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BROWNFIELD ACTION: AN EDUCATION THROUGH
AN ENVIRONMENTAL SCIENCE SIMULATION
EXPERIENCE FOR UNDERGRADUATES

By

Ryan D. Kelsey

Dissertation Committee:

Professor Frank Moretti, Sponsor
Professor Robert McClintock

Approved by the Committee on the Degree of Doctor of Education

Date MAY 1 2 2003

Submitted in partial fulfillment of the
requirements for the Degree of Doctor of Education in
Teachers College, Columbia University

2003

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ABSTRACT

BROWNFIELD ACTION: AN EDUCATION THROUGH
AN ENVIRONMENTAL SCIENCE SIMULATION
EXPERIENCE FOR UNDERGRADUATES

Ryan D. Kelsey

Brownfield Action is a computer simulation experience used by undergraduates in an Introduction to Environmental Science course for non-science majors at Barnard College. Students play the role of environmental consultants given the semester-long task of investigating a potentially contaminated landsite in a simulated town. The simulation serves as the integration mechanism for the entire course. The project is a collaboration between Professor Bower and the Columbia University Center for New Media Teaching and Learning (CCNMTL).

This study chronicles the discovery, design, development, implementation, and evaluation of this project over its four-year history from prototype to full-fledged semester-long integrated lecture and lab experience. The complete project history serves as a model for the development of best practices in contributing to the field of educational technology in higher education through the study of fully designed and implemented projects in real classrooms. Recommendations from the project focus on linking the laboratory and lecture portions of a course, the use of simulations (especially for novice students), instructor adaptation to the use of technology, general educational technology project development, and design research, among others. Findings from the study also emphasize the uniqueness of individual student's growth through the experience, and the depth of understanding that can be gained from embracing the complexity of studying sophisticated learning environments in real classrooms.

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...and the support of all my friends and family

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

> My experience is a text…but it is one that is being continually written. It is a text in the making. This endows it with an openness over and above even that of a completed text or historical epoch. The latter are, in a sense, definite and finished but open to an indefinite number of appropriate interpretations or appropriations. Experience, then, has the openness of being incomplete as well as that of being open to interpretation.
>
> Simpson 1995 p186n20

This dissertation is a series of intertwining texts. It is the story of a fictional town with a host of characters affected by a potentially contaminated land site known in environmental science as a *brownfield*. It is the story of an environmental science instructor committed to transforming his course who comes to see how technology and new media can extend and enhance his teaching practices and his students' learning experiences. It is the story of hundreds of students of environmental science struggling along with us, developing skills and understandings and reporting on their experience. It is the story of an ivy league university committed to pushing on the edge of innovation that puts its trust in a series of individuals committed to the purposeful use of technology in education. It is the story of a continually expanding group of educators and technologists who push on the limits of technology and learn through trial-by-fire how to plan, design, develop, implement, and evaluate their work…and it is the story of me as a student of the purposeful use of technology in education growing alongside this project for the last four years.

CHAPTER I

A Challenge Presented, A Larger Goal Envisioned

I had an amazing chemistry teacher at my suburban Oregon high school by the name of Michael Tinnesand. He looked like a stereotypical science teacher, with wild Einstein hair, crazy ties, and a stained lab coat. He taught me Advanced Chemistry as a sophomore and Biochemistry as a senior. His biggest contribution to my education was to get me to figure out what to do when I did not know what to do next. It was his firm belief that scientists were great at this skill and had to face up to the challenge of *not knowing* constantly. The way he did this was to assign a term-long science experiment, which required each student to carry out the complete scientific method on a topic of their own choosing. My project demonstrated strong evidence that the indoor air quality of many areas of my high school was below OSHA standards due to poor ventilation. A handful of teachers tried unsuccessfully to use the report to lobby the school district for changes to the ventilation system.

Jerome Bruner talks about teaching science using the same method the field of science uses to create new knowledge (Bruner 1996). He was inspired by Robert Karplus, a curriculum reformer from the 1960s and 1970s, who knew that "not knowing" (p.115) was not just a state of the mind of a student of science but also of scientists themselves. Producing science is a matter of creating as elegant and simple a story as one can to explain observable phenomena. In his words, "The process of science making is narrative. It consists of spinning hypotheses about nature, testing them, correcting the hypotheses, and getting one's head straight" (p.126). Most major scientific discoveries can be characterized as narratives of great problem solving. Good science teachers set up situations where students can *make science* by constructing narratives.

Unfortunately, typical university science courses that are required of all non-science undergraduates are often a mishmash of disjoined topics presented in large lecture halls with lab after lab of recipe-following instructions that bore students, leaving them listless, uninterested, and praying for the end of the term. Students often cannot relate to material, they learn little, and go about their lives seeing science as either beyond them or unimportant to their lives. As David

Perkins points out, science (among other subjects) has evolved a "trivial pursuit" educational philosophy, where accumulation of facts across a breadth of topics has become an accepted principle of a good education (Perkins 1992, p. 20).

For many years, Dr. Peter Bower has resisted teaching "trivial pursuit" environmental science at Barnard College. As the instructor responsible for the science credit of approximately 120 students each year (all women) who elect to enroll in Introduction to Environmental Science in lieu of introductory courses in biology, chemistry, or physics, Dr. Bower has pursued a method of teaching that is something other than typical. His basic tenet is that your education is what is left over after you have been out of school for six months. He realized early on in his teaching that in order to make a long-term impact on students, one had to invest a lot of energy conceiving and implementing courses in order to make them transformative experiences.

Dr. Bower's environmental science curriculum is founded on his conviction that environmental science issues are deeply connected to human activity, and that to understand environmental science, one must connect environmental issues to all aspects of social and political life. He is not a typical "scientist" who believes in isolating variables, working in a controlled laboratory setting, or focusing on discovering new principles of knowledge. He is interested in solving and ultimately preventing environmental problems through raising awareness and fostering the comprehensive education of his students. He talks to his advisees about taking full advantage of their college experience in New York City, and tries to get them to understand that college is not simply a collection of courses and grades. Among other jobs, he was a mayor of a small town in New Jersey for a time, so he brings a world of experience to the classroom.

Instinctively, Dr. Bower believed students would gain a better sense of the real-world connectedness of environmental issues through a combination of lectures, readings, problem sets, and what he hesitates to call game play. Dr. Bower and his lab instructors, Joe Liddicoat and Diane Dittrick, used a paper-based version of a "game" known as the Groundwater Project (GWP), which was played for six weeks in the lab portion of this introductory course. Students teamed up and competed to determine the location of several contamination events that occurred in a fictional town. Students filled out forms and instructors and teaching assistants looked up data in an elaborate file system in order to report back to students. Students had a cursory budget that they had to deduct from each round and worked for approximately six weeks on the project making maps and writing reports about their findings.

After a few years of this paper-based method, Dr. Bower saw an opportunity to use technology to expand the GWP into something much more complex. It was at this point that he sought out Dr. Frank Moretti at Teachers College's Institute for Learning Technologies. At this time, Dr. Moretti was in the planning stages of creating the Columbia Center for New Media Teaching and Learning (CCNMTL). Dr. Moretti encouraged Dr. Bower to apply for the Student Technology Assistant Program (STA) funded through Columbia University's Virtual Reading Room. In addition, Barnard College agreed to provide additional support through a portion of a NSF grant. Dr. Bower's STA application called for a student to help develop what he called a *database* of the contamination in the town, so he and his instructors could reduce the paper trail that slowed down students' progress and logistically kept him from making the GWP any more complex or challenging (see Appendix A for a copy of the application).

As a start-up venture of the university, the timing was perfect to take a fledging idea such as Dr. Bower's database and attempt something much more ambitious. That ambition evolved into four years of a project that came to be known as *Brownfield Action*.

Rather than focusing on the database Dr. Bower proposed, we at CCNMTL looked at what he said he was doing in his class and what his educational values might be based on his pedagogical choices. In essence, he had a paper-based simulation of an area with several groundwater contamination problems. The fact that he was using this type of a strategy was strong evidence that he was committed, at least in theory, to a discovery-oriented approach to learning. Since it was the spring term and the course where the GWP was used was taught in the fall, I did not have the opportunity to visit a class to see how the GWP was being implemented for myself, but in talking more with Dr. Bower about the possibilities of multimedia tools, he clearly communicated a desire to expand this large problem of a potentially contaminated land site into something more all-encompassing.

Dr. Bower wanted to eliminate the textbook from the course; it was exactly what you would expect in a traditional introductory environmental science textbook (Miller 2000). The book takes a superficial and compartmentalized approach that was antagonistic to Dr. Bower's goal of integrating disparate topics. Together we saw how a large problem of a land site that had to be investigated could drive all aspects of the course and become much more than a six-week exercise. This large-scale learning activity would give students a reason to internalize the lecture material throughout the semester because they would to have to apply the knowledge and skills gained throughout the course to one complex problem. Students would not be able to learn a topic, pass the exam on it, and then forget it. Instead, they would have to accumulate the knowledge and skills of the course over time and apply them when appropriate to their investigation.

Dr. Bower and I wanted to construct a situation whereby students had to create a narrative to explain a series of phenomena simulated in a virtual town. It would need to be a constructivist, discovery-oriented process with the students in charge of how they would proceed. Over the past few years, there have been innumerable studies on the use of multimedia technologies to foster constructivist learning or discovery-oriented approaches, many of which can be found in Brent Wilson's compilation *Constructivist Learning Environments: Case Studies in Instructional Design* (1996). While it is difficult to measure the conclusiveness or significance of improvement by students who use new media over more traditional media, it does seem clear that new media interventions in classrooms are more effective when they are used with more student-centered methods than with more traditional didactic approaches. Peter Honebein's "Seven Goals for the Design of Constructivist Learning Environments" outlines a set of instructional design principles. He then evaluates two projects based on those principles (Wilson). John B. Black and Robert O. McClintock, similarly, provide an "Interpretation Construction Approach to Constructivist Design," a seven-point system that they apply to three projects created under the Dalton Technology Plan (Wilson). John R. Savery and Thomas M. Duffy borrow from Barrows' model for case-study teaching and learning in order to create a set of principles for problem-based learning (Wilson). More specific to simulations, Margaret Gredler examines one approach for the design and evaluation of simulations in *Designing and Evaluating Games and Simulations: A Process Approach* (1993). Her work involves an interwoven three-part design of role, task, and environment, which I will modify later in this study.

It seemed clear that we could transform the GWP into a computer-based simulation and use the benefits of computer technology to expand the paper-based experience in many more aspects than just helping Dr. Bower and his lab instructors manage the logistics more easily. We could potentially create a much more authentic and transformative experience for students than Dr. Bower and his instructors could reasonably do on paper.

It is asserted here that new media, especially simulations, can be a means to better achieving John Dewey's principles of a good education. In his book *Experience and Education*, Dewey discusses the importance of schools and teachers creating authentic experiences for children that would prepare them for life as democratic citizens, something that has been so difficult to carry out at the same time education has attempted to provide equal opportunity for everyone. Universities have struggled to break free from the standard lecture-based transmission theory of education, the one-to-many approach of an expert orally transmitting knowledge to many novices. Even in laboratory settings the logistics of getting hundreds of students to complete a lab experience has made it all but impossible to create anything authentic for a student to do. The practicalities of equipment, space, time, and personnel heavily sway curricular choices to standardized, known procedures that can be stepped through in sequence.

Fortunately (or unfortunately, depending on how you look at things), life is not standardized. It does not come with known procedures for a fruitful existence engaged in lifelong learning. That can only come with training. Later in his book, Dewey talks about instructors needing to take a back seat to the work students are doing, to play the role of guide and to let the child's interest in the work provide the drive for them to complete the work and learn from the experience. Dewey was interested in determining how our country could create a nation of citizens who knew how to learn, which in his mind boiled down to how one transforms an *experience* into an *education*. It will be argued here that a simulation is one method to this end.

<u>What is a Learning Activity Grounded in a Simulation?</u>

Effective learning activities with simulations have several key components.

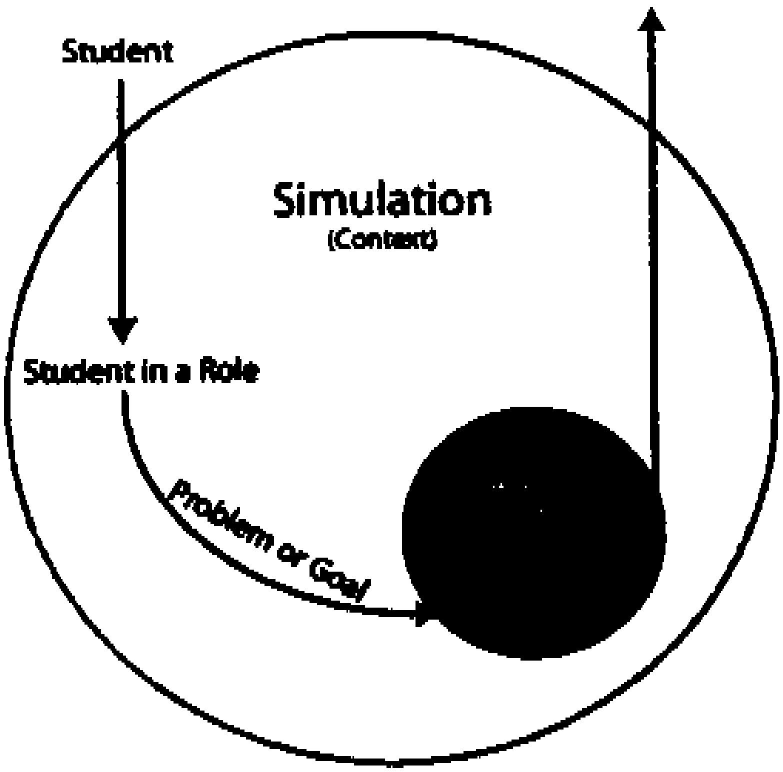

Figure 1. Schematic of an Educational Simulation.

As show in Figure 1, this type of learning activity puts the student in a role (often outside his or her area of expertise) with an objective to accomplish (often a problem to solve), and a place that provides the environment and context to solve the problem.

The place one is put in simplifies what is real for an educational purpose through the use of a simulator or model. A simulator represents a simplified version of the environment and can be accomplished through algorithms and/or datasets, generally run through a series of inputs that can be modified to create different outputs.

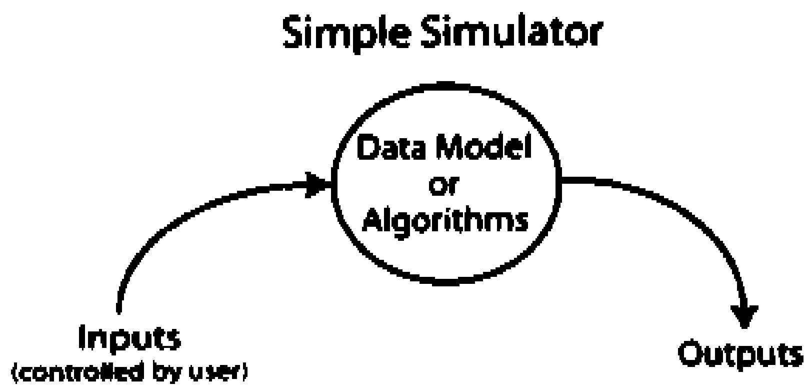

Figure 2. Simple Simulator Schematic.

Often the schematic shown in Figure 2 is called a simulation, but I would define these types of models using the term *simulator*. Simulators are perfectly reasonable teaching tools in their own right, and can be very effective, especially when one wants to become an expert in the system being modeled. One example is CCNMTL's Heart Simulator, which models the pressure-volume dynamics of the left ventricle of the heart for medical students. Instructors in the field of medicine at Columbia University believe it is critical that first-year medical students understand the simulator model as a precursor to trying to perform cardiac diagnoses. Students learn the model through manipulating parameters such as the heart rate, the strength of the muscle, and the resistance in the arteries. In addition, researchers can use simulators such as the Heart Simulator to make predictions and run experiments that are not possible due to the risks to patients or volunteers (see Chapter VII for more).

When using a *simulation*, on the other hand, the goal is often not to teach the model, but to use the model to have students gain problem solving skills and understandings by taking on a role and a problem (Figure 1). In this case, the simulator serves the purpose of providing a seemingly authentic and constructed data source. This type of simulator is more of a *black box* to be believed in for the purposes of the activity than something to be experimented with. The role and problem serve as a method to engage students in an experience, which they can hopefully transfer to their everyday experience with the world. In Dewey's language, the role and the problem serve as the tools to transfer the *experience* into an *education*.

Going back to the heart example, once students show competence with the simulator, then it might be appropriate to raise the experience one level of abstraction through the use of a simulation, which might place the student in the role of emergency room doctor at the local hospital where there are a series of patients that require a quick diagnosis.

In summary, when content expertise around a dynamic system is the goal, providing a simulator with minimal context first is often the recommended strategy. This technique would be followed by a simulation later on to allow students to apply their knowledge of the model or system within a narrative context. When more generalizable skills are the goal and one is not trying to train novices to become experts in the model being simulated, then a simulation with a seemingly authentic and constructed data source acting as the simulator is the more logical choice. Through the simulation's narrative context, students will gain access to the activity and be able to focus on problem solving and related skills.

Beyond the scope of delineating between simulators and simulations, writers such as Frederic Jameson and Jean Baudrillard make the case that we live in a world of simulation, where nearly everything we do is mediated such that we cannot tell if it what we are interacting with is real or simulated. Working with simulators and simulations, in this sense, is a real-world practical skill. Manuel Castells calls it the "culture of real virtuality" (1996, p. 329-330).

More importantly, The point with a simulation or a simulator is that the student must initiate the learning – they must take on the burden of asking the questions, taking a course of action, and evaluating what they discover in a continual cycle that models what Dewey sees as the actions of an educated person. The simulator/simulation does not instruct or direct action in any particular direction. It teaches indirectly, just as one's everyday experience does. If you go about your day not paying attention to what you experience, you learn nothing and will repeat your mistakes and not repeat your successes except for by chance. Simulators and simulations are no different, and thus make for potentially powerful tools for teaching and learning.

Summary of Simulator/Simulation Benefits

Benefits of Simulators
--active method for exploring systems when the user needs to become an expert in the system being modeled
--allows the user to make predictions and run experiments
--can practice potentially dangerous methods/maneuvers in a safe environment prior to having to execute them in reality
Benefits of Simulations
--active method for developing/practicing generalizable problem solving skills
--can explore problems by taking on roles that might not otherwise be accessible to a student group for education purposes, fosters divergent thinking, opportunity to see situations from new perspectives
--models purposeful learning or learning in the context of a structured experience for students with the hope that they will learn to approach problems they encounter in real life similarly
Benefits of Both Simulators and Simulations
--provides a practical knowledge application area where students can apply theoretical principles or general content knowledge in a tangible way and receive immediate feedback
--fosters cause/effect thinking as students interact with the model and observe how their actions change the output of the model
--requires the student to initiate the learning, develops lifelong learning abilities and curiosity
--prepares students for the postmodern "world of simulation"

Table 1. Simulator and Simulation Benefits

The recent literature is full of simulator and simulation examples used for teaching and learning in higher education, as well as research and even game play. Research is available on everything from a paper-based simulation called the Restaurant Game that promotes the learning of market forces and the complexity of starting up a small business venture (Brozik & Zapalaska 2000) to mock war crimes simulations and election campaigns in political science (Jefferson 1999; Kathlene & Baker 1999). The system of population dynamics is a popular simulated system as well. Artzrouni and Gouteux (2001) discuss a model of the spread of sleeping sickness in a population developed and used for research purposes, but that could easily be applied to an educational setting in public health or epidemiology. Even university financial management has been modeled more than once for both research and educational purposes (Barlas & Diker 2000; Virtual U).

Challenges of Using Simulations/Simulators

Using simulators and simulations are also not without their risks. First, they take enormous effort up front in the conceptualizing and designing of the environment before any testing can take place (as an example, see Chapter III for this study's initial development process).

Then there are a host of unanswered questions regarding their effectiveness. Several studies out of the University of Twente in The Netherlands outline the difficulties in assessing the impact of simulation use and the need for supplemental instructional tactics during the use of simulators (Swaak, J., van Joolingen, W. R., & de Jong, T. 1998; Swaak & de Jong 1998; De Jong, T., Martin, E., Zamarro, J., Esquembre, F., Swaak, J., & van Joolingen, W.R. 1999). Their findings point in two directions. One, knowledge gained from simulator use is very difficult to capture. Some call the knowledge tacit; others see it as implicit, intuitive, or simply nonverbal. Their studies have attempted to look at speed and efficiency of tasks between groups who've used a physics simulator versus groups who have not. Their results are mixed but suggest a possible significance in that simulator users who presumably have this more intuitive level of knowledge about a system (in this case collisions from a physics point-of-view) may be able to more quickly answer questions about the system. Their other major work compares groups who receive assignments to carry out using the same physics simulator to groups who experience the simulator as a system that increases in complexity over time to groups who experience the simulator with no guidance. Both model progression and assignments showed promise in increasing intuitive knowledge, but again, results were not definitive. In a sense, what this group of researchers is trying to test are different methods of applying the surrounding context to a simulator, which in my language is the process of transforming a simulator into a simulation.

Earlier related studies look at the role of background information given prior to a simulator's use and advice given during a user session (Leutner 1993). Their findings indicate that students who receive adaptive advice within the use of a simulator gain more content domain knowledge than those who do not. However they learn less about the functionality of the system being modeled than students who do not receive advice. In addition, students who can ask for and receive background knowledge and receive no adaptive advice perform better in delayed memory tests than those who receive adaptive advice. In sum, it appears that if you get advice as you move through a system, you will not learn the system as well, but you will perform better in short-term, more traditional content domain tests. If you don't get advice, but can ask questions, you will learn the system better and perform better in the long term, but you may not gain the short-term content domain knowledge. A study by Korfiatis et al. (1999) backs these findings up in showing that students in population ecology who used a simulator learn the population system but not much biology content. They recommend a combined traditional and simulator-based strategy for best results on both types of knowledge.

A study by Veenman and Elshout (1995) demonstrates that students with prior problem-solving and metacognitive abilities prefer "open" simulators with little support and structure and perform better without that support and structure, while students without those skills require a structured more "closed" simulator experience with much more guidance.

One further earlier study by Laurillard (1992) simply shows that computer simulators are only effective with the use of support systems. All too often she sees students gaining a surface-level understanding of what they experienced with a simulator only to miss out on the more intuitive systemic understanding of the model behind what they observed. She warns that students who do not receive support are likely to miss much of what might be gained from a simulation experience and lists the following conditions that will lead to a poor educational experience: lack of preparation, no value on students' work, lack of a goal, program complexity, tasks too structured, and too much time pressure.

