, nor did they have the expectation that they would. This sense of independence was born through prior experiences in other core curriculum classes.

Student-student communication, although a concern for Prof. Brook, was not a priority. He focussed on developing instructor-student communication, and student-computer communication (interactivity). Online bulletin-boards have been used extensively in other online courses to increase collaboration and communication in general (e.g., Jonassen et

al., 1995; Wegerif, 1998), including other courses offered at Urban College. Despite my repeated suggestions during the study for the adoption and implementation of a bulletin-board forum for posting messages, Prof. Brook chose not to use this tool which was readily available. This decision was based mainly on a lack of experience with such forums and a fear of over-extending himself in terms of learning about and understanding new technology. However, Prof. Brook intends to implement some form of bulletin-board communication in the future.

Student-Centered Learning Online

Student-centered learning allows the student to control aspects of the form, pace and ownership of education. Techniques commonly used in the modern classroom include collaborative learning in which students construct knowledge through sharing ideas, self-pacing and self-direction, and guided inquiry where students are helped to discover knowledge for themselves. Collaborative learning in online education, humanities and business courses has been documented in numerous research papers reporting on non-science courses, however, as in most online science courses it was not yet attempted in Prof. Brook's GEO 101.

By its asynchronous nature online education is self-paced and self-directed. For many of the students interviewed in this study, the opportunity to control their schedule was a key factor in choosing the option of online education. Unlike the classes studied by Wegerif (1998) and Kazmer (2000), the feeling of independence was far more important than feeling "a part of the class". That is not to say that the students in GEO 101 felt disconnected, rather they were more concerned with connection to the instructor.

In this study, the most critical aspects identified for student success in this student-directed format were all related to aspects of student-instructor and self communication. These important aspects were:

1) Clear concise instructions, a factor identified also by Hara and Kling (1999).

2) Effective and efficient communication between the students and the instructor, again an important factor identified by Hara and Kling (1999).

3) A means of low-stakes self-testing such as online quizzes, which is essentially a means of communicating to the student his/her level of personal understanding.

The main instructional method with which Prof. Brook experimented in this class was guided discovery. This was first introduced in the minerals module in a highly directed fashion. Students were required to solve a set of particular problems (e.g., identify Moh's hardness scale, determine the identity of unknown minerals) by collecting physical characteristic data and comparing it with standard charts, with the objective that the class would become familiar both with descriptive geological data and its interpretation. The concepts were simple. The methodology was simple. The activities were interactive and highly visual. Minor ambiguities in the instructions led to frustration with several students but these were mostly cleared up with brief email exchanges. The response from students was positive, with many students stating that it was fun, and certainly their favorite module in the course.

The "Landforms of New York City" was a later and more ambitious attempt at online guided discovery learning. The objectives of this module were to discover something about the students' home environment, integrate some of the knowledge that the class acquired through the term, and gain an understanding of the scientific method through its application. The complexity of the concepts increased with each of successive assignments, whereas the degree of guidance decreased. Although the instructions were generally, although not always, clear, the concepts were often not fully understood and students commonly followed the required steps without appreciating the reasoning or projected outcome. This module was generally frustrating to the class both because of excessive workload and a feeling of being lost.

The success of this conceptually complex module was limited by insufficient communication at several levels. The required integration of numerous concepts in both geology and general science almost guaranteed that students would falter at some point, thereby creating problems for all subsequent concepts and assignments. Students could verify their answers in their data tables but could not verify their understanding of the

more complex concepts due to a lack of quizzes or organized idea exchanges. Even if students actually understood the material, the lack of corroboration left students uncertain and frustrated.

In a classroom environment such a detailed investigation would undoubtedly have been done in groups, probably with some sort of collaboration between groups, whether in a formal or informal sense. Students would be able to share ideas, use each other to fortify their confidence and bridge gaps in knowledge or understanding.

In comparing the reactions of classes to the minerals and landforms modules it is clear that certain communication needs must be met in order to be successful:

1) Students must have a means of officially corroborating their understanding and knowledge to alleviate their personal anxiety. Quizzes and answer checking tables worked effectively in the simpler modules of minerals and maps.