From these studies we get more questions than answers. Most of these studies were attempts at controlled studies, and researchers got semi-significant results more often than not. Trying to study them in less controlled classroom setting is even more difficult. This difficulty is what CCNMTL faces with all its projects, no project more so than Brownfield Action. Another difference is that the tools used in these studies were primarily more along the lines of a simulator and less what I would define as a simulation. However, I would argue that the learning support strategies discussed in these studies all concern themselves with the context and surrounding material that turns a simulator into a simulation. Thus, what they are really talking about is how to turn a simulator into an effective simulation, one of the essential challenges in making Brownfield Action successful.

Questions

In all, we have a host of questions to address through this project:

- How does one design, build, and implement an effective large-scale simulation project in higher education?
- More specifically, how does one develop a simulation for non-science students about environmental science that will lead to the general educational goal of understanding the important role of environmental science in our contemporary world as well as promote content knowledge about a variety of environmental science concepts and generalizable problem solving and analytic skills?
- Even more specifically, how do we provide adequate learning support in the form of instructional materials and techniques for the simulator such that we create a valuable simulation experience?
- Then ultimately, how does one measure whether we've accomplished the above goals in the context of a real classroom and laboratory environment with innumerable variables that cannot be controlled for?

Teacher Adaptation to Technology

As has been pointed out in studies by Mandinach and Cline (1994) and Sandholtz, Ringstaff, and Dwyer (1997), instructors have to travel through stages of development in the use of technology in the classroom that demands facilitation instead of authority. With Brownfield Action, it would be no different, so these two works are important referents.

Design/Development Approach Evolution

As I stated earlier, since Brownfield Action was a project out of CCNMTL, I did not have the luxury of studying this project in a controlled setting. It was to be used for several years in a real college-level environmental science course.

The closest work to the experience of the Brownfield Action design and development process is found in Goodrum, Dorsey, and Schwen's (1993) work on defining and designing Enriched Learning and Information Environments (ELIEs). In this paper, they describe how their experience with designing educational environments led them away from entirely technology-based and theory-based definitions and more towards what they define as a socio-technical definition that focuses on the people involved and the specific work they are asked to perform. They perceive that the latest learning theory and the latest technology does not necessarily lead to innovation. Instead they claim that all innovations are situated within a context of people trying to accomplish work in a particular environment, and a well-designed teaching and learning tool should support that work. They go on to describe their design work as a series of relationship building sessions with users, rapid prototyping with mock-ups and a focus on the tasks that users needed to perform.

While CCNMTL did not begin with a particular research model in place for its work, four years into its existence it is beginning to shape a method based on the field of Design Research. The centerpieces from the literature for this study of Brownfield Action are two articles on Design Research, one by Daniel Edelson (2002), the other by Jan van den Akker (1999) (although the term "design research" or "design experiments" has its roots in work by Allan Collins (1992) and Ann Brown (1992). In the Edelson article, he describes a current trend in educational research towards design. In a traditional research approach one develops a theory, designs something using the theory, and tests the theory. However, a group of researchers has put a twist on this process, pointing out that design can inform theory development. Using this process, researchers start with a set of tentative hypotheses and principles to begin the design process, but theory development is revisited many times in an iterative loop of design, implementation, and theory development. The goal is to describe and continue to refine the theory (Edelson calls it a domain theory) over time and generalize it, so it can be applied in other contexts. Edelson points out that Design Research can also yield design frameworks, generalizable solutions to given sets of educational challenges, such as goal-based scenarios or anchored instruction. Van den Akker calls these frameworks *substantive design principles*. Another outcome of design research is design methodology, principles towards achieving design frameworks. Van den Akker calls these principles *procedural design principles*.

Edelson's process is keyed on design decisions. Each decision in the design process is potential fodder for a researchable hypothesis. A good hypothesis ties a design decision to a desired outcome. When the design is put in practice, the focus shifts to being brutally honest about what works and what doesn't by identifying failures that can be tied back to the design decision in order to revise the hypothesis. The burden of evidence to convince someone that something does not work in one's design is low. It is much easier to convince someone that something you designed failed than to convince someone that it worked. The challenge is to tie the identified failure to the key design decision and to make the appropriate adjustment to the hypothesis.

Continual work on Brownfield Action, in fact, contributed to the identification of Design Research as a possible good approach for CCNMTL. In a way, without knowing it, we were performing some aspects of Design Research intuitively. One might call it Design Research Not by Design. Through the close examination of the four-year design and development process of Brownfield Action, I will show how this project contributed to the development of CCNMTL's action-oriented method of evaluating its work. This method can represented by some form of Design Research as it matches well with our goals of developing and studying projects in the context of real classrooms with real university students. Through this study, I hope to show how Design Research can serve as a model for a new media center's development of its own research and development practices.

CHAPTER II

Year 1: Getting Off the Ground

Approach to the Problem

CCNMTL formally opened its doors in March of 1999. I was a part-time employee and Master's candidate in Communication and Education. When Dr. Bower's STA proposal was accepted shortly thereafter, I was entrusted with managing the project over the summer to see what we could make of his idea. I immediately started drawing visual maps and flowcharts of what the student experience might be like if we were to try to build a complete learning environment for the study of a contaminated land site in a fictional town. Figure 3 is a facsimile of one of those initial charts.

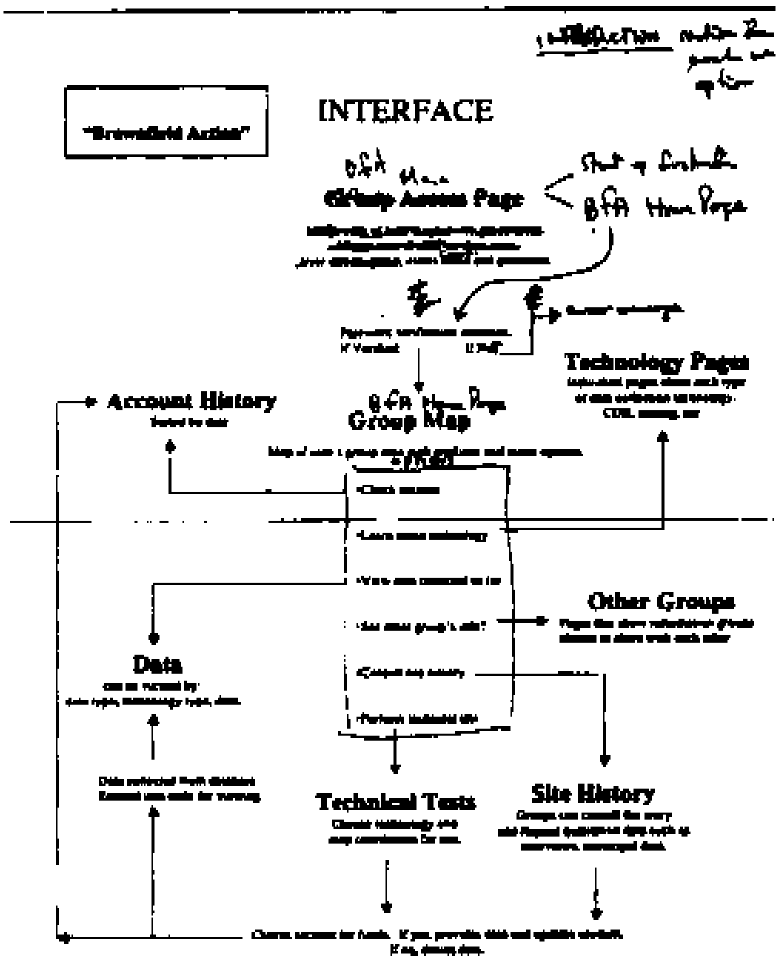

Figure 3. Initial Brownfield Action Flowchart.

We were working from the premise that the goal of what we would build would be the same as what he was doing in his course currently, but that we would try to broaden the capabilities of the students and increase the complexity of the problem. From this mapping came some general concepts of the components that an environmental contamination simulation would require:

Data

We needed to find or construct one or more plumes, three-dimensional balloon-shaped structures representing the underground contamination that students would try to find and then explore. This data would serve as the hard science portion of the simulator. Dr. Bower's GWP had two-dimensional data. We had to expand that to three-dimensions.

Tools for Collecting Data

Students would need a set of tools for describing the area in scientific terms and for locating and "mining" the plumes to determine their location, size, shape, and type. These tools would constitute the method of making requests into the model and extracting scientific data.

Story

Because we wanted to emphasize the connectedness of the plume to human activity, we needed a story, or at least a baseline plot sequence that established causality for the plume and consequences for its continued presence. The students would need a role in this story to serve as the motivating factor for their work collecting the data.

Map

In order to maintain orientation, the simulation would require a map. This map could be provided for students or they could be given the tools to construct a map of the land where the data resided.

Budget

To provide an authentic experience, we need to place constraints on students' actions. Ultimately, money is the limiting factor in a real environmental investigation, so we needed to devise a budget system that would impose some limits on the actions students could carry out. Our hypothesis was that this would foster debate among students about how to proceed with their investigation and lead to them to think about their decisions before acting.

Reference

Since students would be entering this simulation with no prior knowledge, we needed to provide access to reference material that would support their activity. A library of relevant resources would allow students to refer to information as needed and would be driven by their *need-to-know* as opposed to force-feeding it prior to them taking actions.

Approval System

In the paper-based method of the GWP, there was an implicit monitoring process that took place as students made requests and received responses since the instructors filtered all student actions. We believed a larger simulation would require a similar monitoring system. It would allow instructors to monitor student progress and possibly approve or deny student requests or to make adjustments to student accounts.

This list of base elements constituted the basic initial design framework for the first version of Brownfield Action. It would be altered dramatically over the years, but it served as our starting point.

Development

At the time this development process began, CCNMTL did not have a prescribed development cycle or path, set staff for its projects, or a standard method of documentation. The Center also did not have an example of how to build a project of this size and scope. It was April

1999. The class was set to start in September, leaving us approximately four months to do whatever we could get done.

The simulation elements listed in the previous section are a ranked sequence based on importance and difficulty. Dr. Bower agreed we needed to start with the most difficult portion of the development first. That meant the first "nut to crack" was the data model. Without the data model, there was no project and all the other elements would be useless.

Model Development

The objective of the model construction was to come up with a method for providing students with a land area where they could collect data anywhere on the site at as small a distance interval as possible. This model needed to have data in it where every spot was a three-dimensional point in space with values that represented everything that a student could detect at that location.

As Dr. Bower proposed, this seemed at first glance like a fairly straightforward database problem. However, the main platform that CCNMTL had experience in for delivering a simulation or game-like learning environment was Macromedia's Director software. While some groups had developed ways for attaching a database to a Director application, none of us were confident that we could implement this type of solution. In addition, we were concerned that database queries would have a considerable time lag that would be a significant detriment to the students completing the task.

We explored other options. I spent several weeks teaching myself a variety of geological modeling programs to see if we could generate the data we needed in another form and translate it into something Director could handle more easily than a database. David Van Esselstyn and I had several conversations about how this might work. We knew that Director was designed to handle graphics very consistently and that if we could make the data visual in some way, we might be able to avoid using a traditional database solution.

Dr. Bower showed me how environmental scientists typically make contour maps to depict their findings in these types of investigations. I started using Surfer, a geological modeling program that could generate two-dimensional maps, wondering if Director could some how read a map instead of a database. Surfer uses interpolation to generate a given map. To make a map, I would enter in a basic set of approximately 100 data points provided for me by Dr. Bower, and it would estimate the rest of the map for me at whatever detail level I requested. I played with various formatting options for these maps, showing them to David, who had the Director experience, to see if it would spark an idea in his head about how to read them with Director.

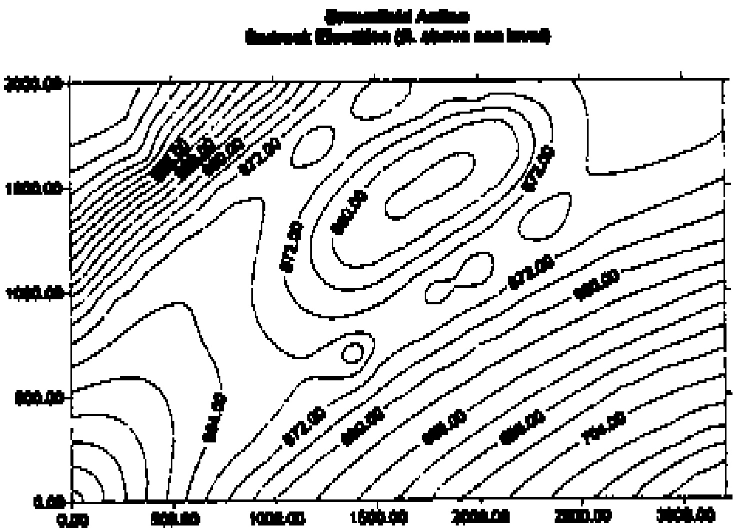

Figure 4. Bedrock Map from Brownfield Action

Through some online hunting through Macromedia support groups, David found the elegant solution we needed. An undocumented command in Lingo, the language Director programmers use to make applications, known as GetPixel, allowed one to take a graphical object, locate a specific pixel in that object, and determine the color of that pixel. These colors could be assigned a key that associated a particular color with a particular value, and this operation was nearly instantaneous. GetPixel was our answer. By making very precise colorized contour maps of all the data required in the model, I could construct a working dataset that Director could interpret and display nearly instantaneously.

Our constraints were the number of pixel colors available. This meant that for each contour map, the range of acceptable values could not exceed 256. This served as the base for the decision about how big the land area could be, what the distance interval between data locations would be, and how many significant figures a particular data type could have.

The land site was to be 3200 feet by 2000 feet. We thought it was reasonable for a student to be able to take a data sample at ten-foot intervals across and down the map in two-dimensional space. This led us to create a grid map with 64,000 points on it (320 along the x-axis by 200 along the y-axis). We also decided that it was reasonable for a student to also be able to drill down into the ground at ten-foot intervals until they hit rock. Using Surfer, Dr. Bower and I generated a fictional bedrock layer that at its lowest point was approximately 150 feet from the surface (Figure 4). This meant that for any object with three-dimensions under the surface we needed up to fifteen layers, or cuts, through it that could be reported to students. We also generated a surface elevation map, and a water table map. Figure 5 gives a sense of how all the layers are arranged under the base map.

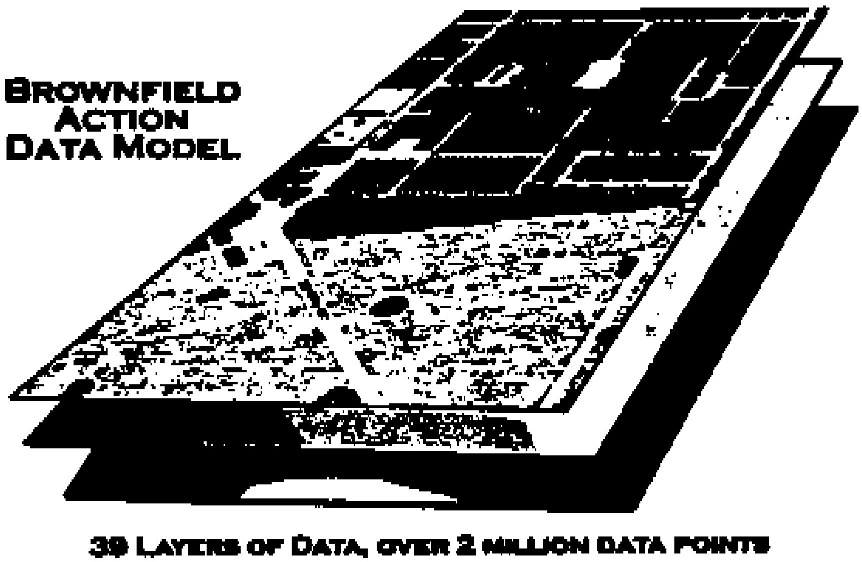

Figure 5. Model showing the data layers underneath the aerial map (map is from Brownfield Action 2.0).

For each of these maps, we had a range of 256 values that could be assigned. The surface elevation varied from approximately 845 feet down to around 800 feet. We could generate tenths of feet because that would have been up to 450 values, but we could do better than just report nearest foot, so we generated data to the nearest half-foot. The water table was relatively flat, so we could report it to the nearest .05 of a foot. Bedrock was reported to the nearest foot because it had the most range. For each type of data a student could collect, we needed 64,000 data points, so I created a colorized contour map of 64,000 pixels for every data type in two-dimensions.

The more difficult maps to create were the cuts through the three-dimensional plumes because they were difficult to lay on top of one another to make sure they lined up properly. I eventually found a method where I would export all 64,000 values from each Surfer map to an Excel sheet. Then using a program called Tecplot, I could load multiple excel sheets at one time and view multiple layers simultaneously in a three-dimensional model that Tecplot would construct for me.

This method allowed us to view all of the contour map data present in the model, everything from the various elevation data to the plumes as well as the soil type.

Dr. Bower also needed to include human-made objects that would be discovered during this type of testing; everything from pipes to underground tanks, septic systems, and landfills. We could not model these objects using Surfer and Tecplot, so we had to find another method. Our solution was to trick the system we created into thinking it was looking at a contour map. For every human-made object, I created a color-map from scratch that when checked, instead of reporting a number value, would report a text message describing what was at that location. By July we had a draft of a full dataset.

It is important to emphasize the highly detailed explanation of the process of the model creation. This explicit description serves as an example of the inventiveness and imagination required to accommodate the challenge of participating in the field of simulation use at the highest level. Good teachers are on-the-fly inventors in the classroom. They create analogies and new methods for approaching problems everyday. As educational designers with technology, we must do the same. The development of the model was true creative design and research in action.

Tools for Data Collecting

Dr. Bower was able to identify tools used in the field for us that we could assign to particular data types. We simplified and combined tools into the set shown in Table 2 below.

TESTING TOOL	REPORTS
Surface Topography	surface elevation of one point
Ground Penetrating Radar	text description of human-made objects along a transect
Magnetometry/Metal Detection	text description of metal objects along a transect
Soil Gas/Soil Analysis	gasoline amount in soil, one given depth
DMF Probe	contamination amount at ten points down 100' also reports water table
DMF Drill	contamination amount at 2 points at any depth also reports water table
Seismic Reflection/Refraction	bedrock elevations along a transect

Table 2. Testing Tools available in first version of Brownfield Action

As shown in Table 2, Surface Topography would mimic setting up a tripod surveyor and taking elevation points. Ground Penetrating Radar would detect any objects under the ground placed by humans. Magnetometry/Metal Detection would sense metal objects under the surface. Soil Gas/Soil Analysis would test soil for the presence of gasoline. The Probe would allow for the collection of water samples every ten feet for one-hundred feet. The Drill would allow deeper collection of water samples at two depths and also report the elevation of the water table. Seismic Reflection/Refraction would report the elevation of the bedrock layer underground. Because we were not interested in having the students become experts in the equipment itself, we decided early on that the use of a tool would constitute the operation of the equipment, the collection of the data or sample, and the analysis of the sample. The decision to use the test and where to test was where we wanted the focus to be.

We then assigned these tools to their appropriate data maps in the application so that the use of a particular tool would only report the data that a selected tool would be able to detect.

The Story

By the time we had the dataset in good working order, there was not much time left for story development in this first year, so we proceeded knowing that in subsequent years we would devote much more time to this component. We decided the setup to the story would be essential to getting started, so we focused all our energy into what the students would receive at the outset of the simulation. Dr. Bower drew up a contract that the students would sign that constituted the assignment given to the students. This agreement stipulated that he was a real estate developer hiring every pair of students (representing a site investigation company) to separately and competitively investigate a land site he was interested in developing in the fictional township of Moraine. This contract outlined that the students would agree to provide a Phase One Site Assessment, which constitutes a comprehensive description of the site and surrounding area, details on any problems discovered including the presence, extent, and cause of any contamination, a recommendation about whether or not to purchase the site, a series of maps as evidence, and a budget summary of expenses (see Appendix B for contract draft). Once this was complete, student companies would proceed together with a more detailed Phase Two investigation pending the time remaining in the semester. The Phase Two investigation is when invasive testing involving excavating and drilling come into play.

The contract essentially spelled out the roles for the students, the problem to be solved, and the ground rules for accomplishing the objective successfully. The initial challenge for students would be for them to read through the legal language that the contract contained and interpret the assignment. We would also use the contract as the account creation procedure where students created a login name and password for continuing their work from week to week. These accounts would be stored locally on one machine, so each week students would have to use the same machine in order to continue.

To spell out the context of the problem to be solved prior to the contract, Dr. Bower and I developed a video interview of Dr. Bower playing the role of the real estate developer discussing his plans to replace an abandoned factory site with a mall (Figure 6). In the interview, he describes how this mall will help the economy of the township by bringing in jobs and tax dollars from people who come to shop there. The one item holding up his purchase is his concern that the factory or its staff may have intentionally or unintentionally contaminated the site, and he does not want to be responsible for the clean-up, as current government regulations require of new land owners.

Figure 6. Screenshot from the Introductory Video of Dr. Peter Bower playing the role of a Real Estate Developer

Finally, because we were concerned about students having a starting point for exploring the site and surrounding area after agreeing to the contract, we developed a tour of the township that we named the Visual Reconnaissance. In actual investigations, this is a common initial step that investigators take to get oriented to the area to be studied. Rather than having students develop their own reconnaissance, we provided a written text of a tour that we would indicate was performed by a fictional staff member in their company (see Appendix C for initial version). This served as further context for the story and orientation to the problem to be solved.

The contract, video, and Visual Reconnaissance, constituted all the story elements the students would receive at the beginning of the simulation. Beyond that, we were out of time to develop more story material that could be given out over the course of the investigation, so the only other step we could take was to create open functionality for adding more story later. This was done by creating a list of the businesses and residences in the town and giving students the opportunity to visit these locations and ask questions of the virtual people who lived and worked at these locations. These questions would be sent via email to an instructor bulletin board where Dr. Bower and his instructors could respond to students (also via email) playing the role of the people in the town. We planned to use the questions and answers generated on the fly over the semester as a base for creating a more elaborate story the following year. The bulletin board would serve as an archive of the student questions and the instructor responses.

The Maps

Dr. Bower spent several days generating a hand drawn map of a portion of the township where the factory site was located along with the surrounding businesses and residences. We hired a technical drawer who quickly made a blueprint-like drawing of the town for students to see where they were at all times (Figure 7).

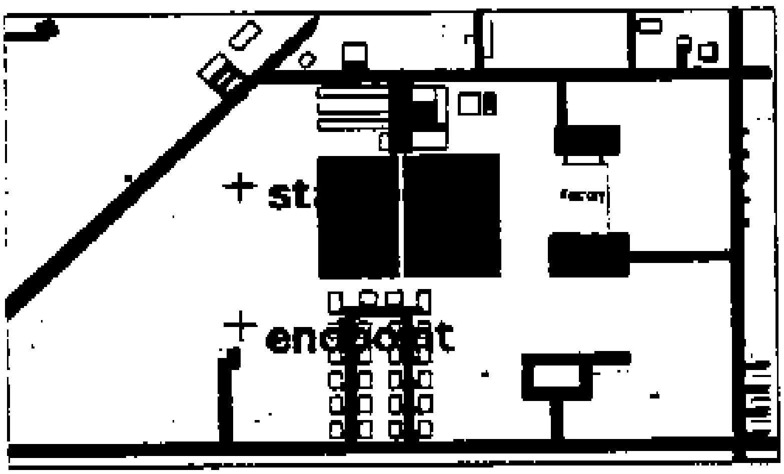

Figure 7. Map from first version. Yellow indicates dirt roads. Black indicates pavement. Buildings are outlined white boxes.

Students were going to be required to generate their own version of this map (referred to as the base map), and then layer translucent sheets of paper with the various data they collected throughout the project.

Budget

In order to prevent students from using a trial-and-error method for working through the assignment in the simulation, we instituted a cost structure for every action a company could take. Students would be allotted $45,000 to begin their investigation and would receive an additional $15,000 upon successful completion of the initial investigation as stipulated by the contract (in later years we raised the initial budget amount to $60,000). Testing tools that were minimally invasive and provided minimal data were cheaper than complex drilling tests that are typically very expensive out in the field. Rewards were built into the cost structure for students who planned out a complete test using one tool and did not have to go back to it later. This was meant to simulate the renting of equipment and pay for operators that typically takes place with real investigations. Again, we were trying to emphasize planning and decision-making with this design choice.

We created an account portion of the application where students could see a running list of every action they had taken and how much money was remaining in their budget. We believed this could be a valuable method for evaluating their decisions as an instructor could look at each company's account and see the sequence of choices each team employed.

Reference

We could safely assume that students would come into the course with no idea how one of these investigations was to be performed, let alone how the detailed testing procedures worked. The novel, *A Civil Action* (Harr 1995), was added to the curriculum and served as a model of an investigation, but it did not detail the testing procedures we created for the simulation. We used Richard Nussbaum, the student technology assistant assigned to us from

Dr. Bower's original proposal, to research and write-up reference material on the tests that we would provide students. This material was programmed into the application in this initial version.

Dr. Bower wanted to implement a quiz within the simulation for each testing tool to ensure students studied the procedures, but we had to postpone that work due to time constraints. Joe and Diane did these quizzes on paper with the students during the semester.

As it stood when it was time for students to begin, we went ahead with implementation with a fairly minimal amount of reference material, hoping we could guide students along when it got to the point where they needed to understand the tests.

Approval

Our hopes for an approval system that would allow Dr. Bower and his instructors to monitor student progress was not feasible the first year. Instead, at the last possible moment, literally the day we installed the application in the lab, just days prior to first use, we decided to write a command in the application that would automatically export all the student company data (the money they spent, the data they had collected, their names and passwords) into a hidden file on the hard drive that we could look at for monitoring purposes and modify if any errors arose. This proved essential for the implementation phase of the project as we ran into numerous instances where we had to make corrections to student accounts.

Interface

We spent considerably less time developing a usable interface than we would have liked, but David Miele was able to create a simple, straightforward look and feel for the application with menus and tabs based on a specification I did (Figures 8-11). I developed a very quick user manual to be distributed to students to help them work through all the controls, and we hoped for the best. We knew this area was going to need improvement before we ever had a student try to use it.

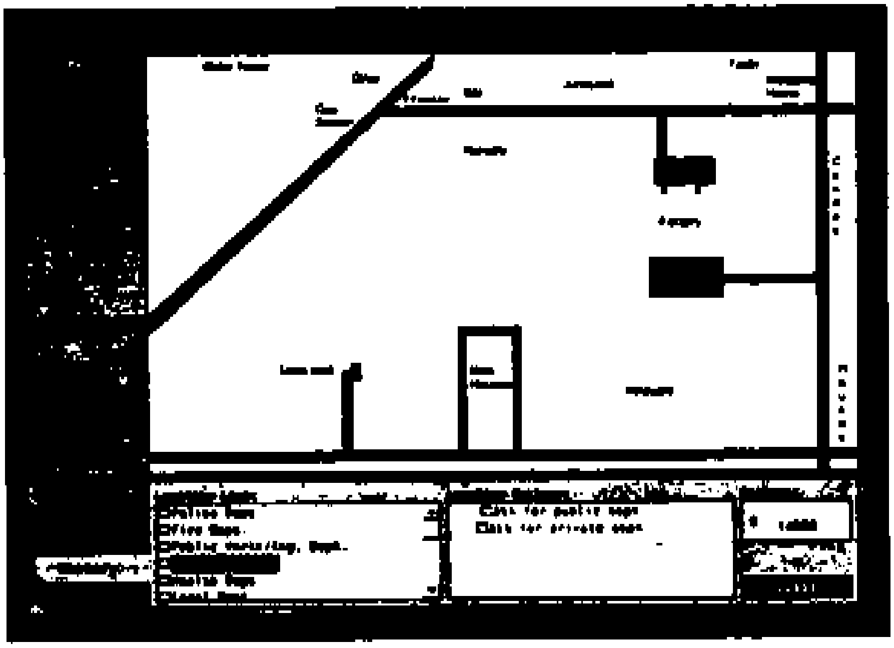

Figure 8. The History section of the interface.

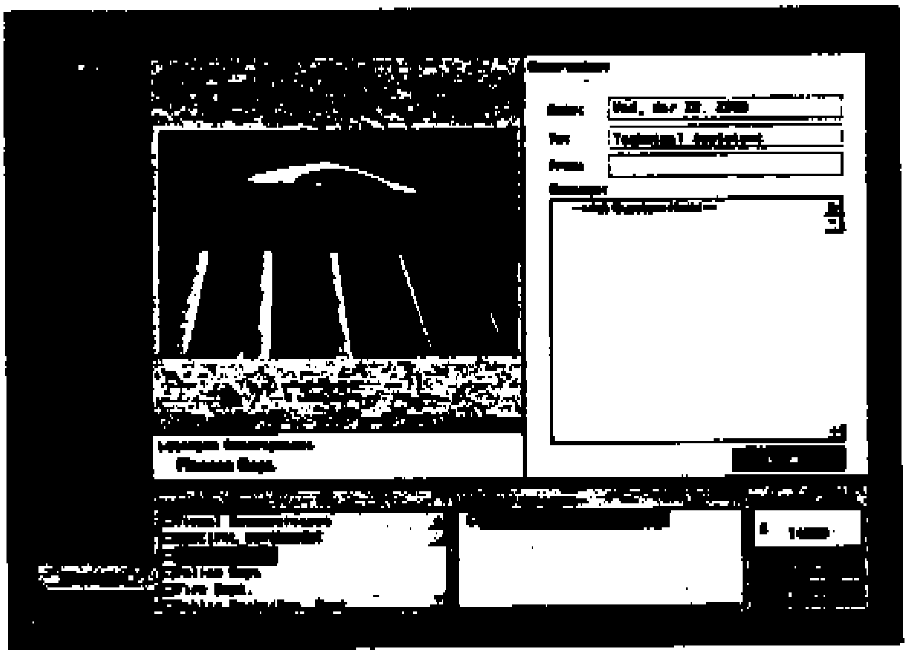

Figure 9. On a visit to the Finance Dept. in the history interface.

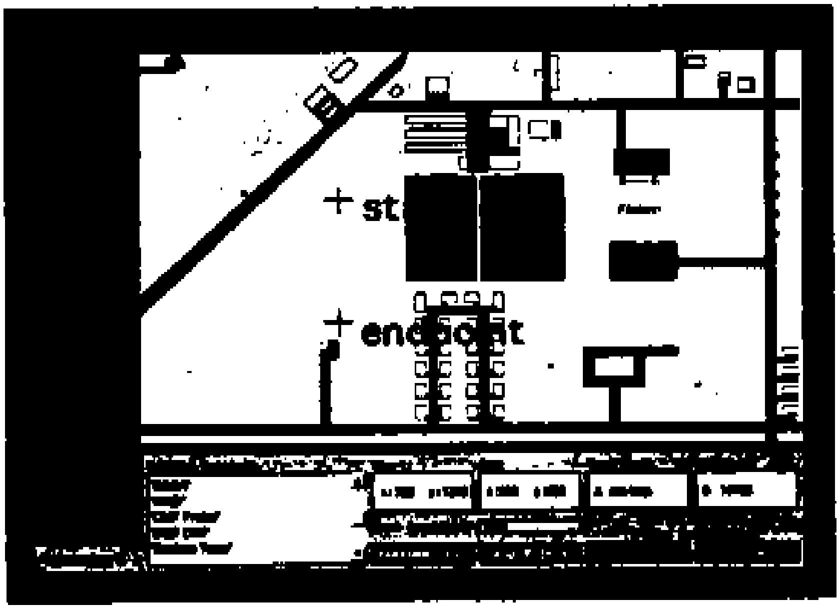

Figure 10. Testing portion of the first interface.

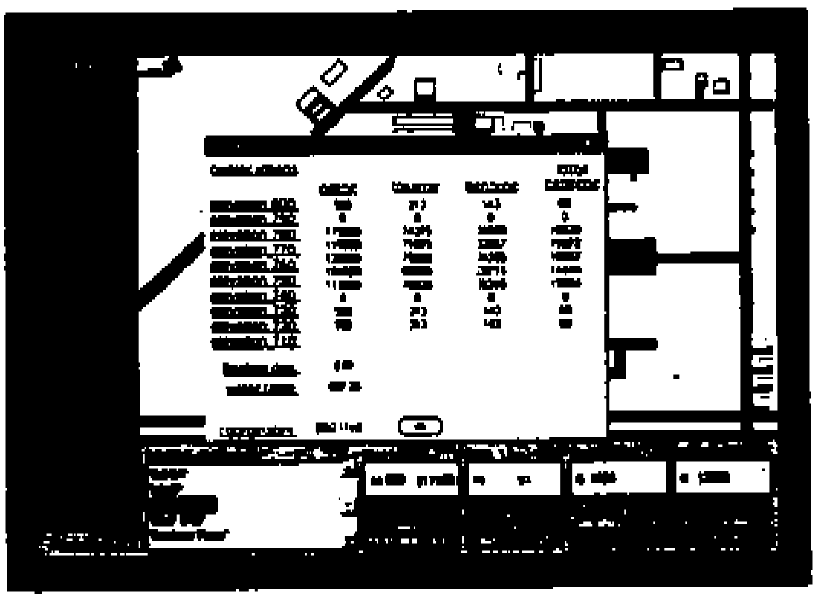

Figure 11. Test data from a Probe test.

Reflecting on the Design

The most common question that arose when we first described the data model to colleagues and other faculty members was, "Why didn't you use *real* data from a *real* site?" We considered this possibility, but deliberately chose constructed data verified with experts as realistic for several reasons. Real sites where real investigations occur do not have the granularity of data organized the way we needed it to provide for students. Even if we started with real data, we still would have had to do a significant amount of guesswork to construct the model into something novice students could work with. Then there is the undeniable fact that all real sites have the noise of irregularities and inconsistencies that would have undermined our pedagogical strategy.

This problem comes up in any discipline where case studies are used, especially in the medical field. For medical students, it is very important to be faced with those irregularities, since they are training to become doctors who will live in that world of irregularity. Because we are dealing with introductory students who are not training to become environmental investigators, we wanted to avoid irregularities that could not be explained. We felt better about tweaking values in a made-up set more than having to justify changes to a real dataset.

As long as the dataset was realistic, we could make the teaching points we wanted to make and students could discover the data and infer its causes to a satisfactory level. If we were dealing with more sophisticated students or people training to be professionals in the field, we would have made a different choice, but given our audience, *realistic* data seemed more appropriate than *real* data.

The value of real data is its authenticity; the knowledge that what is being studied is something that actually occurs in the real world gives meaning to the work being done.
We also knew that down the line that it would be very difficult to model a real story of a town authentically – how could we be true to all the events that took place – again we would be guessing and inventing and probably do a disservice to the actual people involved in what really occurred. The students were already reading *A Civil Action*, which gave them a story that is real, and provides that sense of authenticity to this kind of work. Having them transfer the real story to a model story in Brownfield Action seemed to make sense intuitively. Another factor we had minor concerns about was that if we used a real site, students could who could find information about the real site would have a significant advantage.

Training/Implementation

It was unfortunate due to time constraints that we could not devote more than a couple days to training the lab instructors on the use of the simulation before they were put in the position of trying to get through it with student labs every week. Each week there were eight labs with approximately sixteen students in each lab. Labs were scheduled for three hours. Brownfield Action was meant to take up approximately six to seven weeks of the lab experience.

As soon as we had a partially working version of the complete system, I installed it on laptops (that CCNMTL rented for the semester because there was no budget to purchase machines at that point) for Diane and Joe to try out. Dr. Bower was coordinating the lecture activity and made a point of not interacting with the labs for fear of Diane and Joe losing authority and because of his own time limitations (he teaches several other courses).

It should not have come as a surprise that Joe and Diane did not have general technical savviness when it came to using computers. They are long-time teachers with a lot of experience. While they were proficient at typing simple word processor documents and using email, the use of a simulation application on a Macintosh laptop proved to be a substantial challenge for them. Ideally we would have spent at least two weeks going through the complete use of the simulation and what the students would be doing week by week. Because we were short on time, I chose to walk them through its use very didactically just enough to get them through enough steps to survive week-by-week. Not surprisingly, they used my instructional approach with them as a model for how to get the students through the tasks of the simulation. This had many negative ramifications that came out in the evaluation.

Evaluation

At the time Brownfield Action was ready to launch in early October 1999, CCNMTL had not hired a staff member to lead the evaluation of its work. I had no experience in evaluation beyond what I had read in theory classes in the Master's program at Teacher's College, but I proceeded as best I could.

I developed a pre-survey for students to fill out at the start of the semester to help us gain a picture of what their experience and interests were coming into college and this course. Students were generally very bright, with high SAT scores and solid high school GPAs. They ranged across all four years of undergraduate work. Students ranged from first-years with no declared major to seniors putting off their science requirement as long as possible.

During the semester, I spent a lot of time in the lab troubleshooting technical problems, and each week Dr. Bower, Joe, Diane, and I would debrief on what had happened in each lab and what to expect in the coming week. We essentially battled our way through problems as they arose and made the best of what we had completed. My evaluation as we were working through the simulation boiled down to my observations of each lab and conversations with individual students as they hit obstacles. In a way, I was an additional instructor in the lab on an as-needed basis.

It is interesting to note that even this early on, my instinct was to proceed using a very active, nimble method of modifying the curriculum with respect to the technology. We would alter the curriculum each week based on our observations and the students' work very much as a design researcher might, even though at that point, none of had heard of Design Research and the Edelson article was three years away from being written. The van den Akker chapter was published that year in *Principles and Method of Developmental Research*, but we were not aware of it.

Then as the semester progressed, an evaluation manager came on, Robert Highsmith (Bob), who worked with me, and a student assistant, Portia Rivera, to design and run a series of student focus groups and interviews with Joe, Diane, and Dr. Bower towards the end of the semester to see how the program ended up working in a fairly summative manner. This concept of evaluation led us away from the active approach I had begun.

Bob indicates in his report that the project was by-and-large a success in that it demonstrated how a simulation had the potential to transform a course (Highsmith 2000). Students produced well-written reports that in Bob's opinion met or exceeded student performance on similar tasks in the course in previous years. In comparing the reports students wrote this year versus reports produced for the Groundwater Project, he saw more mastery of the subject matter and analysis in the Brownfield reports. Even though GWP reports were longer, and students from that year had a chance to write drafts, get feedback, and make revisions, in Bob's estimation they focused on describing the lab activities and less on constructing an analysis of the contamination problem. In his opinion, the Brownfield Action reports were more authentic and demonstrated more clearly that students had learned from the experience.

Bob's initial hypothesis about why student reports were better in Brownfield Action than in the earlier GWP focuses on the precision and depth of content available in Brownfield Action. In short, students in Brownfield Action had more to write about. Then, he goes on to say that Brownfield Action provided a means for students to collect data and develop their own hypotheses about the events that took place in Brownfield Action. He infers that the Groundwater Project did not provide this type of opportunity as it was less authentic and less rich of a simulation. Brownfield Action also provided a learning environment that integrated all the components of an investigation, so it is not surprising that students who experienced that integration would reflect it in their reports.

Bob's opportunities for further success focused on outlining clear objectives for the course and the project, so that we would have a baseline with which to measure against in future studies. He also recommended making these goals explicit to the students in the orientation to the project to help get them off on the right foot.

Bob picked up on the need for better lab instructor training to help them understand the goals of the project and the full features of the simulation that were available for students. He pointed out that many students got frustrated with the delay in responses to questions to characters in Brownfield Action sent over email. The delay made it very difficult to proceed with the historical side of the investigation.

Finally, Bob recommended that we add functionality to allow students be able to access Brownfield Action outside the lab on Windows and Macintosh operating systems, so they would not be restricted to in-lab use on a set computer.

In sum, there were many kinks to be worked out in the next year and several additions to the project that we wanted to include in a second version, but we had a foot in the door to something very powerful.

Reflecting on the Evaluation

Looking back on this first year, there were many mistakes that we needed to learn from at all levels of the project. Our lack of attention to instructor training was one of the biggest mistakes of all. We spent so much energy in the building of the product that we left no time for getting the users and trainers of users to a point where whatever we made could be used effectively. I compounded the mistake by training the instructors using the exact wrong model of instruction.

Also, we never looked at Dr. Bower's lectures. We did not talk about how it would affect the lab portion of the course and how he would have to change to accommodate this new activity. In fact he did his lectures almost exactly as he had done them the year prior, with no real mention of Brownfield Action. This was confusing for the students as they were not sure how much of a priority to make the project since he rarely mentioned it in lecture.

Bob Highsmith was the first Manager of Evaluation at CCNMTL. Bob's evaluation of the project was the Center's first foray into evaluation. Because he knew it would be made available to the public, he struggled to write it in a way that would be both useful to the design team and serve the political interests of Center. Obviously, if he and the Center had understood the Design Research process at this point, we could have served both. In truth, I used more of what I saw with my own eyes week-by-week to determine what we should do the following year more than the evaluation report. I had already concluded most everything included in the report and more before the semester had ended.

Still, CCNMTL had not matured to a point where we had a deliberate methodology for how to evaluate projects so the information drawn out would give an accurate portrayal of what occurred and be helpful for future designs. This first run of Brownfield Action was one of the first real test of the limits of what we knew how to accomplish, and we needed to show improvement the following year. We had to shift from a mindset that focused on evaluating what we built to one where we understood that we must look at the entire surround of a course and the product we built together as one project.

My primary concern during this first evaluation was to get feedback from the students on the technical functioning of the application we developed and what was needed to get them to be self-sufficient using it. Students' primary feedback was focused on their desire to use it outside of class so they would be less rushed and less constrained week-by-week in what they could do. Many of the students understood implicitly that this was supposed to be a discovery-oriented exercise, but because the instructors were not confident in the technology, they (we) constrained student activity so much that we made discovery a moot point since all the students were essentially acting in unison. Students also wanted better guidance from instructors. They picked up very quickly that the instructors did not know much about the larger goals or design of the project. This was not the lab instructors' fault. We did not involve Joe and Diane in the creation process and did not leave enough time for training except by the most didactic of methods. Students also did not benefit from the historical portion of the simulation where they could pose questions via email because there was too much of a delay in getting responses back. Our plan to archive the questions and answers did not really work because Dr. Bower got so bogged down in responding to the same questions over and over. He was always running behind. Students also complained about the tediousness of much of the work, especially the creation of the maps, which required nearly half the semester to complete. They felt they did not learn much from doing that much grunt work and recommended we provide some kind of base template for the next year.

Some of Bob's unpublished recorded comments that he summarized for me from his student focus groups give some real insight into what was going on in the lab the first year, both positive and negative (Highsmith 2000).

Regarding the simulation (p. 2):

- "It's real. It's rare that most of us do anything with a real component."

- "The Brownfield Action technology is impressive."
- "The simulation is well done."
- "It captures reality."

Compare those positive comments with the comments about the actual computers used in the lab (p.4):

- "We need better computers – the touch-pads don't work; they stink."
- The computer screens were hard to read. The screen was so light you couldn't find the mouse. It's hard to manipulate and use."

It seems clear from these comments, that we were at least on the right track with what we had built, but we needed better machines for implementing them. This is not surprising, as we had to rent used computers at the last possible moment, and had no control over their quality.

When asked about the instructional design, students had several ideas about how to improve the project. Mapping was the first big area (p. 6):

- "I don't object to building map skills, but I object to the repetition of it."
- "The computer map just sat there, and we copied it, a boring exercise. The pace would have been quicker if the computer had been programmed to permit plotting we had to do by hand."
- "Provide masters that locate coordinates for all points and then give students opportunities to pick and choose coordinates they want…"

Clearly, we needed to make the mapping less tedious, and they told us how to do it. Give them points to choose from or plot the base map for them.

The second area was the email functionality for doing interviews with characters in the town (p. 7):

- "Responses to email were sporadic."
- "We didn't receive answers to email and hence didn't learn the things the simulation relied upon email to teach."
- "Email is a good idea, but it needs to be refined."

Clearly, we needed another mechanism for students to get interview information. Students again saw the value, but pointed out the glaring flaws in this year's method.

There was less consensus on other design areas, but we could pick up from student comments that the budget might need to be refined as some students struggled to understand the cost of their activities and the tracking of the budget.

When asked about the instructors' preparedness, students overwhelmingly confirmed the effects of poor training (p. 8):

- "Lab instructors were poorly informed."
- "The instructors didn't always know how to use the program. You'd ask questions and the instructor would spend twenty minutes trying to figure out how to do it. Similarly the TA's. It wasn't their fault; they hadn't been trained, and they were supposed to be teaching us.
- "Laboratory instructors were not comfortable with Brownfield Action, and did not always support it."
- "Lab instructors didn't know what they were talking about; explanations were sometimes poor and ambiguous."

What was interesting was that at least some students realized not only that the instruction was poor, but that it was not the instructors' fault. It was our fault. This comment was a clue we missed back then that shows perceptiveness on the part of the students that we should have taken more advantage of throughout the years of the project.

When asked about the organization of the course, students told us where our mistakes were right from the beginning, starting with the lack of goals and objectives (p. 10):

- "A statement is need up-front of the goals of Brownfield Action."
- "We never really knew or understood what the goals and objectives were…"
- "The introduction to Brownfield Action was limited to 'We're starting Brownfield Action and it's going to be big.' That's all! No overview was provided to give us a sense of where the simulation was going."
- "Explain what students are to do and why."
- "Tell us what's going on."
- "I didn't understand why I did what I was doing."
- "Brownfield needs step-by-step instructions. It relies too heavily on the instructor."

Obviously we had not properly oriented them to the project as these comments were echoed in every lab.