2) The module must not be overly ambitious or rushed. Students must have time to assimilate and interpret new information and new linkages, as well as having the opportunity to communicate their understanding.

3) The more complex and integrated the concepts are, the more detailed and extensive the communication must be. Simple email is sufficient to clarify procedural or logistical issues but fuller communication, perhaps bulletin boards, is necessary for communicating ideas.

Use of Comic-Style Delivery

In his initial attempt to create an online module Prof. Brook avoided the typical "electronic textbook" presentation partly by the adoption of the comicbook-style dialogue between two characters. The character of Lulu acted as a mentor to the character of Lou who was trying to learn how to understand and interpret maps. The intent was to transfer some of the more natural dialogue-style of face-to-face delivery to the internet. Such comicbook-style delivery has been acknowledged to be an effective way to reach New York City youth with organizations such as the New York City Department of Health

commonly attempting to inform youth about AIDS and other STD's by means of comic strip posters in subways. But does this delivery strategy work as part of an online college course?

Student perceptions of Lou and Lulu changed throughout the study. Response was generally negative in the initial offering but improved in subsequent offerings. The main criticism against the dialogue was that it was wordier than a regular text delivery and thus it increased the amount of time required to complete the course work. As the text was edited to remove unnecessary dialogue and reduce the overall length the dialogue was better received. However, it still became a minor irritant whenever students were overwhelmed by workload or frustrated by other aspects of the website. The dialogue became one more obstacle to slow students down. More work is necessary to further streamline the text.

The adjunct who examined the site predicted that students would be offended by the perception of Lou and Lulu's dialogue being childish. This was indeed the case with two students in particular. Both students were strong-minded, female seniors who were in their thirties. Given that the audience for this particular course was highly varied in age and experience it is not surprising that there was significant variation in acceptance of the Lou and Lulu dialogue. It certainly seems to be most accepted by younger, less experienced students, although there are no absolute criteria for acceptance or rejection of this technique.

By the final term of the study most students felt that they benefited from the cartoon format. Most students felt that Lou and Lulu made the experience more enjoyable by creating a game-like atmosphere and/or by creating a sense of interest in the story-like format, in essence creating curiosity about what was coming next. With skilled story writers such a delivery mechanism could have great potential.

One of the greatest strengths of Lou and Lulu's dialogue stemmed from the fact that Prof. Brook's years of experience in the classroom allowed him to predict many of the questions that students would ask. There was a sense of satisfaction from students when they saw their questions being asked on-screen by the character of Lou.

The use of dialogue exposition in websites certainly has potential benefits to students if it is well crafted. Perhaps its greatest benefit is its simplicity. The web-designer/instructor would not have to know any complex scripting and so could implement such delivery from the outset to add a sense of personality to the website. The main considerations are pedagogical rather than technical. The instructor must know the intended audience in order to be successful. It must be both interesting and concise. It must be designed considering the needs and questions of the students. It must have visual clues to allow for skimming and quick review.

3. GENERAL RECOMMENDATIONS FOR ONLINE SCIENCE EDUCATION

The primary purpose of the study was to further understand the learning process for students taking an online geoscience course, rather than a rigorous evaluation of the value of online education. Nevertheless, from the results of this study it is possible to make certain general recommendations for future web-developers of earth science education sites. Before constructing a web course, an instructor/developer should ask several critical questions that follow.

Is There a Justifiable Need for a Web-Based Course?

At the time of completion of this study, the GEO 101 website had been in development for two years, with an additional year of general training and education in scripting and pedagogical considerations. However, as this is being written Prof. Brook is once again significantly redesigning the maps and geology of New York City modules for the courses' fourth offering, and initial considerations are being made for changes for the further improvements in the fifth iteration.

For the past three years, Prof. Brook has devoted most of his time and energy to the development of this online course, with no other research projects, no students to supervise, and a reduced teaching load as well. For Prof. Brook the development of his online course was a labour of love. Few other instructors would be able to match, or even

approach, the total time committed to this particular project. Accordingly, it is important to ask if such a significant allocation of time and resources is truly justified.