When it came to the discovery process, they had ideas for improvement as well (p. 11):

- "Instruction should be organized so that we have an opportunity to discover more things…"
- To get the point of Brownfield, we needed to analyze/hypothesize more often than the last session. We didn't talk throughout the course about what the points we were plotting meant."
- "I felt I was doing busy work without interpretation."
- "No analysis was encouraged, to help us to figure out things, like what the toxins were."

Students also went back to the mapping as a source for the lack of analysis/discovery (p. 11):

- "You get so hung up getting the map to look better and getting it done that you forget what the point is."
- "Lab work and quizzes appeared to focus on testing to make better maps rather than understanding. Students got too caught up in details."

A composite student construction of the experience might be summarized as follows:

The simulation is a good idea and interesting. The technology generally worked, but we could use better machines and access outside of lab. The project needs explicit goals. The instructors need training on the software and how to guide a discovery process. Because we spent so much time on mundane and tedious mapping and other details, we often lost our connection to the analysis work that was the point of the project.

So even though we did not give students any goals and we provided poor instructional support to the lab instructors, students still found positive things to say and did see the point of the exercise, even if they did not really experience it in full. They knew they were guinea pigs, and they fought through it and gave us plenty to work with the next year. I would like to honor them all with purple hearts of valor for putting up with us.

Bob's recording of Dr. Bower, Joe, and Diane's comments can also be looked at for more insight into the first year.

Dr. Bower was impressed that CCNMTL and his instructors even got the implementation of the project in place and the students survived it without mutiny. He stated that students got more this year than in past years, especially in areas of groundwater, toxics, and human health. He knew the students needed access to the project outside of lab on Windows machines. He needed to understand the simulation better himself and use it to better integrate his lectures. Because of the workload he had, he was well aware that an alternative to the email feature was needed and he had heard from students and Joe, Diane, and myself that the maps were just too much tedium. Still, he thought the simulation was terrific and had lots of potential.

Diane believed students learned more than in year's past, and she was surprised by the degree of success given the circumstances. She saw better student engagement as a result of the computer use, and better attention and focus on details than in past years. She liked the idea of a real world problem and the fact that it felt authentic. Diane also pointed out the need for an email alternative. She also requested more supplemental materials surrounding Brownfield Action to support student activity. She felt supported by CCNMTL throughout the semester, indicating that it made it possible to keep going with the implementation week after week.

Joe was less complimentary overall, but saw that students learned something at the end of the semester when they got into the drilling portion of the project. He felt the Groundwater Project did a better job of providing opportunities for success throughout the semester, rather than students having to wait until the end. Because of that, and the fact that students produced longer reports, he saw the Groundwater Project as a better method. Still, he thought the computers enhanced learning and that the design of the simulation was good. Joe picked up on the access problem and identified that students struggled with the budget component. He was complimentary of the support received over the semester, but knew he needed more instruction on the use of the computer, and wondered if there was a technical background required to be a good teacher with Brownfield Action. He thought there were good linkages to the lecture, but that attendance needed to be emphasized more in the lecture so that students could get the clues they needed from *A Civil Action* and the lecture content.

Taken together, the comments from the instructors pointed to a few key recommendations:

- Train the instructors better. Maintain good support level.
- Fix the mapping, email, and budget components.
- Get students to attend more lectures.
- Provide opportunities for student success throughout the semester, not just at the end.
- Provide more supplementary information to students to support their work.

Comparing this list against the student list and my list, they are all nearly identical. The direction to head in year two was clear. Or was it?

CHAPTER III

Year 2: Rebuilding, Renewing

Proposal for Version 2.0

Brownfield Action became the first CCNMTL project to complete a development cycle with an evaluation. At that point it was not clear what to do next because we were at the forefront of what we knew how to do as a Center. No one had decided what happens to a project after it is evaluated. One thing that was clear to Dr. Bower and me was there was much more to do on this project.

In April of 2000, I proposed to CCNMTL management that we develop Brownfield Action 2.0, an upgraded version of the original simulation with several new components and improvements based on what we learned in the past year and that we ran out of time to include the previous year. The new version would include the following major additions:

- Networked data storage to allow students to store their progress on a server so they could work from any computer with a cd rom and a high bandwidth internet connection.

This upgrade addressed the students' concern about not having enough time and being locked into using the same computer every week. If we could find a way to store their work centrally instead of on the local drive, they could work on this project twenty-four hours a day seven days a week if they had a computer and connection in their dorm room.

- A more robust historical section with characters played by actors who live and work in the town and are available to respond to student questions via video.
- A town newspaper that reveals clues at key points through the semester.
- An expanded municipal complex with additional locations for gathering historical evidence.

- Key documents that provide evidence and clues for the historical portion of the investigation.

Clearly, students needed quicker and better feedback on the story going on in the town as they were proceeding with their investigation. We had planned all along to develop characters, but could not do it in the time allowed the first year. In order to provide guidance about where to proceed with the planned larger historical section, a small local newspaper that occasionally contained articles relevant to the investigation was also proposed. Environmental investigations always involve interaction with city and state governments. To provide more authenticity, we planned to implement an additional set of locations within the municipal complex with characters that could be visited. Some of these characters would be able to provide documents that could serve as evidence in the investigation.

- Additional test data and testing tools for a more complete investigation
- A certification procedure to ensure students are knowledgeable about testing tools before they are used in the study

We ran of out time in the first year before we could introduce additional tests such as excavation and measures that would prevent a student from testing on top of a building. We also planned to implement the quizzes and a practice map area for learning about the testing tools and certifying that they had the knowledge needed to run the test properly.

- A more robust reference section with comprehensive info on all testing tools

We needed to complete the reference material that was not completed the first year.

- An improved interface for easier navigation, more intuitive user control, and more reliable performance

- A clearer and more authentic map

We needed to spend much more time working out an improved interface for more intuitive use by the students. The most crucial part of the interface would be the map, which needed a cleaner clearer look and much more detail.

These upgrades would take the application from a functional prototype with many gaps to a full-scale application. It would require a major development effort with the participation of almost every staff member at CCNMTL as well as a level of coordination yet to be attempted by me or anyone else at the Center at that point in time.

Development

Brownfield Action 2.0 began with specification work in the spring of 2000 outlining everything proposed in great detail. Once that was complete, work began on several fronts simultaneously.

Networked Storage

David Van Esselstyn and I knew that Director came with an add-on package known as the Multi-User Server that was designed to network a Director application. It came with several capabilities, one being a simple database program that could store user account information. As a proof of concept, David was able to change version 1.0 of Brownfield Action to store information on the server instead of locally. From there we waited for the rest of the upgrades to be completed before creating the new master program.

Historical/Story

A student assistant, Kelly Koscuiszka, was instrumental in creating characters for all the locations in the town. These characters were designed to respond to a set of nine questions we developed that students would commonly need to ask in order to deduce the causality of any contamination problem they found. Some of these questions were reworkings of the questions students had asked over email the previous year, while others were derived by us. In all, we had forty-nine characters. We chose five key characters with the most crucial information to be videotaped using actors. We got CCNMTL staff to volunteer to play these characters, developed scripts, scouted locations, and used the newly CCNMTL formed video team to produce these videos rather than me doing it myself as I had in year one. The rest of the characters were simulated with photographs and text responses. One of the questions a character was programmed to answer allowed that character to provide any documentation that could serve as evidence of something they said. For the nine characters that would provide documentation, we altered real government forms and permits. The characters' answers and their respective documents would serve as the story of the town that students would explore in conjunction with the data model. The basic plot for the story is that the Self-Lume Corporation illegally dumped radioactive waste (tritium) into their septic system in order to cut costs. Some former employees in the town try to cover up this information while others are more than happy to reveal various rumors and tidbits of knowledge that serve as clues to what took place. There are also red herrings and subplots including a contamination problem at the local gas station as well.

Once the Phase One reports were turned in, students would be instructed to move on to a Phase Two investigation governed by the Environmental Protection Agency. Student teams would work together sharing data in order to reconstruct the plumes of contamination they discovered with however much time was left at the end of the semester.

Kelly also wrote five newspaper articles that were relevant to the investigation that would be made available to students at key points during the semester. The articles added a chronological element to the story as information about relevant events taking place in the town would be revealed over time.

We did not remove the ability to email questions in or for Dr. Bower to respond to. In fact, we wanted to retain that flexibility, and hoped that the questions students asked characters in the town would be more sophisticated because they would have received basic information from the programmed-in questions and answers. Kelly was kept on staff for the fall to help respond to the expected email questions in an effort to eliminate the delay in responding to students.

Tests, Tools, and Quizzes

We made corrections to errors in the data that we picked up on the first year. We added an Excavation test that essentially allowed a student to dig up a ten-foot square plot on the map to look for objects buried underground. This test reported back text messages similar to the metal detection and ground penetrating radar tests and was crucial for students to verify their presumptions about something detected using one of those noninvasive tests. We also added measures to prevent students from being able to test on top of buildings, added more underground objects that would be present in this type of town, all in an effort to add more detail and authenticity to the simulated task of testing.

As planned, we also added a certification procedure for the use of each test that served as a checkpoint. Before a student team could use a testing tool in their investigation, they needed to take the certification quiz. We debated for some time about what percentage score, if any, a team needed to achieve on the test, before they could move on. Because we had no way of knowing which student from the team did the exam, or if they did it together, Dr. Bower and I ultimately decided we would rely on good student intentions and not require a percentage. If a student team performed poorly on the test, they would know that they could be held accountable for similar questions about the tests on actual laboratory quizzes that counted towards their grade and they would still be allowed to move on. This ended up being a poor choice on our part as will be revealed in the evaluation.

In addition, we applied some of the traditional lab experiments to the simulation. For example, students would normally do a soil sediment analysis lab to see how different chemicals flow through different soil types at different rates based on the permeability and porosity of the soil. Students would now be told they were testing a soil sample from the Self-Lume site and that they should use the results of their experiments in their ongoing investigation.

Reference

In version 1.0, the limited reference information was contained within the simulation. Thinking that we might want to update the reference material more frequently than each new issue of a cd rom, we moved the reference information to the web. We also filled it out more completely and linked to real online resources that are available about testing tools provided by actual companies that rent and service equipment (Figure 12).

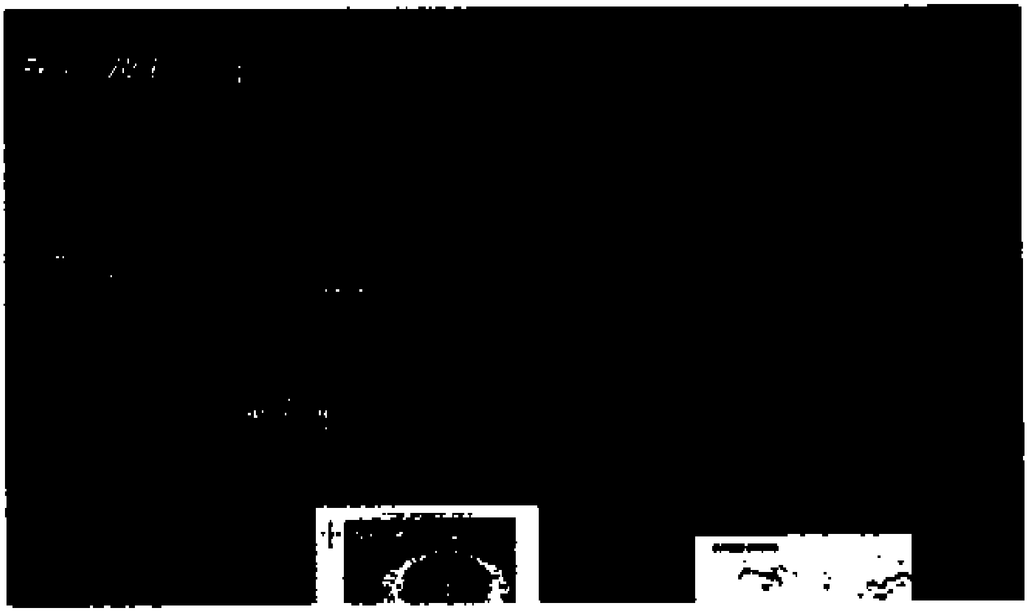

Figure 12. Screenshot of Reference Website showing background information on Magnetometry and Metal Detection.

<u>Interface/Map</u>

We hired Marc Ackerson, a Columbia architecture student, to develop an improved map (Figure 13). He came through beautifully with a high-resolution version of the map that we could build a zoom tool on top of. We also chopped the map up into individual properties to provide an easy method for students to plot the buildings onto their base map. We hoped this would remove some of the tedium of the mapmaking process, but still force students to get to know the locations very well. We were not interested in accommodating students entirely because we believed their was no better way to demonstrate basic understanding of what was represented on the map than to have to draw it.

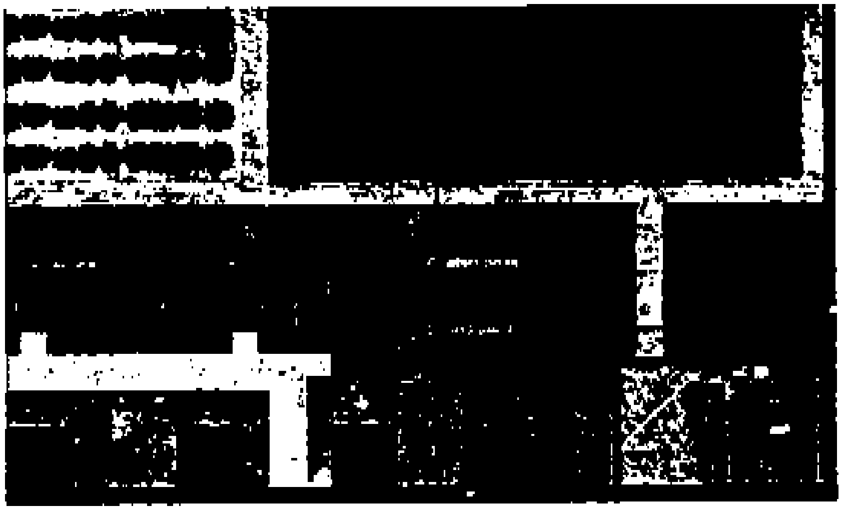

Figure 13. Zoom-in screen shot on map with inset full map.

We hired David Sun, a School of the Arts student, to design and implement a new interface and to lead the programming of the new version (Figures 14-18). He did beautiful and reliable work but was not able to meet the late August deadline. We were delayed into late September, so the project started late and did not leave adequate time for training or focus on implementation.

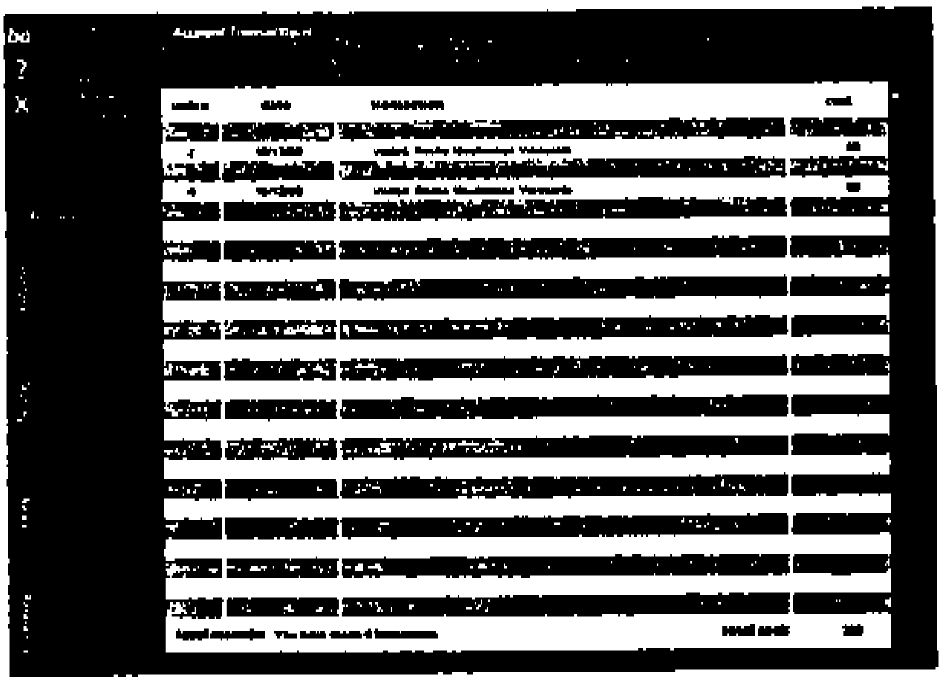

Figure 14. Screenshot of Account Interface in version 2.0.

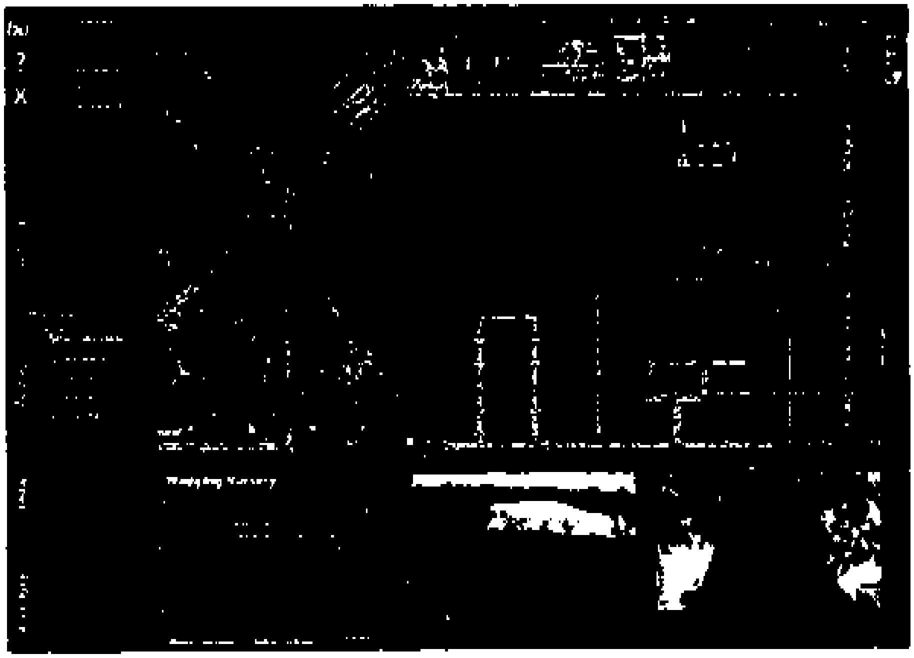

Figure 15. Screenshot of History interface in version 2.0.

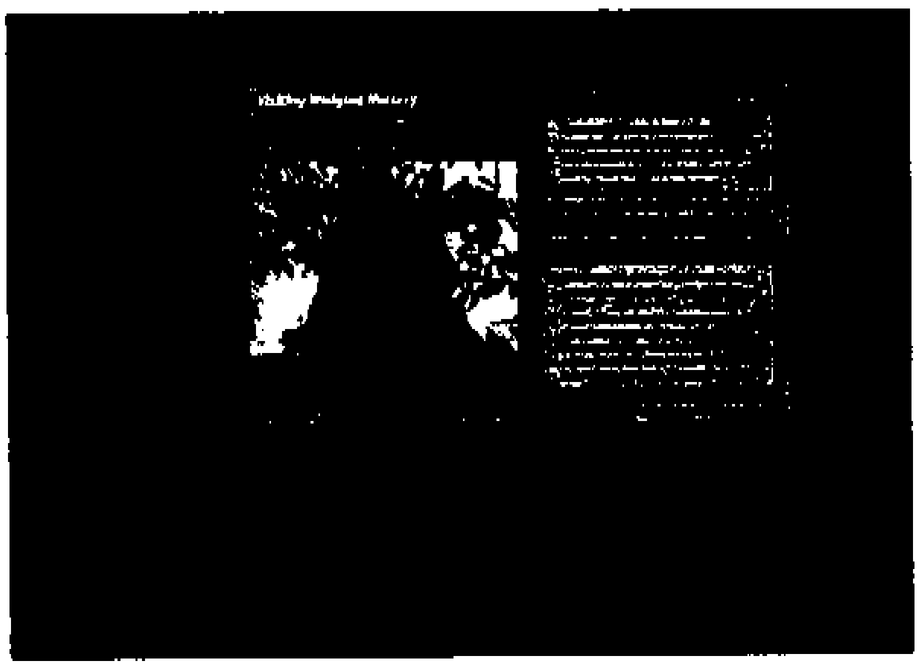

Figure 16. Screenshot of a visit within the History portion.

Figure 17. Screenshot of the newspaper interface in version 2.0.

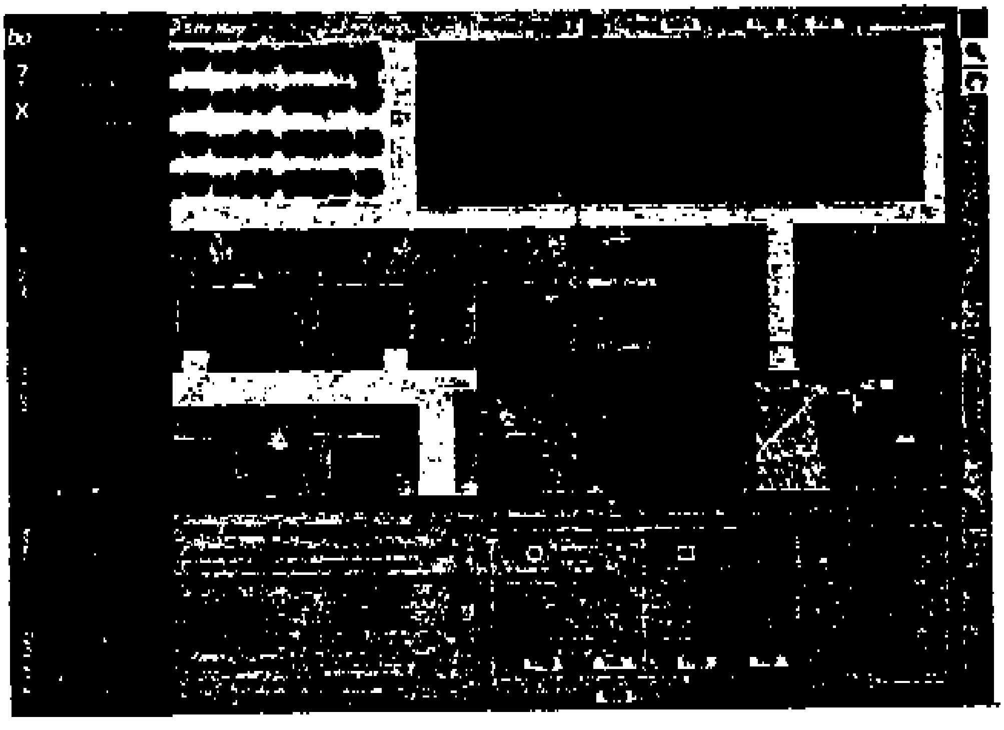

Figure 18. Screenshot of the testing interface in version 2.0.

(For a complete walkthrough of the new interface see Appendix E)

Reflecting on the Design and Development

Once development was completed, I was very satisfied with what we had accomplished on the design side. We had been able to implement all of the proposed changes, and since all the changes came directly out of the feedback we got from the previous year, I was anxious to see how much improvement we had made. Still, I had yet to fully realize how even a much improved simulation application was only one factor in the success of this course.

Training/Implementation

With what little time we had, I quickly tried to get Joe and Diane up to speed, but knowing what happened last time, I tried to avoid the trap of teaching them didactically. Unfortunately, this did not work, because I could not motivate them to study it and report back to me the way that we wanted students to proceed. Joe and Diane did not see any benefits to going through the project on their own because they had survived last year. Again, Joe and Diane wanted to move the students in lockstep, so it was almost like starting over trying to get them comfortable enough to let students go about exploring on their own. This was frustrating because I knew I could teach a great lab with what we had produced and it seemed unlikely Joe and Diane would ever get as comfortable as we needed them to be.

We did agree early on that if we noticed a trend in student behavior or if our tentative plans were not working out, that we would act. We noticed that students were not making good progress on the project, and based on the amount of work we knew remained, we wondered why. Dr. Bower realized that students were waiting for his exams to do anything. His lecture curriculum had two mid-terms and a final exam. Up to the first exam, students were slacking off until the last minute, when they started showing up for class again and cramming for the test. We realized we had to change this behavior. It was decided that he and I would intervene on the lecture one day, step out of the simulation, and debrief students mid-stream about how much of a mountain they were leaving to climb. He and I explained that it was not possible to complete the simulation and get anything out of the experience through cramming it all in. It was our belief that students needed to pace themselves and work through the process steadily in order to received the full benefits of the simulation.

This was a breakthrough moment for Dr. Bower when he realized that the structure of his lecture did not support the kind of authentic experience he was trying to foster in the lab. The lecture reinforced waves of activity around the exams, and a slacking off between exams. This cycle was carrying over into the lab work as well. We agreed this must change the next year and Dr. Bower decided the midterm exams would be eliminated the next year and be replaced with weekly quizzes that would enforce progress on a weekly basis.

A breakthrough moment for me came about around this same time when I verified what had come up in a couple other Center projects. Dave Van Esselstyn, one of the programmers for this project, had been working on another project called Third Space and come to the realization that it was much better for faculty to demonstrate proficiency with our projects to their students than for one of us to come into a classroom as an outsider and demonstrate the tool. Having an outsider demonstrate tools devalues the importance of the tool and does not give students confidence that the faculty sees it as important and useful. I had seen this happening with a project I was working on called the CU Analyzer, but I realized during this year's implementation that this was also true in the laboratory with Brownfield Action. My mere presence in the lab was devaluing the project as Joe and Diane were constantly deferring to me and undermining their own authority in the class. This made students question the instructors' competency and made them lose confidence and engagement in the activity. I knew that I had to divorce myself from the lab in the coming year.

Evaluation

I used Bob as a resource back at the proposal stage to validate the list of upgrades we wanted to pursue. Bob was eager to be involved in the entire development process. His first tactic was to get Dr. Bower and I to be explicit about the goals for the project and the course. This was a good thing. The statements we made about the goals along with the feedback we received from year one would serve as an effective and logical guide for year two's development and evaluation.

Since the point of the introductory course was not to train students to be environmental investigators, it seemed more appropriate to state the goals more generally. We agreed that students who experienced Brownfield Action should be able to explain their approach to the solution of a scientific problem by:

- Describing the strategy used to discover contamination sites in Brownfield Action
- Identifying and explaining the outcomes of the environmental tests they conduct and related information, making recommendations and demonstrating awareness of the consequences of their decisions
- Drawing inferences from data about structures that contribute to environmental contamination
- Describing a method or strategy of exploration that was abandoned and explain the evidence for why it was abandoned

We also wanted to state more indirectly our hope that students would:

- Read articles on ecology with different understanding, interest, and personal commitment
- Appreciate that real world decision-making about ecology involves ambiguity rather than certainty

Once implementation was underway, Bob and Lori Ramsey, another student assistant, again ran surveys, focus groups, and interviews at the end of the semester with everyone involved to try to get a sense of what we accomplished with version 2.0 (Highsmith 2001). They claimed that the majority of students did indeed demonstrate proficiency with describing their solution to the problem of Brownfield Action through their excellent written reports and maps, that again surpassed the accomplishments of students who did GWP and last year's group who used version 1.0. Student responses to survey questions and focus groups again centered on pieces of the course that fell outside of the technology. Students were primarily critical of the lab instructors teaching strategies and the lack of connection between Brownfield Action and the lecture.

Most students enjoyed the experience and felt it worthwhile, but the complete course was still lacking in certain areas. Our improvements to the map and interface, the ability to store progress online, the characters, and newspaper were all well received and contributed to their ability to proceed through the investigation more smoothly than in the previous year. However, students still could not live with the delay in responses to email questions. It was as if the basic questions provided stirred their interest and made them more reliant on the email. Even though we had Kelly hired on to assist in responding, she and Dr. Bower could not keep up with the bombardment of questions that poured in over the semester. Students also were not satisfied with our certification procedure decision. They quickly realized that they did not have to achieve a good score to become certified for a test. Therefore it became meaningless busy work, which they appropriately did not appreciate having to do.

There were no substantive requests for technical changes to what we had built. There were minor corrections to be made where students ran into data errors, and some students had trouble logging in at the beginning of the semester (we corrected that with a patch to the application that we distributed via the course website). But in sum, all the areas for improvement focused on other aspects of the project other than the technology component.

Reflecting on the Evaluation

The evaluation of the second year demonstrates more evidence that a Design Research process would move us in a better direction. This time we ran into what CCNMTL now knows to be a classic problem; that is, what happens when we do most everything right on the production side and the faculty member and supporting cast are not able to carry it out effectively because we put minimal time into the implementation.

The first year we focused the evaluation on the digital environment we developed. This second year we evaluated the whole course, but since we did not do anything to improve the instruction or curriculum, we saw no improvement from the year before. It should not have been a surprise.

Again we were still making mistakes not involving the lab instructors in the development process. We still had not learned that and now it was too late, since we had no reason to do more substantive development on the technology side of the project.

It was unfortunate that our evaluation did not formally tap into the issues regarding the students' study habits and the lack of lecture-lab integration as that was a signature moment for changing Dr. Bower's approach to his lecture. It also did not cover the issues I raised about CCNMTL staff member's involvement in demonstrating and hovering over projects. We needed an evaluation process that would pick up on these bits of wisdom, and we still did not have it.

More than any of this, the evaluation, as with all CCNMTL evaluations at that point, was still focused primarily on student and faculty perceptions of learning, rather than looking for actual evidence of learning. Bob and Lori determined that about three-quarters of the students thought they could make recommendations based on environmental tests and be aware of the consequences of their recommendation. Three-quarters also said they thought they could draw inferences from data about structures that contribute to environmental contamination, and over half the class (57%) thought they could (or did) describe their strategy for discovering contamination sites. Nearly three-quarters (74%) thought the project succeeded in helping them appreciate that real-world decision-making about ecology involves ambiguity, and nearly two-thirds (65%) say they read articles on ecology with different understanding, interest, and personal commitment because of the experience.

These positive results hinge on what students think they know, not what they actually showed evidence of knowing. I realize these concepts are difficult to determine, and the literature I referred to earlier backs up this assertion. Still, we did not as yet know much about what the students were really getting from the experience

Bob and Lori also looked at students' perception of skills and knowledge. While students rated themselves as having shown significant improvement in all areas except working with others on a team, which they rated high on the pre-test and post-test, we did not look at their actual performance on any tests on content to see if this was true. The only other factor we had to look at were the reports, which did show better analysis than the year prior (in Lori's opinion). The criteria for the report analysis were not made explicit however. All we have from Bob's writing is one paragraph stating generally that students did a better job of integrating mathematics and understanding the vulnerability of the town to the problem.

When students were asked about the experience as they were last year, there were a couple shining comments from students who clearly benefited from the project and saw the point:

> It was really close to what you would do in the real world and that made it more exciting. The use of both quantitative and qualitative data made it more textured. Not knowing the structure made it more exciting. Investigating the information was overwhelming, but in the real world that's what you get. You have to sift through it and pick the essential information from the inessential information.
>
> Highsmith 2001 p.4

> It's hands-on. The focus in not on learning the content but on learning to solve problems. I understand what it means to conduct environmental tests and how to do them considerably better than if someone told me about them. Brownfield Action was frustrating the way fieldwork in the real world is frustrating. The simulation made things a lot more interesting compared with learning these things from a textbook.
>
> Highsmith 2001 p.7

Not all the comments were this shining, and it was clear there was still much more to be done on the curriculum and training side. We still had comments regarding the orientation to the project:

> They should tell us at the beginning that all our labs would help with the report at the end of the semester.
>
> I think in the beginning we were told to assess the site and sign a contract, but we plunged into the project without really knowing what we were expected to produce at the end of it.
>
> Highsmith 2001 p.10

Clearly, we still had work to do to get some students started on the right path. But then overall, we had problems getting students to realize that uncertainty was part of the process:

> I didn't realize that the confusion I experienced is part of the reality that Brownfield was simulating. I wanted a list of what to do, and I never understood why I couldn't have it.
>
> Highsmith 2001 p.10

This student eventually figured this out, but points out that had she known it all along, she would have been better off.

Bob and Lori's biggest recommendation, which I supported, was that we should create a strong set of support materials to help students and instructors move through this complex experience. It would have to be constructed carefully to prevent the experience from becoming too didactic. These support materials should include content from the lecture, and the lecture should directly address the project.

At the end of year two, we had a nearly complete digital environment. Some students seemed to have had a positive experience, while others were still not getting the point. Some technical issues remained to be hammered out. Most of all, we had a need for still better training and support materials and connection between everything in the course. Year three would be less technical development and much more work on the other aspects of the course.

CHAPTER IV

Year 3: Following the Teaching

Again, we were in new territory after the end of the second year. Brownfield Action was the only Center project to have completed two development cycles with two evaluations. The second evaluation made the case that, from a production point-of-view, our job was nearly complete. The remaining work needed to be concentrated on the curriculum and instructional techniques. Using this project as a model, CCNMTL was beginning to realize that in order for its projects to be successful, we had to get much more involved in all aspects of the courses that were using our projects.

Proposal/Development for Version 2.1

Because I did not plan on making substantive changes to the version of the software we had created, I did not propose a version 3.0 of the software. Instead I proposed minor changes that would take us from 2.0 to 2.1. The largest of the changes were to:

- Move the certification from the simulation application to the web with the reference material

The certification process did not work as intended using the good faith of the students. We felt we needed individual accountability for the exams. By moving it out to the web, we could use a different system to track individual students completing the exams. We still did not believe requiring a particular percentage on the exams matched well with the type of experience we had created. However, this time we set up the exam system so that it would tell students when an answer was incorrect, and require them to go back and correct the error. In this way, the intention was that every student would end up knowing all the correct answers by the time they completed the exam.

- Modify some of the character responses to reduce email onslaught

Adding the character interaction led to many, many email questions that the response team could not keep up with. To prevent frustration, we decided we would modify some of the character responses to reveal more information, and thus allow students to complete the historical portion of the investigation with minimal need for email. We also decided to increase the cost of sending an email question to discourage overuse.

In addition to the software, Joe and Diane would formally dedicate time to work on the project over the summer with Dr. Bower to become more prepared to teach with the simulation and to better integrate all the components of the course, including the lectures. They agreed to create a teacher's guide for the lab, and Dr. Bower was going to modify his lectures to better align them with the order of events happening in Brownfield Action. In addition, I took substantial time redeveloping the student manual, so that a self-motivated student might be able complete the experience with minimal assistance from the lab instructors.

Training/Implementation

This year, I did minimal training with Joe and Diane since the simulation application itself was virtually unchanged from the year before, and they had worked out a plan for the complete semester on their own that they were comfortable with. We had several discussions about the importance of a proper introduction to the project and allowing students to drive the project forward.

The plan was for them to try to carry out the complete semester with no input from me, technical, pedagogical, or otherwise so that I would not undermine their authority in the lab or their confidence in their approach.

Evaluation

With Bob's departure from CCNMTL, the Center realized that it was impossible to ask one evaluator to effectively understand and manage the research work of so many projects. In a new experiment, an army of graduate students was hired to work with Peter Sommer, the Center's Director of Education, as evaluators. Bruce Strothenke, a Teachers College doctoral student, was hired to carry out year three's evaluation for Brownfield Action (Strothenke 2002). His focus was almost entirely on the instructional techniques used with the simulation since we were confident from the previous year that the tools in place were adequately developed. He spent each week observing the labs and lectures focusing on Joe, Diane, and Dr. Bower's approach, keeping just a minimal eye on the technology. He also did end-of-semester group interviews with four the eight labs and had all students fill out surveys.

After a few observations, it was clear to Bruce that Diane had made substantial gains in her ability to run the simulation as we intended, while Joe had not. Bruce cites several observations of Diane providing context for students when presenting material such as Darcy's Law, the mathematical equation used to determine groundwater flow. Diane properly connected the reason students had to learn this law to its use in determining where to drill by predicting how fast a chemical might be traveling underground in the simulation. She did the same with the contour maps, citing that neat, clearly drawn maps would be assessed as more professional, and that it was an important task for environmental consultants to know how to do. By providing explanations tied to the learning activities in the simulation, Diane was able to increase enthusiasm for the work being done and reduced complaints about the tediousness of the exercise. Bruce's surveys show that students in Diane's labs had fewer complaints about the mapmaking than students in Joe's labs. Joe chose not to connect the lab exercises to the simulation even though he had excellent command of the procedures needed to complete each exercise. For example, Joe demonstrated a clear ability to teach students how to create contour maps (better than Diane), but he did not give students a reason for doing them well beyond, "...be neat because these maps are graded," (p. 7). This technique tended to create resentment among the students about doing the tasks.

When it came to offering guidance to students about how to proceed in the simulation, Diane offered as much or more assistance than necessary. Bruce observed that students felt very comfortable working in her labs and she clearly developed a solid rapport with most of her students. Joe tended to encourage students to think for themselves and pushed them to try methods before he would intervene. However, Bruce never observed him praising students for good performance, and he tended to foster adversarial relationships with students that made him seem unapproachable.

When it came to reflecting on their experience in the labs, students appeared to not distinguish between Joe and Diane, rating their experience doing the simulation equally on surveys no matter which instructor led their lab. These findings led Bruce to believe that perhaps the simulation stood well enough on its own that even with minimal guidance, students still had a worthwhile experience and enjoyed it in the meantime.

Bruce also surveyed students on a number of aspects of the course that we had evaluated in the past. Just as Bob had in the previous two years, Bruce determined that nearly all students felt that Brownfield Action was a worthwhile experience that aided their learning. Students often commented that it made the material more like real life and gave purpose to learning the content of the course.

Some of the comments Bruce collected include (p. 13):

- It helped my understanding to actually apply the course material.
- The simulation helped me visualize the contamination and its flow.
- Because it was hands on, learning felt like less work (than in other courses?).
- It was very interactive, which helped me learn.
- It made learning more enjoyable (some even said "fun!").
- BA provided an overview of the whole course, plus how to run a company.

Five of the ninety-two students he polled disagreed with the above comments, citing:

- It was a lot of tedious busy work, specifically the maps (3)
- I am not a visual learner, so I would have learned more from a text. (1)
- By focusing on so many details, the big picture was lost. (1)

Bruce also tried to determine from the students how connected the lab and lecture parts of the course were. Comments from students included (p. 14):

- I didn't understand the lecture material until I got to lab.
- Material presented in the lecture was made real in the lab.
- I learned more from the simulation than from the lecture.
- It seemed like two separate courses, one in lecture and one in the lab.
- The material could have been taught effectively without the lecture.
- I learned more from my classmates than from the instructor.

From these comments, Bruce states, "Learning was taking place through collaboration, use of the simulation, getting the 'big picture' and applying the material" (p. 15). He wondered if this could have been made explicit to students at the beginning of the semester as a method for reducing some of their frustration in the beginning and middle of the project. This also came up in his questions to students about the discovery process of doing a simulation. When students were asked if what they had to do was clear, most students chose yes on the survey (70 out of 92). Those that said "no" made comments including (p. 16):

- At times, we were confused about what to do next.
- I found myself experimenting a lot.
- There was not enough instruction about the simulation from the lab instructor and I often had to ask for assistance.
- I wasn't always sure which information would be pertinent.
- It took trial and error, but as the semester progressed, it became clearer.

These comments make it appear that if students had been told that experimentation, trial and error, and filtering important information from noise were important parts of discovery learning, that they would not have been so troubled about not knowing what to do.

Bruce tried to assess the new manual that had been created. One interesting correlation he found was that students who rated the manual highly were more likely to cite that the directions about what to do next were clear than students who rated the manual low. However, this correlation was not found when he matched manual ratings against technical problems. Still, without asking students how much they used the manual, it is difficult to tell how effective it really was.

Through the interviews, Bruce reports several more comments and suggestions for improvement that did not come out of the surveys or observations. The primary student complaint focused on the certification exams, which still stuck out as meaningless busy work that did not contribute to the completion of the simulation. Because the questions and answers had nothing to do with the actual performance of the tools in the simulation, they learned nothing from this memorization and just went through the motions of completing it as instructed.

At the end of the course, students appreciated the complete experience, including the tedious mapmaking. They understood its importance in the scheme of the simulation and saw the complete experience as an excellent method for applying the course material. They universally said it helped them understand the material better and felt they would remember it longer.

Students were still frustrated with how the project was introduced and that they could not see the benefit of what they were doing until it all came together in the end. Even though we had succeeded in getting students to pace their work and not cram it all around the course exams (which were now weekly quizzes), they still did not have a way to gauge their progress in the middle of the project to know if they were on the right track. Not surprisingly, Bruce recommended addressing this through a better introduction scheme next year.

Students remained confused about the use of the budget. Students did not see the range of costs of the various activities in the tools and claimed to receive inconsistent guidance about spending their resources. Bruce recommended a short lecture on the importance of budgets and a consensus among the instructors on the proper guidance to provide students.

The email function within the interviews was under-utilized. Several students who tried it did not receive answers and did not seek assistance to resolve the problem. It is unclear whether this function was still needed to have a complete and authentic experience of an investigation.

Bruce also reported a small number of technical problems that should be addressed the following year along with the above issues.

Reflecting on the Evaluation

Bruce's evaluation validated many of our earlier findings and raised some interesting questions. We felt confident we had created a valuable simulation experience for most of the students in the course. The vast majority of students enjoyed the experience, saw its value as an opportunity to apply the content of the course, and believed it would be beneficial to them going forward in their respective careers.

Our attempt this year to improve the performance of the lab instructors yielded mixed results at best. Diane appears to have adapted the approach into helping students get through the experience through enthusiasm and making the students comfortable. Joe adapted the approach into taking a "tough love" attitude and getting students to solve it themselves, even at the cost of students feeling lost and resentful. Students rated the experience the same on a general question about the overall experience. It seemed a combination of the two strategies might be ideal. Diane may have made it more fun and easier to get through at the expense of students discovering much of anything themselves, while Joe made students do the simulation on their own at the expense of some students seeing the project as tedious and frustrating. It is difficult to comment on which method is ultimately better (or worse) for students. Bruce took the stance that Diane's strategy was generally better based on his observations and end-of-year interviews because the students felt better about what they were doing and more often knew why they were doing it. However, if the students are handheld too much, we really are not helping them to build discovery or problem-solving skills that they can use on their own in the real world. The question for Diane's labs for next year becomes: *Does too much guidance and niceness prevent the building of discovery and problem solving skills?* Joe's method may have ultimately made students work harder and get more out of the discovery process, working together to experiment and try different strategies. However, if they got too resentful of the experience, they would no longer really be participating in the simulation. They would be focused just on trying to get the assignment done, which might not lead students to the end goal of internalizing the strategies they were undertaking. In other words, they might be discovering, but not aware of it or hating it so much they would want to avoid similar situations or not know they were in them in the future. The question for Joe's labs for the next year becomes the opposite of Diane's: *What is the minimal amount of guidance and encouragement needed to maintain student interest and reduce frustration such that students can face the challenges of the simulation experience on their own?*

As for the connection between lab and lecture, it is still unclear how much one affects the other. Some students saw them as separate courses, while others saw clear connections. Many said the lecture informed the lab, giving purpose to the work they were assigned to do. Others said the lab would be better off without the lecture. These results are confounding and warrant further exploration if we are to understand the importance of providing a coherent complete course that has lecture and lab as equally valuable components.

We still did not have a way of really seeing how student thinking was changing over the semester. We still made the mistake of focusing our resources on interpreting through observation and waiting until after the experience was over to ask questions of students. Since students did not turn in any intermediary work through the term, it was up to this point impossible to gauge any transformation taking place while they were in the simulation experience except by talking with them, which we didn't do until the end. Summative evaluation was just not getting it done. We had another example of a generally positive review with suggestions for minor improvements without knowing any more precisely than in the past what students were thinking or learning.

At this time CCNMTL was coming to the realization that hiring outside people to do evaluation work was putting us into this cycle of minimal sharing of the knowledge created from our work. By having outside people review projects from the outside in, we were proceeding too slowly at moving everyone in the organization to a place of better understanding about the impact of our work. Brownfield Action was the only project with three evaluations, and our knowledge of what was going on in the classroom had plateaued at this "generally successful" level without much detail or nuance as to what we had done for students. Other projects had even less confidence in their effectiveness because the project managers were not involved in the implementation or evaluation in any way.

This is when Design Research surfaced as a possible methodology for our work. If we could generate hypotheses about the challenges or goals we were addressing with our projects, Design Research could help us measure for those hypotheses through research questions without us having to pull the projects out of their context of use. We could use the results to modify our designs and ultimately create new hypotheses to test in future projects. In sum, Design Research could help us systematize the evaluations of all our various projects to feed each other in an effort to create new knowledge. This knowledge would be in the form of working hypotheses or theories for the use of specific designs in specific domains, for developing generalized solutions for common educational challenges across domains, and for our processes or frameworks for how we approach educational problems.

Those of us working on Brownfield Action had many working hypotheses for all the components built into the course, from the technological tools, to the supplemental documents, to the teaching strategies and so on. However, we had not developed explicit research questions to address with the students through our observations. I have some of them above already, one for Joe's labs and one for Diane's labs. One could ask many more questions of students *while they were in the experience*, not just after. For year four, these questions and others would serve as the crux of a series of student interviews I would do to try to learn more from what we had accomplished.