- Is there a significant population of distance-learning students who would otherwise be excluded from an in-class course?
- Does the online presentation allow students to simulate aspects of the science that would be impossible to demonstrate in a classroom? Are the associated materials hazardous, prohibitively expensive and/or inaccessible? Does the website simulate the use of lab equipment to which students would not have access?
- Is the online module flexible in design so that it could be used for multiple courses?
- Do you have a research interest in educational technology so that investment in web development will benefit both teaching and research?
- Does your college administration truly encourage and support web-based course development?

Do the Objectives of the Course Suit Web-Based Delivery?

Simulations by their nature are simplifications of real world phenomena. From the outset the programmer must decide which variables will be included in the simulation and what degree of variation will be allowed and presented to the user. Thus a simulation will give the user experience with the problem but most likely will not make the user familiar with the related real-world situation.

Prof. Brook chose to deliver the mineral identification module through the internet by means of a property testing simulation. In the simulation the natural variability of minerals was eliminated. Minerals in the simulation did not vary in colour or hardness despite the fact that natural variations in chemical composition can cause these properties to vary significantly. In addition, variation in the hardness of the testing materials was also eliminated in the simulation: the hardness of steel did not vary with quality, the testing steel did not develop a troublesome oxidized layer of softer material, everyone's

fingernail was exactly the same hardness. Thus in the mineral property simulation the tests were definitive and exact whereas in reality there is considerable variability in natural properties as well as the interpretation of the tests themselves (e.g., is that a scratch on the mineral or a streak of powder left behind from the testing material?).

When students were faced with real samples on the exam students had difficulty interpreting tests and matching color names. They lacked experience and confidence in dealing with real materials despite having had good results in the online mineral property simulation. Clearly the online experience did not prepare students for real-world mineral identification with all of its natural ambiguities. However, it did provide an effective means to introduce the more general concepts of data collection, classification and decision making.

It is important to realize that the internet is a distinct educational medium with inherent strengths and weaknesses compared with the in-class environment. To have the potential of being successful, the learning objectives of a given online module must actually be suited to the online medium. Some important considerations for suitability are listed below:

- Have you clearly articulated the objectives of each given module? Are the objectives based on thought processes (e.g., data collection, reasoning, classification) or on skills such as identification? Generalized thought processes and reasoning have a far better chance of success.

- Does the online lesson comprise all or part of the module? An online simulation with its necessary simplification of real-world phenomena can provide an effective introduction. Once the fundamentals have been taught online, the instructor can augment the lesson with more complex and variable situations in the classroom. Furthermore, the online material can act as an effective and readily accessible means of review.

- What is the target level of the course? The generalized knowledge that is associated with online simulations is best suited to introductory courses and non-majors courses.

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1995 University of Calgary Post-Doctoral Fellowship
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INSTRUCTOR / LAB CO-ORDINATOR
University of Calgary, Department of Geology and Geophysics August 1997-August 1999
- Designed innovative exercises for first-year geology labs
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- Taught *GLGY 203: Principles of Geology II, GLGY 209: Introduction to Geology,GLGY 399.01: Geology and Fossils of the Burgess Shale,GLGY 337: Geologic Field Methods I, GLGY 339: Geologic Field Methods II*

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Mount Royal College, Department of Geology September 1997-August 1999
- Taught *GEOL 3307: The Geological History of Life*, a second-year course for non-majors
- Developed a special session of *GEOL 2209: Introduction to Geology*, specifically designed for the wants and needs of Calgary area teachers

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- Taught *GLGY 209: Introduction to Geology, GLGY 337: Geologic Field Methods,* and *GLGY 331: Introduction to Minerals and Rocks*

GEOSCIENCE INTERPRETIVE GUIDE
Yoho-Burgess Shale Research Foundation June 1995-September 1997
- Wrote a non-technical guidebook for the Burgess Shale and the region
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University of Calgary, Department of Geology and Geophysics June 1994-April 1997
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Noranda Minerals Inc., Geco Division May 1990 - September 1990
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