CHAPTER V

Year 4: Following the Students

It was determined that the changes recommended by Bruce did not warrant the expense of a third redevelopment cycle, so year four was implemented with the exact same simulation environment and no further training of the lab instructors. We had set up a repeat of the third year experiment with a new student population and instructors with one more year of experience teaching with the simulation.

Evaluation Strategy

Working on my own this time, I decided to take the goals of the Brownfield project that we had developed over the last three years and turn them into research questions that I would test through monthly student interviews with a group of eight student volunteers.

We stated earlier that students who experienced Brownfield Action should be able to explain their approach to the solution of a scientific problem by:

- Describing the strategy used to discover contamination sites in Brownfield Action
- Identifying and explaining the outcomes of the environmental tests they conduct and related information, making recommendations and demonstrating awareness of the consequences of their decisions
- Drawing inferences from data about structures that contribute to environmental contamination

We also wanted to state more indirectly our hope that students would:

- Read articles on ecology with different understanding, interest, and personal commitment.
- Appreciate that real world decision-making about ecology involves ambiguity rather than certainty

Based on my experience with the project, I tried to make explicit a number of the working hypotheses in my head for our work. They ranged across a series of issues, many of which can be related directly to the goals of the project:

- Simulations are a useful way for students to apply content knowledge and thus can be a useful way to connect a course with lecture and lab components.
- Simulations are a useful method for developing scientific thinking and problem solving skills through the exploration and analysis of a complex system.
- Guidance is an important element in the use of simulations. Too much guidance limits discovery. Too little guidance generates frustration and resentment.
- Humor can be a useful method for engaging students in a seemingly overwhelming activity.
- Working with a partner on a simulation provides important support to an unstructured activity and adds a realistic team element to the work that is important for students to develop regardless of their chosen career path.
- Students who experience a quality simulation activity will apply the experience and the content and processes they used in that activity to their life

These hypotheses lead to a series of related research questions:

- In what way does Brownfield Action help connect the lecture and lab components of the course it is used in? What benefits do students receive from a more connected experience?
- Can students discuss their scientific or analytic thinking processes and demonstrate growth in their articulation through the use of Brownfield Action?
- What are the essential characteristics of effective guidance and support for Brownfield Action at its introductory, middle, and ending stages?
- In what way does humor assist novice students in engaging complex content?

- How does the partner dynamic affect the benefits one receives from Brownfield Action? What benefits do students receive from working in pairs?
- Do students demonstrate growth in their personal relationship to environmental issues through the use of Brownfield Action and/or the course? How might the experience affect their real-life decision-making and approach to science?

I would argue that this substantive list of researchable questions emerged from and is dependent on the three years of design and implementation completed up to this point. Designing and building the project for use in a real classroom with our constant self-reflection, rooted in our experiences as educators and technologists, opened up the possibilities for research across a whole range of issues that would have been more limited in a traditional approach. I believe this point in this project to be a unique moment in the study of the purposeful use of educational technology.

The Perspective of Eight Students

The following testimonies of eight students were collected from September to December 2002 though monthly audio taped lectures. The names of the students have been changed to protect them from any potential harm due to the candid nature of their commentary. Students volunteered to be interviewed and were given a small monetary compensation. I conducted all the interviews at Columbia University's Center for New Media Teaching and Learning (For the list of sample starter questions used to begin the first and last interviews, see Appendix D).

Student 1: Victoria

September. Victoria is a second-year student in one of Diane's labs. She is studying political science and women's studies at Barnard. She is considering working for a non-profit organization or going to law school once she graduates. She is always smiling, generally positive with lots of energy, good communication skills, and pleasant to talk with. Her family moved several times while she was growing up, so she attended several high schools all across the country. She describes herself as someone who received less than adequate science and math instruction in high school and in no way sees herself as a scientific person. When I asked her to describe the traits of a scientist, she said they are logical, systematic, and they do not think abstractly, the antithesis of how she describes herself. She gets frustrated with details (also a poor trait for a scientist) and calls herself a, "Big picture," person. She is taking the class to fulfill her science requirement, and she is taking it pass/no pass instead of for a letter grade.

After attending the first few lectures and two labs, she said, "The lecture part is the part that worries me, the lab actually gives me the incentive to go to class," and that, "The lab part is really good for those of us who aren't really scientifically oriented....It's not so difficult that we can't catch on but it's interesting." I asked her why lab was better for the non-scientist types. She responded that lab is slower and there are more opportunities to ask questions since it is a smaller group of students. At this point Victoria did not see much of a connection between lecture and lab.

She had been introduced to the Brownfield Action assignment, but could not describe the goal of it to me. When I asked her what she might get out of the assignment, she said, "Working with another person will help me develop teamwork," and that the legal aspect of the course will be useful eventually. When asked about the prospects of using a computer in the lab to participate in a simulation, she said, "It reminds me of *Carmen San Diego*," a popular commercial edutainment software program. She talked about not being a computer person but that a computer was nonetheless more accessible to her than putting chemicals in a beaker and more useful to her in the long term. She appreciated the humor of the opening sequence of Brownfield Action, and suggested it made the experience less intimidating, calling it a, "Good icebreaker." She also said, "I feel like I have to shift gears when I go to this class since I haven't taken a science course in three years and don't plan on taking a math course until senior year...have to shift gears into a different mode of thinking - like - more detailed." She hopes the class will help her develop, "A different mode of thinking, which I think will useful to me, have to be more systematic, can't jump to the point, see the same thing in this class." In most of her other courses, she takes a big picture perspective and she does not think that will work in this class where, according to her, the focus is on the details.

Victoria's main early concern is that this is a detail-oriented class and she is a big picture person. The introduction of the course and project had failed to leave a clear impression of what the larger goals were. Essentially, she was missing the context, which is significant since she claims to be someone whose strengths lie in abstract concepts and a broader perspective.

<u>October.</u> When she returned three weeks later, Victoria had much more to say about the specifics of the project. She immediately mentioned that ideas are connecting for her between lecture and lab with the recent focus on groundwater. She had been working on the bedrock map in lab, but she could not recall the name or the function of the testing tool used to collect bedrock data even though she said she did well on the certification test for it. The laboratory quizzes, "Help me focus on things," she said, such as the Visual Reconnaissance. While she and her lab partner might not be friends, they are working well together by meeting regularly before lab and dividing the work evenly. However, despite the work being even, it takes Victoria longer to do the same amount of work ("I have a hard time keeping pace," when it comes to plotting points on the maps). She mentions that Diane's guidance in the laboratory is sometimes too time consuming, but, "Sometimes it takes me a while to catch on," so she would, "Rather have too much than not enough," when it comes to explanations. I asked her about the specifics of the mapping, and Victoria was able to draw a quick and accurate sketch of the topography of the site for me from memory. When I asked her about the difficulty of the work, she said, "I don't think it's hard per se…but it's harder for *me* [italics added]." For Victoria, this class is turning out to be more work than her other courses but she sees the value of it. She said, "It all rings a faint bell," and later, "Doing maps helps us pay more attention to detail….If we were just handed a topo map of the factory…would glance at it [but now] I know it inside out." When I asked her if she and her partner had a strategy for approaching the project, she indicated that was not the case. She commented that they are, "Trying to get what we need to get done done, not thinking about exploring other options."

In lecture, the class is halfway through *A Civil Action* at this point, which is a slow reading pace for Victoria compared to her other classes, although she insisted, "It's all coming together." When asked about the weekly lecture tests, she said she was doing poorly on them and has since sought out tutoring assistance. She mentioned, "Lab is more personal…makes more sense to me," and later, "Sometimes in lecture I tend to get lost." When I asked her about how she was handling the reality of needing tutoring assistance, her was response was, "Oh my God, frightening. Never ever in my life have I ever got a grade this low ever." However, she then said, "It's not - like - condescending or anything," and that she had been an English tutor in the past. She was adjusting to this blow to her pride. I asked her how it was, "All coming together," (as she put it) if she was struggling, and she said she was looking at things differently and used an example from her reading of *A Civil Action*. She described a different mode of thinking that she was developing where she was, "Not looking for foreshadowing," but instead looking at, "Oh, groundwater." I asked her to describe this technique some more and she said, "Switching to a different frame of mind," would definitely be useful to her and that it will translate into other aspects of her work or life. She went on to say that she was, "Not looking at it [contamination] as a social problem or a government issue we need to take up….I'm looking at it - like - scientific." I asked her how this related to her concerns about being a big picture thinker and we started talking about the lecture Dr. Bower does on groundwater. Victoria said she, "Really liked that lecture…understood it and saw its relevance." At that moment I think she realized that the big picture had clicked, as she said, "It *is* [italics added] big picture," at that point in our discussion.

At the very end of the interview, she said "I just want to say that I really like lab. I had awful memories of lab in high school." I asked her if this experience was better because it was game-like and she said it was more like a puzzle. I asked if this trivialized the work. Her response was that, "A puzzle isn't necessarily trivial, but it's fun…it's not a party, but…"

Victoria was struggling to put into specifics how this course was helping her develop new skills, but clearly there were some light bulbs going off in her head.

<u>November.</u> When we talked again in early November, Victoria was wrapping up her Phase One report. She had just been performing a lot of the historical detective work by interviewing residents of the town. She said, "The interviews were so much fun....They're fun but kind of a pain sometimes. You can't understand what they're saying." She mentioned a struggle she had listening to the bartender mispronounce Pleistocene Court and her enjoyment of the names like Ann O. Ying, Anne Spector, and that, "D.S. Grundl was really helpful and he was really fun." Victoria accurately talked me through the story of the town, and that she was recommending to the real estate developer that he get the factory's septic system and landfill checked out as well as a fire that occurred in the boiler room. She also said, "I want to tell you that the interview part made the program seem very well put together....I was very impressed."

Clearly, Victoria had gotten some of the context she needed out of the town's story, and that made many of the details fit together for her. She was able to talk generally about the use of the soil sample exercises they did in lab in order to determine the length of time for contamination from Self-Lume to reach the town well. However, she still showed confusion about the relevance of the bedrock map to this potential flow and did not know if contamination from the gas station or factory could reach the well because of it. One small suggestion she had for the interface was that adding addresses to each visit pop-up box would help students note where they had been and save revisiting time and money.

Going back to lecture content, Victoria said, "With a lot of stuff in lecture...he explains it well but I don't always catch on.... when I go to lab Diane clears everything up." I asked her for examples. She said, "A lot of stuff...like the bedrock stuff...but during lab while making the map...it did help me understand it better, actually drawing it."

Victoria's partner relationship had taken a downturn since we last talked. Her partner had been giving excuses for not doing her portion of the work. Victoria bailed her out once. When it happened again, she confronted her partner and while things seemed to have since improved, their working relationship was still tenuous. One example was that her partner had the notes for Darcy's Law (the equation for calculating the speed of groundwater contaminants) while they were away on the fall break trying to write up the report. Still, she said, "Writing the report, everything came together…it was good." She mentioned that writing the paper took nearly twice as long to write as a typical paper, on the order of one hour per page instead of thirty to forty-five minutes per page.

Moving on in lab, she was wondering if a Phase Two investigation was coming up next and had trouble remembering the tests they had used that week to explore the septic system, underground storage tanks, and landfill on the factory site.

I asked her again about the lecture and lab connection. She said, "The topics relate better," and later, "When he addresses it [Brownfield Action] directly I find it kind of redundant…rather have him talk about topics that will help us with the lab than the lab itself."

I asked her what she was taking away from the class and she mentioned practical things such as, "When I fill my gas tank up," and, "If I ever buy a house with a septic tank, I'll know what to watch out for." I asked her to think about what she learned from writing the report. She said, "It was a clash between the two [modes of thinking]," and that might be why it took longer combined with the fact that she was intent on doing quality work because of poor performance on the lecture quizzes.

She was still struggling with the lecture quizzes. She had a new tutor who was not much help. I asked her about the source of this problem and she said the questions on the quizzes should be more specific if more specific answers were required. Her caveat was that it also depended on who graded them.

I asked her about big picture versus detailed thinking. She said:

> When I was writing my report it was about both because I was recommending these big picture things but I was backing it up with small details…. the people reading it don't know the huge amount of work that went into getting that small detail.

Then again, at the end of our session she commented:

> I love lab…. Brownfield Action ties everything together…lab gives me an incentive to go to class [lecture] but Brownfield gives me an incentive to go to lab…really impressed with how it all worked out…proud of my thing [report].

<u>December.</u> When we got together again in early December, Victoria was excited to tell me that she did well on her report. She felt the way she organized it was the strongest part of her work. She was surprised that people who did better on the lecture quizzes than her did not do as well on their reports. I asked to explain why this might have happened. She said, "While writing it a lot of things came together," and she was able to put her argument into her own words. She said:

> I want to credit Diane with helping me understand what was going on…at first it just built up because she explained everything from the start then at the end when she made it all tie together…she really went through step by step in the report, not like what we should write but what we should include and what we should keep in mind while we were writing it.

One concern she raised was that for all the effort she and her partner spent on the maps, they were only worth a few points and that seemed odd.

There was nothing further to report of consequence between her and her partner, so we went on to discussing Phase Two. Since the lab had not had a Phase Two prior to this year it was not surprising to hear Victoria say that Diane was unclear about what was going on and did not really clear it up until the last lab. Victoria talked about doing the Drilling and Direct Push tests, and she was unclear how she was going to write the Phase Two memo that was due a week later. At the same time, she thought the time spent mapping out the characters in lab as a group was helpful because she had missed a couple characters in her interview work.

Returning to the lecture and lab connection, Victoria said, "It's definitely connected and everything makes tons of sense." It also seemed logical to her that Dr. Bower had moved on to pesticides after the unit on groundwater. She was enjoying *Silent Spring* more than *A Civil Action* because, "*Silent Spring* gets to the point," and the questions are easier because, "It's all laid out." When asked if lab was still pushing her to attend lecture, she said she liked the pesticide content so she was more motivated about lecture now.

I asked Victoria what she would be taking away from the course and she mentioned, "Organic vs. non-organic, things I never would have paid attention to before," and that she would, "Question a lot of different things that I never would have questioned before." As an example, she brought up the use of pharmaceuticals saying that she now asks herself, "What will this do to me?" such as when she thinks about using a contraceptive pill. Instead of assuming that her doctor is right she will now question him or her, seek out resources, and be a better consumer. She, "Had all this loving trust in science," before this class. She did not expect this change to happen, nor did she think she would learn a lot from this course or to be able to apply what she learned to her life, but clearly she can and she has.

When it comes to Brownfield Action, Victoria says she got what she expected. However, she, "Didn't expect to have the light bulb moment that I did when I was writing it [the report]." I asked her how she might propagate more light bulb moments in the future for herself and she said she will have incentive to do it. She mentioned that because of this class she is aware of things in the world that have to be looked at, and that, "The tools from this class I can definitely apply to other disciplines." She commented, "In other papers I've become more detail oriented instead of assuming people will catch on eventually."

I asked her what she would tell others about the experience and she said she has, "A new way of looking at the world," that she now has this, "Other hat that I can put on to think differently," and that, "Scientists aren't always right." I asked her to tell me what the most important things about environmental science that she was taking away from the class were and she said, "It affects everything… it's not just recycling like I thought. It pulls all the sciences together to question and examine what you do….Environmental science is really important because it's in everything," and that, "Just like I analyze gender in everything," she can do the same with environmental science.

All in all she said, "I don't like science at all but as far as digestible science, this is definitely one…not just a requirement to get through, something I'm glad that I took…actually looking forward to second semester."

<u>Reflecting on Victoria's Case</u>

Some readers of Victoria's testimony might be inclined to say she was *blowing smoke* and not believable, but Victoria is one of the more naive college students that I have met. She really did think environmental science was about recycling and did not realize (or was not able to articulate) that while science may pay a lot of attention to detail, the goal of it is to solve broader problems. Victoria had trouble describing what she meant by her ability to think in a new way, but in the end she was able to talk about using detailed scientific evidence to make her case in her report, which she realized was a big picture argument.

Victoria was the lone student in my study to say that she benefited from Diane's practice of reviewing the lecture material in lab. Because Victoria struggled with the lecture material, it was crucial she had Diane to back her up, and yet still, Victoria had to seek tutoring assistance to survive lecture. In that way, it seems Victoria probably would not have had as successful experience in this course as she did if the lecture and lab were not well connected. As Victoria said, it was Brownfield Action that tied everything together.

Victoria found the process of doing Brownfield Action fun and engaging throughout. She appreciated the humor, had very few complaints, and did not seem overwhelmed at any point. However, Victoria did struggle with her lab partner, as did many students in the study. Victoria chose to confront her partner after two negative incidents, and got improved performance from doing that. Victoria discussed one of the best examples of how what she had learned from the course had affected her life directly. This was the most promising evidence that was she was saying was truthful.

Victoria represents a significant number of students in the course (and in universities around the country) who have strong humanities skills coupled with an innate belief that they are not scientists, cannot attain scientific skills, and should generally avoid science whenever possible. And yet, the Brownfield Action experience, with a supportive lab environment, gave Victoria a new sense of what she was capable of, which can now grow into a new side of herself that she can draw upon as she goes forward. Transformative educational experiences clear away barriers placed by years of non-transformative experiences that unnecessarily lock young people into believing in phantom limitations. Brownfield Action opened up a new avenue within Victoria that is not tied to her grade in the course or the details of the content she had to use. Even if she forgets all the details of the science she used in her report, Victoria will not forget the confidence in using science to make an argument that she gained through this experience.

Student 2: Michelle

September. Michelle is a third-year psychology major in one of Diane's labs. She says she studies psychology because she is interested in, "Understanding why people do what they do, why I do the things that I do." Michelle is considering a career in law or child psychology. She chose to take environmental science because she took the standard science courses (biology, chemistry, and physics) in high school and she wanted something new. She also identified that environmental science is related to law, although she is not really considering environmental law as a career option at this point. Michelle is concerned about the environment, calling herself, "Crazy into recycling." She added that she is, "Interested in how people contaminate and other people can get hurt by it." Michelle is also interested in education and spends time teaching and tutoring at the elementary school level. She said, "I like being around kids because I think learning is so fun....I just like to find out interesting things and share them with people." She is also fulfilling a science requirement by taking this course, and she is taking it for a letter grade.

When I asked Michelle if she saw any scientific traits in herself, she said, "I know I'm really analytical, but that doesn't have to be science." However, she did say she was meticulous, detail-oriented, and good at discovering, classifying, and organizing. In her mind, this course should be right up her alley the way it is structured. Still, she noted that, "More than the material, I think I'm trying to get down a technique for how to really look at things. I'm sure the material won't last forever, but the technique might." I asked her what she meant by technique and she said:

> The way Jan Schlictman [the protagonist of *A Civil Action*] is... he's kind of new to what he's doing, doesn't know what the procedure [is], but he's doing it all on his own...I just mean that we're figuring out a way to go about how to investigate, what things to look at, what's important, so that I mean it can be applied to a bunch of different situations.

When I asked her if she saw any of the humor in the opening stages of Brownfield Action, she said, "I thought it was so funny." I asked her if she thought it was an important aspect of the project or a distraction, and she said she was not sure but added, "I think humor is an important part of my life."

When asked about using a simulation for learning in this course, Michelle stated, "When it comes to learning, I think anything that helps you be more engaged will help you learn and the fact that you're doing something, you'll get something out of it, even if you're trying not to."

I asked her if she knew what the goal of the Brownfield Action project was, and she indicated she did not receive a good explanation of how to start off, which left her frustrated. "I know you guys don't want to tell us all the answers but I did expect to be told how to use the equipment," was her main feedback on this issue. One problem she ran into early on was that Diane seemed to be asking each company to do the Visual Reconnaissance tour repeatedly, and they were being charged each time.

Michelle was not cramming for this class as she might with other courses because of the weekly quiz format in lecture. She described the quiz strategy as, "Annoying, but it's very effective."

She saw lecture and lab as very separate at this point, and even within lecture, topics seemed disparate. She cited the difference between reading *A Civil Action* and studying the properties of isotopes and nuclides as an example. When I asked her to tell me the difference between lab and lecture, Michelle said, "The course [lecture] is more informational, the lab is more skills," and later that lecture, "Helps me appreciate what we're doing in the lab...Civil Action is really good because it makes see why the things we do in lab are so important."

<u>October.</u> When Michelle returned a few weeks later, she had just missed lab, which was supposed to be on the bedrock. When I asked how her partner felt about this, she said that she worked it out ahead of time and had done more of the work early on in the project anyway. I asked her if she had a good relationship with her partner. Her response was, "We work simultaneously...we just do the work, we don't socialize." I asked her if she was getting good guidance from Diane. Michelle indicated that she was not. She said, "The professor forewarned us that it was going to be ambiguous...ambiguous meant we won't know exactly what to look for," but Michelle felt, "It wasn't supposed to mean we wouldn't know *how* [italics added] to look for it."

It seemed Michelle was much more in tune with Dr. Bower. She explained, "What he tells us in class is more clear than what I actually hear when we get to the lab…when I get to lab…it doesn't seem as clear." She attributed most of this problem to Diane, adding, "My friends in Joe's lab don't love his teaching style but don't leave the room any more confused." I asked if this project would be going better if she had better instruction. Her response was:

> I definitely think that…I think I'm very cheesy when it comes to learning in general. I just get excited about learning something and doing something and I feel like a lot of that isn't there this time so I can't get as engaged.

Michelle had no complaints about the technology, saying, "The confusion isn't in the buttons, it's in the explanations you get for how to do what you're doing. " She was also not thrilled about the maps, commenting, "I appreciate it but as far as its usefulness and time commitment; once you get the point of what you're doing, you don't need to do it anymore…usefulness of something should be proportional to the time spent on it." The effort on the mapping did not seem to be matching up for Michelle. She went on to describe her mapping process at home, where she is multitasking several different assignments for different courses and other personal matters. She commented, "Because it's so much of the same exact thing, I'm less involved because it's so boring."

I asked Michelle for some more details on Diane's teaching strategies. She said Diane, "Talks for a long time but her instructions aren't all that thorough." It is not that Michelle thinks Diane isn't trying. In fact, it is quite the opposite. At one point, Michelle said, "She's [Diane] so sweet but I don't understand."

I moved on to asking Michelle about the lab quizzes. She agreed with Victoria's assessment that the quizzes were helpful, citing the quiz on the Visual Reconnaissance. She said, "It was good because it orients you…we didn't know what to pay attention to…made you use that information."

Humor had apparently been absent since we last talked, as she said, "I would like to say that I very much enjoy laughing, so if I saw any inkling of humor, I would seize it….With what we're doing now, I don't expect humor."

Moving on to the lecture, Michelle was more positive. She said, "I've heard a lot of mixed feelings about Peter Bower…however if you're talking about entertainment, he's it….He's lively….I'm very easily engaged in lecture courses." She stated that she looked forward to going to lecture and was getting something out of every class. When I asked her if the lecture was connecting to the lab, Michelle said that when Dr. Bower is talking about a topic that relates to the project, he mentions it. On the other hand, she also mentioned, "In a way I do feel like I'm taking two separate courses….I really find his explanations in class very thorough, just in general." For Michelle, the relevance of lecture to lab was mostly foreshadowing.

Michelle commented some more about how important *A Civil Action* was to her learning in this course, saying, "I really like Civil Action a lot." When I asked for specifics she mentioned the courtroom drama and that Schlictman was an engaging character. Then she returned to her technique comments from our last conversation.

> In lecture the way we look at Schlictman I see in his actions kind of a technique, when we talk about it class, the things Peter Bower talks about, it all comes together, but in lab section…I know what we're doing, but I don't feel like it's anything I'm going to do again.

I asked her if she could generalize any of the things she was learning to her life, and she said no, but added:

> I'm totally not in a position where I've given up on the project, I'm very enthusiastic about it, I am very busy…making the maps is the most annoying thing in the world to me…I'm so sure that once we're done with that [mapmaking] and starting doing stuff with them it will matter.

When I reminded her of her comment the last time that lecture helps her appreciate what she does in lab, she was surprised and asked to change *appreciate* to *tolerate*. Then she said she knew the maps were important, "Because of Civil Action, I know that, if we weren't reading that, I'd be 'Why are we doing this?'"

So far Michelle was hanging in because of the appeal of the lecture and the novel, but she was losing patience with the lab process and to some degree, Diane.

November. When Michelle I and met in early November, she has just turned in her Phase One report. She said, "I feel very relieved, very exhausted." When asked it was worth the effort, she said, "We'll see when my grade gets here."

I asked her about the separation between lecture and lab since that had been a key point she had made the last two times. She talked about the sediment test from lab and Darcy's Law, which she learned in lecture, and said there was, "Overlap there, that was nice."

She mentioned her favorite part of the investigation being the people's names in the interviews, although, "It seemed somewhat contrived because the names kind of gave away..." She talked me through her hypothesis about the factory's septic system being contaminated with tritium and that Shea D'Bisnez was likely the culprit because, "She denied it before you asked her about it - 'I didn't do it.'"

I asked her about her spending and she admitted that she and another group shared information to prevent having to overspend. I asked how difficult it was to share information, and she said she made printouts of most of the interviews, except the video interviews, all of which she tediously transcribed in order to share with others.

In writing the report, Michelle relied heavily on the Visual Reconnaissance for the physical description and used the maps in general terms. All in all, she said she spent between thirty and fifty hours writing the report and that this was not unreasonable. She wondered if the experience would have been improved by having different pieces of the report due at different times over the semester, claiming that she would have, "Put more attention into each section." I asked her if this might prevent students from putting it all together in the end, and she said, "I don't know, I only really saw every piece fit together last night."

Moving on to Phase Two, she was frustrated at not finding much useful data in the landfill and not understanding the transition to Phase Two. Speaking about Diane, "All she said was we were going to look at the areas where there was possible contamination, but we really didn't find them."

Going back to lecture, she was still very high on Dr. Bower but was clearly crushed by the ending of *A Civil Action*, saying, "I don't even want to talk about it. I was very, very upset at the ending of the book, I almost wish I didn't read it...I couldn't just say oh whatever, it's not real - yes, it is!" She was clearly very attached to Schlictman, who lost everything in the end.

Michelle had mixed feelings about the lecture quizzing, saying that although Dr. Bower was always very clear about what would be asked on each quiz that the grading was not consistent. Her best example involved a question that seemed to ask for a date from the book, but actually required additional information even though the question did not specifically ask for it.

I asked her about her partner, and she said she was relieved that, "When it got to crunch time we really worked together," and they, "Talked about their ideas," for the report.

From a larger perspective, Michelle had an interesting observation about how she was going about moving through the project. She said, "At this point I've given up waiting for help...I've just been like scraping and scraping trying to figure things out myself and I guess that was the point."

So even though she was not happy, Michele did figure out one of my goals for the project, which was that real life and good science are about knowing what to do when you do not know what to do next.

<u>December.</u> At our December meeting, Michelle began by telling me how her partner had basically abandoned her for the last lab. She was not that upset though because Diane had bent over backwards to make the Phase Two assignment clear. "She really wrote the memo for us, I didn't mind that at all, that was very clear and thorough," Michelle said almost sheepishly as if she had gotten out of some work.

When I asked her about how she felt about her assessment on her report, she said she heard Joe graded the reports much more leniently, but that she did fine anyway. She told me some of the positive comments she received included that her report was well written and thorough.

I asked her if the story of the town had become any clearer. She mentioned that the character mapping exercise in lab helped her since she didn't check all the characters but that no one has said if her theory about the factory was correct or had explained anything about the problems at the gas station. I asked her if she was satisfied with things being left somewhat unresolved and she said, "To me it's sufficient only because I was under the impression that the Self-Lume factory site was the most important so to just know that something went on over there [at the gas station] was ok."

Michelle was less positive about lecture than she had been in the past. She was disappointed in *Silent Spring*, stating that she needed more of a story to get her engaged in the material. I asked her if the fact that *A Civil Action* and Brownfield Action were narratives influenced her thinking on this. She said this was not necessarily true. Michelle generally finds narratives more appealing and that she had always been that way.

In general she said, "I'm not pleased ...I think my grade's going to be a 'B.' I put so much time into it [this course]." Her disappointment stems from her feeling that she stepped up her typical level of effort for this course, and yet her lecture test scores were most likely going to bring her grade down.

When I asked her whether or not the course met her expectations, she said:

> I kind of got what I expected to a certain extent because he gave us a big lecture on ambiguity, and I for some reason just imagined we were going to be on a scavenger hunt in the dark...we really didn't find that much of the information on our own, we were very much like 'go in this direction'...didn't do any major discovery on our own, very much guided all along the way.

When I indicated that her comment made it sound like she did not get as much as she expected, she said it was fine because she would not really want anything in her grades to be that ambiguous. She said that it would have been more fun to, "Hunt around," and learn more on her own, but she is so preoccupied with her grades that she did not want uncertainty. In her opinion, there was not much uncertainty in this project the way she experienced it. I offered that Diane tends to provide more structure in her labs, and Michelle agreed she got more help than her friends in Joe's labs. I asked for her recommendation on improving the guidance for the future. She said, "I wouldn't want to say less guidance," because of grades, but that Dr. Bower could minimize the emphasis he placed on ambiguity in his lectures since it was not really true in her experience.

I asked Michelle to compare this course's approach to teaching to more traditional science courses. She indicated that if the goal is learning, then the current approach was effective. If the goal is getting a good grade, then this strategy is worse for the student because getting a good grade in this class requires more tactics and one can not get away with working the system as much as other courses. Michelle said that by the third week of the semester it was clear that students, "Can't even withdraw even a little bit," and survive as easily using standard techniques.

When I asked her what she thought Dr. Bower's goal for the course was, she said:

> He said that in the beginning that he thought...his goal was to teach you things that will - you know - go beyond the exam so it's not just - you know - content driven, memorize these facts, but - like - lessons in a sense...things that you'll take with you.

I asked her if the class had to be run the way it was done to accomplish this. Michelle responded,

> Yes, almost indirectly....I'm a very different student now. I feel like the way college works, you can *get by*...this returned me to being a good student...I wasn't like, what do I need to know for the test...couldn't take that approach...helped me as a student...I told my mom you shouldn't use stuff on the lawn. I call them and tell them everything like did you know....pesticide stuff.

She went on to tell me a story about how her boyfriend got sick from spilling gasoline on himself, and how she was lecturing him on the various ways one can get dosed by gas.

Her expectation about developing a technique like Schlictman was not as fulfilled. She said, "Seeing how much guidance we got I'm not sure those skills were developed...we got told a lot."

When I asked her about using the computer and the simulation for other courses, Michelle said, "It depends on the goal...if the goal is to discover thing on your own, leave the computer as it is and get less guidance from Diane." She even offered her own teaching strategy for the introduction to the project, saying, "This is the case, you have this contaminated property, it's your job to find out how contaminated it is and how to clean [it up]." She then suggested the instructor could give a few suggestions, but, "Then we would have been able to find out about Direct Push [for example], so in that sense we'd be developing more skills." I asked her how this would work if several groups set off in different directions with their investigation, but she was confident it would not have changed what people did all that much. It just would have been, "More fun."

Michelle's closing comments about environmental science focused on the awareness she gained from the class. She said, "I think people to a certain extent people recognize that nature exists...but we really, really take it for granted...the environment is interactive...[we are] really, really dependent on it." I asked her what the major factor was that contributed to her gaining this perspective. Her answer was not surprising. "Professor Bower, the way he lectured, like he didn't just give us information and percentages and figures, those kind of illustrated, those weren't the focus of the discussion, he put things in perspective a lot." She then described more examples of how the lectures affected her daily life. The lectures inspired her to go home and check her detergent bottles and to think about the need for people's right to not be poisoned to be recognized as other rights are in the Bill of Rights.

I asked her what the bottom line impact of Brownfield Action was for her. Michelle said, "You can have a lot of information and not have it mean anything." Brownfield Action, "Put a face on what we were talking about [in lecture], showed you how it happened and what can be done, different than Civil Action because there was control [on the part of the student]."

One small suggestion she also mentioned at the end was to have a lab quiz on the instruction manual to force the same kind of attention to detail on that document as the elements within the simulation in order to reduce confusion about the power of the computer application.

<u>Reflecting on Michelle's Case</u>

Michelle was a tough but important case for this project. Her biggest contribution to the project was that she is aware that she uses techniques for beating the college system. Michelle's stated goal was that this course would give her a generalizable analytic technique in spite of the tactics she knew she would employ. As one of the older students in the study, Michelle had the maturity to step out of her role as the student doing what she needed to do to *get-by*, and talk about the project from a more idealized point-of-view. At the same time, her actions in the course suggested that the *get-by* strategy was too ingrained in her to avoid completely.

Michelle developed more awareness of environmental issues due to her engagement in the lecture, but it is unclear how much Brownfield Action helped Michelle develop analytical skills. Michelle's claim that if she had not been given so much help from Diane seems to hold some weight. It is plausible that had she been in one of Joe's labs, that his style would have forced her to do more work on her own and gain more from the lab experience. At the same time, Michelle was one of the few students to identify that this project taught her something about what to do when she was not getting the help she needed. In some of her comments, it seemed like she was not getting told as much as she would have liked. This train of thought was Michelle pining for the path of least resistance that she had been trained to excel at through her prior schooling. This training may have been against her will, as she was also the lone student to identify that this course brought her back to some of the traits of being a more idealized student who was engaged in material for the right reasons and not just grades.

The undercurrent of the conversations with Michelle was that she wanted to be that more ideal student who studies for learning's sake, but she seemed to acknowledge through her actions in the course and her comments that the traditional student path was like a tractor beam with its gravitational pull towards the easy way out. It is completely possible and all too common for today's college students to coast through their studies having only experienced the surfaces of what could have been deep, personal, and possibly transformative experiences. Michelle was mature enough to see that she was playing the role of the student in the bureaucracy of college, and expressed a desire to rise above it. Brownfield Action gave her a taste of real engagement, but could not completely overcome the ingrained well-oiled machine built inside Michelle by years of academic institutionalization that breeds the surface level *get-by* approach.

<u>**Student 3: Josephine**</u>

<u>**September.**</u> Josephine is a third-year religion major at Barnard who is considering international politics as a profession. She is in one of Joe's labs. She is taking this course because she liked

earth science in the past and environmental science seemed close to that. She is also fulfilling her science requirement by taking this course. Josephine's friends told her that when they took this course, they did not like Brownfield Action and that the amount of lab work scares many people. She also heard through the grapevine that the class was less scientific and more sociological than the other science options. When I asked her to describe herself compared to a scientist, she said, "Someone told me I'm not methodical enough to be scientific," and she identifies science people as more studious than her and better at memorization. She also said, "I'm a little more idealistic," and less practical than science people.

When I asked her how the class had been going so far, she said the class seemed more humanitarian since the point of the lab project was to help people. She thought this was atypical and that her past science courses had been more divorced from life or reality. I asked her how this might benefit her and Josephine responded that the class might make her more well rounded and added, "Hopefully I'll be able to gain some real-world perspective." She also hoped it might make her more studious, but she did not expect the course to make her into any more of a scientist.

Josephine appreciated the weekly quizzing format in the lecture as it helped her pace her effort. As for the early stages of lab, her main comment was, "It was kind of fun, reminded me of *SimCity*, that video game where you are the mayor, so far so good." She went on to identify the main objective of the project as her assignment to recommend whether the factory site be purchased or not based on her investigation. I asked her how she felt about working with a partner, and she said she was concerned about it because her partner seemed uncomfortable making decisions and reluctant to spend money within the simulation. When asked about the introduction, rather than focusing on the humor as many other students did, Josephine said, "The video made it more familiar." I asked her if her *SimCity* comparison was a positive correlation or a negative one. She told me that she was really bad at *SimCity*, that she typically spends all her money without thinking about what she is doing knowing that she can always restart the game. She did not think her behavior in Brownfield Action would be the same because, "Having a partner forces me to consult."

While Josephine was not sure what she would get out of doing the project, she mentioned that it, "Looks really realistic, you're hired to do something." I asked her if realism was important to learning, and she agreed. She also pointed out that when it comes to the computer, graphics are a key factor and that the process should be fun. It was here that Josephine suggested that humor could play a role as well since in her opinion, "Humor keeps people interested, makes people lighthearted."

The bottom line of the course is that it fulfills a requirement for her, and that her tendency would be to just try to get all the tasks done and not concern herself with too much reflection. She did not see how any skills from the class will translate into her life. However, Josephine was one of the rare students to identify a small early connection between lab and lecture with the topic of exit signs, saying, "The whole idea of Self-Lume company and how he talks about exit signs." No one else in the study seemed to have caught this foreshadowing remark by Dr. Bower. She was referring to the fact that exit signs have traces of radioactivity in them and Self-Lume made exit signs.

From an environmental science point-of-view, Josephine is interested in radioactivity, nuclear chemistry and their relationship to her possible career plans in politics. She identified, "We really don't treat the land very well," as the main message of environmental science.

October. At our next meeting, Josephine and I began by talking about how the lab was going. She was concerned that her maps were sloppy but pleased that the testing was easier than she expected. I asked her if the certification testing process played a role in that, and she said, "I liked it," referring to the SRR and topography certification tests. She said, "It helps a lot before actually going in and performing the tests." Josephine was able to draw a quick sketch of the topography from memory and remembered the name of the bedrock test as SRR and how it basically worked.

Josephine and her partner had gotten to know each other better since our last meeting, so that relationship was more comfortable. They were not overspending since the costs of the tests seemed reasonable so far. One unique concern that she pointed out was they did not know if they were allowed to test on top of buildings. When asked if she and her partner had developed any strategies for the investigation, she said they were still following orders and doing the fundamentals.

When asked about Joe, Josephine had several comments, including:

> People said he was mean but I'm going to try to close my ears to it…one day he was really happy with our progress or something…I kind of like the fact that he isn't over our heads telling us 'do it like this…do it like this'…independence helps you grow as a student.

She could not identify any downsides to his teaching style except to note that he gets annoyed when teams talk too much. All in all, she said, "I enjoy going to lab a lot more than I thought was." When I asked her what the major factor was, she said it was the project because it was interesting. She mentioned no one had been complaining about it as she expected would happen and wondered aloud, "Am I weird because I like it?" She talked about how quickly the three hours goes in lab and that she and her partner had a tendency to try to finish as quickly as possible and probably should pay some more attention to neatness when it comes to the map. Josephine was still high on the lab quizzes, stating (as many others did) that the quizzes pointed her to what to pay attention to.

The one complaint she had about the technology was the lack of a mouse attached to the laptops in the lab.

Moving on to the lecture, Josephine pointed out that the recent lecture on groundwater was the most relevant so far, but that overall the lab was better than the lecture because it was, "More hands on." When I asked if the radioactivity lectures had any relevance, she said that while there was a connection to the Self-Lume site, "He didn't tie it in…not as well as the groundwater lecture."

In talking about *A Civil Action*, unlike Michelle, Josephine was not relating to the main character or to the story as much. She talked about how Schlictman hired many people to do the jobs she was doing in Brownfield Action, and that she did not feel as connected to the characters in Brownfield Action's town (Moraine) as Schlictman was in Woburn.

We went back to her thoughts from the first meeting about gaining real-world perspective, and she said, the lab made her think, "In real life you don't always get things done right away…you have to wait…it's like real life experience…a progressive thing." She went on to describe how students have to get used to this and dealing with people and trying to think about the project as if it was a real town. The process is not like reading a book, answering questions, and then being done as is more typical of her other courses. When I asked her if she still felt like she was just fulfilling a science requirement, Josephine disagreed, saying, "Moraine could have been our town…you don't think about what's being produced." She then went on to describe her concerns about how the majority of our water is contaminated and her desire to do a real investigation or to see a real one in action, especially one on nuclear power plants (she had seen a television special on problems with Russian reactors). She was still unsure how her actions might be changed by this course, but she said she was definitely thinking about these issues as she drove around the greater metropolitan area.

November. When we met in early November, Josephine has just turned in her Phase One report. She joked about her back being cramped from hunching over and said, "It's a great sense of accomplishment having it done…think the maps turned out really well…not really sure about the report." Her uncertainty stemmed from not having specific guidelines from Joe about how to do the report and the fact that she and her partner did the work completely separately although they came to the same general conclusions.

She talked me through the expected areas that needed further checking around the factory site. She was concerned about tritium dumping in the septic tank, saying, "Just in case people were throwing things down the drain, I'm sure people can get a little sloppy." Josephine also explained the relevance of the soil sieving exercise that they did in lab to Darcy's Law in order to determine how long it would take contaminants to flow from the factory to the town well. She pointed out that Darcy's Law was, "The most complicated thing I've ever learned."

I asked her about the interviews, and she said her partner did them all, sharing the costs with another group and gave her the notes. She said this made it difficult for her in that, "It was hard because I didn't hear them [the characters in Brownfield Action] say it." She mentioned that the people's names were helpful clues, but that she basically missed out on an entire side of the project. When asked about the actual writing of the report, Josephine said she struggled to figure out how to begin with the style, that she tried to do it scientifically, which in her mind meant cutting it down to the point. Her report was shorter than most, just ten pages, and she spent relatively little time on it (four hours). She said, "I didn't feel like it was that difficult to put it together."

She mentioned her concern that Dr. Bower talked about septic tanks recently but that some labs could not include that information in their reports because they were already turned in. She suggested a set due date for all the lab reports rather than staggered due dates based on the day students had lab.

Josephine was proudest of her maps, so I asked her if the effort of making the maps took away from the game-like aspect she identified early on. She agreed and added that the amount of busywork in general contributed to that feeling as well.

Returning to lecture, she said she learned Darcy's Law better in lab and that the end of *A Civil Action* was, "Frustratingly annoying," and later, "Towards the end I felt like I was in law class." When I asked her if it helped her complete the Brownfield Action project she disagreed, saying, "All it was…somebody sort of similar…if it didn't start with medical perspective it would have been different."

When I asked her what she got out of the project, she made several comments. The project, "Makes you more aware of what's going on around you," and it is:

> …a responsibility you have to take on, which was really helpful…makes me feel better because I think I work better in more realistic, even though I said at the beginning that I wasn't a realist, I don't know, I think I work better under these - it wasn't just analyzing, it touched you more…than reading about literary criticism sort of like made up, academic, you know real…I'm sure it's happening all over the country or all over the world where people do this kind of stuff.

I asked her what skills she got from doing the project so far and she talked about learning to write differently, saying that, "Getting to the point, think clearly, start thinking…can't make it up…no one has to believe you in literary situations, it's what you believe." Her biggest comment was:

> I have a feeling if someone read my Phase One [report] and wasn't an expert I have a feeling they would understand it better than if someone read one of my religion papers [because] people care more about this, it affects people's life.

Josephine had not talked about Joe at all this time, so I asked how that had been going. She again repeated that she liked Joe's style, but mentioned that he, "Started annoying me… we were really confused about something and he really wouldn't help." Then later he said, "You guys are slow," and she was really bothered by that comment and his comment, "You guys are going to take forever."

I asked her about the lecture/lab connection and she said they were separate because in lab, "All I was thinking about was I have to write this report," even though she admitted to using lecture notes to do it. In lab, she commented that she could have used, "Some hint that said what this lab meant in the big picture…people kept losing that." Then contrary to her focus on writing the report, she said she, "Pushed away the idea that I would have to put it together." I asked her about these opposing viewpoints and she said she was tired and that while the whole idea of the project was really interesting, "It sorted of ended up becoming just like any other final lab like a dissection…standard procedure, standard experiment you would have to do."

<u>December.</u> When Josephine returned in December, she was shocked that she got a good grade on her report since she did it at the last minute. She felt she did well because it was, "Well organized and got to the point." Her concern about not writing enough pages ended up being a strength in her opinion.

Moving on to the Phase Two work they had been doing, Josephine said it was not working out that well to work as a larger group because:

> People who aren't as motivated sit on the sidelines and the really bossy people try to get in…one girl who was so overbearing and she was too busy trying to figure out if she was right instead of helping us.

She said the same people were taking command of the lab each week and that made her not want to pay attention. She tried to position herself to be one who did the testing because it was more fun than plotting data on the maps.

I asked her if the situation with Joe had improved, but it had deteriorated further. She said, "He isolated me and said I bet [Josephine] doesn't know what she's doing and I felt like, 'Thanks a lot Joe for letting me know'. Two girls jumped to my defense. When I work I tend to talk, annoyed by that whole thing."

We began talking about lecture and the book *Silent Spring*. She said it is, "More of a scientific book, she [Rachel Carson] writes really well, she's not difficult to understand…questions are easier because they're more straightforward." I asked her if she still preferred lab to lecture, and she said they flipped over time due to the momentum lost after turning in the Phase One report (and probably because of Joe's remarks, although she did not mention that at this time, she was clearly disheartened by that).

Looking back at her expectations, Josephine said the realism wore off and that she was annoyed at having done so much work. She agreed that working on the interviews herself, "Would have made it more realistic." I asked her what she got from the project. Her basic response was awareness, but then she added, "Now I can sort my thoughts, more defined, clear…a lot of what we had to do was associate things." She gave the example of understanding the Self-Lume trucks use diesel fuel so those tanks could not have contaminated the town's well. She then went back to her writing comments, saying, "The fact that I have written it so differently than any other report," was important to her.

I asked what made the most impact on her in the course and she said Rachel Carson's book (*Silent Spring)* because, "I see direct effects on animals and humans…something that would affect me and my children." She did not relate well to *A Civil Action* by comparison. She said it seemed isolated since she had never lived near a factory

I asked her what she thought of the way the course was structured, and surprisingly she said, "I like it the best." When I asked why, given her other comments, she said that typically:

> You dissect and you walk away and that's it, like this keeps you involved, like I have a better appreciation of labs, each lab is relevant and was a building block of a bigger thing versus like me leaving and saying 'What did I learn?'

She added that this kind of a class had the most potential. She said, "I wish second semester had something sort of similar but a little bit better." I asked her what the benefit of this type of a class was where the labs accumulate over time. Her response was:

> ...that you don't forget, that you somehow keep relearning and building a bigger thing...have to learn to associate, you know ok this happened in lab 1 and now we're in lab 5 and 'oh my god that happened in lab one', so I don't forget.

She added, "This is the most I've ever done in college," and that she was concerned about getting a job in the, "Real world," because, "I didn't feel like a student. I felt like a employee. Joe was my boss and I had to be sure my boss was happy with my results." I asked her if the lecture helped alleviate that feeling at all. She said the lecture was more academic, but that in lab she never really thought about lecture or Dr. Bower. In her mind, the parts of the class were, "Perfect in their own way," and not overbearing on each other.

One additional accomplishment she was proud of was the knowledge that she is able to construct a map and perform something like a Phase One investigation. She also added that the interview process with me was therapeutic for her because it allowed her to get her thoughts out and reflect.

Reflecting on Josephine's Case

Josephine's case might appear confusing because up until the end of the last session, one might assume she had a primarily negative experience. Yet in the end, she said this project was the best way to run a lecture/lab course. She identified that she learned a new way to write and that the structure of accumulating labs helped her retain more knowledge than she would have otherwise.

Clearly, not participating in the interview portion of the project caused Josephine to withdraw from her role in the simulation and turned the project into more of a standard assignment. She may have been the most engaged in her role out of all the study participants at the beginning stages of the project (recall her concern about testing on buildings and her comments about people who, "Can get a little sloppy," which show empathy for the fictional characters). However, she also identified later on how she did not know the characters of Brownfield Action as well as Schlictman knew the people in Woburn. The interviews could have done a lot to maintain Josephine's engagement in the simulation world.

Josephine was happy with the way the course was structured and is not walking away empty-handed, but falling out of her role in the simulation and Joe's insensitivity towards the end of the semester took away a significant portion of the experience for her. Josephine's experience points to the importance of all the factors of a simulation working in unison. Josephine demonstrated an understanding of the data model, or simulator, and she deduced the causes and effects that occurred in the town in putting together her report. However, the narrative broke down for her mid-stream because she compromised the integrity of the full experience by allowing her partner to take over the interviewing. It is no surprise that making this choice removed the very aspect of the project that she said was most important to her: the realism. Simulations need enough realism to allow the participant to suspend their disbelief and buy into their role in the narrative. In Josephine's case, the exigencies of college life and the partner dynamic she developed led to certain choices on her part that minimized some of the potential impact of Brownfield Action. These choices did not ruin the experience, but instead changed the arc of the path that this project tries to lay out.

Josephine's experience also shows how much control of the experience is in the hands of the students and how their ability to think and reflect about their experience is a learning process going on at the same time as their academic pursuits. At the very end of her last interview with me, we discussed how spending a few hours with me spread out over the semester was therapeutic and helped her sort out what she was getting out of the course and where she was headed in life.

College students are beings-in-the-making. They are young adults learning how the things they say and do are coming from them and not from anyone telling them what to do. College is the time for self-realization and self-actualization, the start of figuring out what one wants separate from what anyone suggested one should want. These young women are coming into their own in the midst of complex learning opportunities such as Brownfield Action in the midst of a complex bureaucratic machine known as college in the midst of one of the world's most complex metropolitan areas. Contradictions, hypocrisy and constant mind and taste changes are to be expected, and no survey or controlled learning experiment is going to be able to explain these things if they even pick up on them. To me, Josephine's rambling manner and inconsistent statements suggest she is right in the middle of this transformative phase of her life. Her approach to life is in formation and the experience of Brownfield Action was subjected to the same kind of experiment for her as everything else in her life. She tried diving in at first. Later she withdrew and compromised. In the end, through reflection, she realized she was walking away from this experience with many tangible gains and was thankful for it.

Student 4: Janet

September. Janet is a first-year student from the Northeast. She has not declared a major yet, but she is interested in political science and political theory, especially in the area of education and the environment. Before coming to Barnard, she taught environmental science to inner city children and thought it was a great experience. Advanced placement biology was her favorite course in high school, and she sees herself as somewhat of a scientific thinker. She grew up thinking she would become a biologist, but has since shifted to wanting a position related to science that has more of a community role. "I want to make things better," she said at one point, though she seemed to feel a little silly saying it. Janet's lab instructor is Diane.

When I asked her what she thought she would get from this course, Janet said she thought she would get different things than what she expected when she signed up. She said:

> I thought I was going to get more science-based knowledge...I feel like the course is more directed to more the policy aspect, which is good. It's what I'm interested in but it seems to be less doing of actual - less of a hard science, more of an interpretative science, more of a social science...definitely like it...don't think I'll get as much of the hard science, which I would have liked.

Janet was disappointed in how the lab was starting out, saying, "It's the most tedious thing that I've done." Diane's pace was clearly too slow for her, as evidenced by this example:

> Diane, she literally takes an hour on where to get a poster tube. She'll repeat the directions numerous times. We don't need her to do the sheets with us, ends up taking twice as long, not actually doing them…can get away with not knowing anything….As a test I decided to do all the sheets while she was doing the directions…I did it in the time she did the directions.

Janet had no issues with her lab partner except that it seemed they might have trouble matching up their schedules. She enjoyed the introduction to Brownfield Action, saying it was, "Fun to pretend you're investigating," and that, "It [video] was a good introduction." She was not sure what the goal of the project was beyond simulating a Phase One Site Investigation, but she was comfortable not knowing. She said, "I wouldn't like it if they [lab instructors and Dr. Bower] just told me."

As for using a computer simulation, Janet was positive with her comments. She hoped the computer would be a good tool and resource that would mix up the dynamic of the class and allow her to, "Deal with material at her own speed." When I asked her what she might get out of the project, she said:

> I hope I get a sense of what an applicable use of environmental science would be…a lot times we do stuff in school where you just kind of get information and have to regurgitate it and it's not like, like you know, you are learning stuff that can be useful in a conversation or building contextual background for reading a book…but here's more of a clear application for what I'm learning.

When I asked her if she thought she might gain any skills, she was not sure, but she hoped she would, "Get more comfortable with using technology." Later she added:

> I think that it'll definitely give us a chance to use those analytical skills…we're kind of solving a mystery…we have a lot of information right now…and sort or sorting through that data, figuring out what's important and what's not."

She also pointed out, "You're going to get a lot of stuff and you have to figure out what's important and what to ignore."

When I asked Janet about maps, she said she often refers to them but that topographical maps are new to her. She commented that so far making maps had been really tedious and yet, "There's a difference between having something handed to you and having to construct it."

Looking at the connection between lab and lecture, Janet reported that Diane often repeats the lecture material unnecessarily while Dr. Bower had rarely mentioned Brownfield Action up to that point in the lecture. Clearly, the biggest adjustment for her in the lecture was dealing with the softening of the science in favor of more policy and social issues. "For me coming from a hard science background, I see that he's choosing to not go in detail…good balance because we talk about nuclear reaction interspersed with more policy things." As for *A Civil Action*, Janet thought it was strange to use a novel as a textbook with study questions. Her first reaction was, "Am in seventh grade?" On the other hand she appreciated the connection between this real-life story and the lab project, saying that it was, "Fun to get into that mindset, of being the lawyer, investigating this…it's nice to have that to think about…it's good to have that supplement…foreshadowing of what's going to happen."

Janet saw the weekly quizzes as a chore and would rather have had less frequent testing and in general less handholding. She saw how the pedagogical strategies being used help those who are less motivated and interested, but from her point-of-view, she would rather have had more independence. She said the workload of this course compared to other classes was comparable in terms of time commitment but was less difficult.

In the end, she was still hopeful that the course would give her insight on environmental issues such as material and land usage, but it seemed clear she needed a more hands-off approach.

<u>October.</u> When Janet returned in October, we got caught up on her progress in the lab. She was upset with other groups for not being systematic with their data collection, but admitted that the, "Directions were not that clear…it wasn't straightforward." She was also disappointed in her partner, who to this point was not doing her share of the work on the maps. I asked Janet why they had to make the maps. She responded that they needed the maps to, "Determine the site,

the lay of the land, see the relationships, get a visual idea, put picture to numbers." I asked if this could be accomplished even if the maps were just given to her. Janet said, "We wouldn't look at them as much if we were given them," and later, "I think it's useful to construct the maps, but it's time consuming for what it is." She added, "I wouldn't know the map as well," if she did not have to make them, but she was unclear if knowing the map well was necessary to do the project well. Janet could not draw me a sketch of the topography map, saying her partner made the contours after she plotted the individual points. She knew that the tool to collect bedrock data worked like sonar, but could not remember the name of the tool. Janet was still frustrated with Diane's slow pace, saying, "The directions took so long, it ended up a lot like her telling us the answers," in reference to the certification exams. I asked her if the exams were worthwhile. Janet said, "I definitely learned more than otherwise," and later, "I'd rather spend the time learning what I'm doing than plotting the points."

As for lecture, Janet said it was giving her the big picture while lab was more specific. She struggled to see the relevance of *A Civil Action* beyond it being, "A similar application to what we're doing." She admitted she had read the story before and seen the movie, and thought the legal material was more or less irrelevant to the course. Since we last talked, Janet seemed to have adjusted to the weekly quiz structure and was less annoyed with it. One concern she did raise was that the lecture quizzes had detail requirements that did not seem to match up with the broader approach Dr. Bower was taking in the lecture. When I asked her if the workload was still comparable to her other courses, she said, "It's different, it's more spread out. I don't have like big assignments, lots of little things." I asked her if any part of this course was any fun. Her response was, "I have appreciated the corny nature of it," referring to the people in the newspaper articles that are part of Brownfield Action. I asked her to elaborate on the lecture/lab connection. She said, "By the end it will come together...I'm assuming...things we're doing in lecture will have relevance but we're not there yet."

I asked her if she had any new comments about what she might get out of the class. She repeated her desire for a real-life application of environmental science, but she added it was turning out to be, "A sense of something, this is something that's relevant, the topic, the project, it matters, I tend to get very wrapped up in current issues, everywhere we go there is this kind of pollution." I asked her if this approach was appropriate for a non-majors science course. She said:

> It's really important especially because it's something that's tangible to take away…a lot of the people that take environmental science are not the hard science people and so that's a way for people to grasp on to it….I think more of the people in the class have more of a humanities brain than a science brain, therefore you should speak to those people.

She went on to say that the course was, "Tying science into real life," and used the example that, "There is poison in the air you are breathing right now." I asked her why this kind of teaching was better for humanities brains. Her response was that people are, "Better at socially abstracting than scientifically abstracting."

Looking back at her past comments, Janet returned to her frustration with Diane, saying that she was forced to stay in lab an extra forty-five minutes in order to see a two-second demonstration. In her experience, Diane's poor teaching practices made, "Simple tasks become so confusing," despite her good intentions. I asked if Diane was the main problem with the lab experience. She agreed, and added that her friends in Joe's labs had different problems, but they were not being handheld as she was.

<u>November.</u> Janet started out our next session talking about how her partner had been stepping up her performance lately. Her Phase One report was in her school bag, ready to turn in. I asked her how the report writing went. She said, "I feel like I could kind of get away without knowing a whole lot," since all she had to say was more investigation was needed. She took me through her recommendation that the death of Mal Sangre and the septic system be checked out. When I asked if it had been any fun since we last talked, Janet said, "It was definitely interesting…yeah it was cool." I asked what had changed that left her feeling more positive, and she mentioned that Diane had backed off and been more flexible in recent weeks. Also, her friends in Joe's labs said lately he had been mean and made them feel stupid.

Still, writing the report was tedious and painful, and she felt like she had to stretch her paper to get it to the minimum ten pages. She said it took her about fifteen hours to write the report, and she did it completely separate from her lab partner. I asked her what the report writing was like. She said, "You have to put everything together…it's like a glorified lab report."

It was at this point that Janet told me that she was traveling with a friend who was in business school at another university, so she showed her the Brownfield Action work she was doing. She said her friend joked, "'Oh so you're playing computer games, I'm glad your college money is going to good use.'" Janet's response was somewhat surprising. She said, "But then I said, 'No it's good we get to see what the tests are like'…I got to defend it [the project]." I asked her if this gave her any different perspective on the project, but she was noncommittal.

Janet had some new thoughts about the mapmaking from our last conversation and was convinced that, "If I would have had points on a map and drawn the contour lines, I would have gotten just as much out of it."

She did not have much to say about lecture, except that, "It's always sort of relevant." Recently, she thought it was strange to ask students to read 160 pages of *A Civil Action* in one week after such fine-level focus in earlier chapters. I asked her if the course still made sense to her. She agreed overall, but said there are, "Lots of little things that could be shaved."

<u>December.</u> When we met in December, Janet was feeling good about her report and her partner. She had done well on her report. She said, "I think the way I organized the paper made it clear," and she and her partner evened the work out towards the end of the semester.

Moving into Phase Two, she was unclear how she was going to get the memo assignment done since the groups in the lab did not share their info from the last class. She saw Phase Two as mostly a way to fill up the last three labs. She was somewhat displeased that they were not told there would be an additional writing assignment for Phase Two, and pointed out that Diane was not as engaged in the last few labs and seemed to not want students to have to do the Phase Two memo individually. This made Janet think it would not be graded too hard, so she was not going to put in much effort. Given the choice, Janet would have rather had the class do it as a group since they spent so much time talking about how to do it anyway. In general, she said she had gotten used to Diane's teaching style and liked her as a person. I asked her if she would stay with Diane in second semester. Janet said she was going to take a more difficult climate class to get more of a challenge.

With regard to lecture, Janet had found *Silent Spring*, "More relevant than *Civil Action* because…now we're focusing on pesticide use and land use and how people use and think about pesticides," and that this was a better argument than the, "Corporations are bad," focus in *A Civil Action* and in Brownfield Action. I asked her to elaborate on this comment since it seemed it was unique to her experience. She said that when she taught environmental education, her trainer said something to the effect of, "Don't harp on social justice and environmental issues because that's so easy." Janet's trainer instructed her to emphasize issues that affect everyone but that people do not comprehend so easily. Janet said those comments, "Really hit home with me."

I asked her if she still felt like she got away without learning much. She said she had a lot of background in this area, but her general feeling was, "Why didn't everyone get a hundred because all you had to do was piece everything together?" Then she mentioned how her partner lost points in her report for putting in extra material that was not required whereas Janet knew from her experience with the quiz grading that she was better off just doing exactly what was asked to get a good grade. I asked Janet if she was good at beating the system. She said, "I didn't realize this [course] was the easy way out of the science requirement for a lot of people," and that people who did not use her approach may have gotten more out of the course than she did. She thought her partner actually wrote a better Phase One report than she did, even thought Janet got a higher score.

I asked Janet if her overall impression of the project and the course was positive or negative. She said, "Overall I feel like I put a much more negative spin on it [than it really was]." She said her partner and her often joked, "We should clean up Moraine," and that they got into deciphering all the character names. When asked what she got out of the project, Janet said it fell short of her expectations, but, "I did get a general base of application for environmental science and some general problems I guess I'd say of contemporary society's use of toxics." This was in spite of the tediousness of the work. She also spoke positively about doing a project with map work, saying, "It was good to do something related to the maps, like, that I'm glad I had to do something like that and see what goes into that." I asked her if this was also true about writing a Phase One report. She agreed, saying, "It is a skill to be able to put together a straightforward report." She called it a, "More concrete type of writing."

She then added a more personal story about her grandfather dying of cancer and the likely cause being pesticides because of his work as an etymologist. From the class, Janet said, "I gained more of a sense of the importance of understanding the chemical aspect of it, the more technical, although I didn't gain a perfect understanding. I want to gain a perfect understanding," so she can argue for change in environmental policy from more solid ground than the, "Corporations are bad," point-of-view she mentioned earlier when talking about her environmental education experience.

When I asked her about using simulations, her initial assessment was essentially unchanged, except she added it would have been nice to supplement it with real experience outside, even if it was loosely connected. Alternatively, she agreed with me that having an outside consultant come in would have been a good addition as well.

I asked her if she would look forward to another class with a lab project that accumulated over time as Brownfield Action did. She said:

> Yeah, I think it's really useful…you get to look at lots of different aspects of the same problem, so you're doing the same discrete things but they're connected so you have a sense of why it's important.

Later on she added, "You have to keep coming back to it," referring to what she had learned in previous labs. I asked her to identify any disadvantages to this type of educational strategy. She said, "It can become less - don't know the right word - spending two minutes on this part and two minutes on this part - but ways to solving it, not looking at it deeply, not enough weight to the various topics." She realized the simulation environment allowed the class to do things they could not otherwise have done, and added, "A lot times simulations aren't real but this makes it more real."

Finally, I asked her what the critical environmental science messages were from the course and the project. Janet said:

> It [environmental science] does affect everyone and it's relevant. It's not just an issue for bleeding heart liberals…there are things you can do in your everyday life and in the attention that you pay that can positively affect the environment and yourself.

From Brownfield Action, she said the main message was to, "Look critically at where you live."

<u>Reflecting on Janet's Case</u>

Janet's case provides an interesting example of a first-year student since she came into the class with more environmental science background and more confidence than many of the other older students. She clearly would have benefited more from a Joe-style lab where she had more control over what she was doing and less handholding. As it was, she had a similar experience to Michelle, in that Diane's guidance made it possible to fulfill the course requirements without much of a challenge.

Janet's method of evaluating the course and reflecting was to separate herself from the standard students who were not comfortable with science that she saw around her. She often discussed how the class worked well for other students and that this class was generally beneath her abilities. Perhaps it was targeted for students with less science aptitude than her, but she still did not walk away empty-handed. She identified mapping skills and writing skills and enough experience in a realistic example of an investigation to inspire her to want to get more into details of the science behind these types of environmental catastrophes. She came into the class wanting a real-life application for what she was learning, and she received that. The problem was she at least believed she did not really have to figure it out or work very hard.

Still, Janet's willingness to admit towards the end of the last interview that she was characterizing the course and the project much more negatively than she really felt says something about her ability to be honest about her experience once out from underneath the weight of it. We have to remember that Janet is a younger student and that it should not be surprising that her comments while in the middle of the experience would be less nuanced than someone like Michelle, who was able to step outside of her student role and comment on the context of the college system. After the experience rounded out, Janet seemed to reflect differently and realized that there is a larger endgame at work with the project than just a series of assignments that on their own might not carry much challenge with them.

Janet's story about her grandfather points to her motivation to want to take advantage of the strengths she sees in herself to engage in more challenging science that lies beyond what this course tries to delve into. This idealism in her to make the world better and contribute to something that affected her family very directly is a deeply held conviction that has the potential to drive her to a great contribution to society through science if she continues to foster it. Her experience prior to college that showed her the value of science in the context of human lives only augments her potential further. Many people never achieve that kind of insight at any point in their lifetime.

<u>Student 5: Akira</u>

<u>September.</u> Akira is a first-year Barnard student in one of Joe's labs. She has not declared a major but is considering economics and political science. She loves the political theory course she has this semester. As we talked about science and traits of scientists, Akira had a tendency to compare herself to her sister, who recently graduated from Barnard. Akira started out saying, "I'm really bad at science…something I can't grasp," while she sees her sister as, "Very fundamental, she sees how one thing relates to another." She said her sister is much more of scientist than she is. I asked her why she thought she struggled with science. Her response was that she has a hard time memorizing things she does not understand and that science was a lot of memorizing. I asked Akira why she chose to take environmental science in her first semester of college. She said she wanted to get the requirement out of the way and, "I'm actually interested in it." I asked her what was interesting, and she said, "It more directly affects you. There's lot of things about the environment that I don't understand…environmental science had more to do with the area you live in – you're affect on the environment." She went on say that she thought environmental science had less math even though she liked math. I asked her if she thought she

was mathematical. Akira said, "In some ways I am." She also said she liked logic and agreed that she was curious about how things work. I said to her that it sounded like she had several traits of a scientist, and she tentatively agreed. Still, her main comment about the course was, "I'm going into the class hoping that it's an easy science."

As we started talking about the lab, Akira said the first lab was boring, but that the introduction to Brownfield Action in the second lab was interesting. She said the video, "Made me feel like we were in some kind of game," and that it reminded her of *Charlie's Angels*. I asked her if this meant she would take the project less seriously. She disagreed, and said it seemed like a good way to do the class. She went on to describe a math program where she had to do math problems online. She talked about how much work it was to type everything out on the computer as an example of what she did not like about using a computer for learning. When asked what was good about doing a project with a computer, Akira said, "Every student gets same thing from the program," and it is, "More universal." She later added that Brownfield Action seemed somewhat realistic, that the situation presented was not unusual. She also said:

> It's good because it actually makes science something you can relate to more. It's something that's realistic so you're applying science to a real life situation. I think that's good. It's always good to know that something that you're learning actually has something to do with what goes on around you.

I asked her if humor played an important role in learning for her. "Humor has its place, especially in lab when you're in there for three hours."

Akira said she was treating the lecture and the lab separately, since in her mind, the lecture topics had nothing to do with what they were doing in lab so far. When asked about the weekly quizzes, Akira said they were fine when she remembered there were no midterms. I asked her what had stuck with her about environmental science so far. She said, "Everything has a history...makes you think." I asked her what her other environmental concerns were, and she said that she and her sister had talked about global warming.

We spoke briefly about maps. Akira described herself as a map-oriented person who has a good sense of direction and often does the navigating when her family travels.

In general she talked about how college seemed so different than high school, that it was much more interesting and real.

<u>October.</u> At our next meeting, Akira had trouble remembering the tools she had used to do the testing procedures. She said the lab on topography was, "Really annoying," and she, "Didn't really learn anything." I asked her about the guidance she was receiving from Joe. She said, "Joe really expects us to figure things out ourselves." I asked if Joe was doing the right thing. She said, "It's good for us, but it's kind of annoying…I don't think he's totally right…kind of lost, waste time trying to figure things out." She went on to describe how the lab groups were supposed to share data with each other, but that Joe did not explain that they should be strategic about where they test so that each group's test data lined up. She did not seem as upset about this as other students were with similar issues, saying, "I kind of understand that if we were a real company we'd have to do the same thing, understand that you're trying to make it as realistic as possible." However, at the same time, she was concerned as she said, "I don't even know what's going to happen," and later added that the uncertainty is, "Still annoying."

Akira and her partner seemed to getting along well. She worked on the computer while her partner plotted points on the map.

I asked her about the quizzes, which she said were good because they led her and her partner to a lot of important information. She said she was glad they had a contract quiz because it, "Will help in Phase One because it will make sure we know what we have to do." She indicated they typically wait for Joe to tell them what to do in lab still and did not have their own strategy for how to continue the investigation on their own.

Moving on to lecture, Akira said she was struggling to understand how carbon connected to what they were doing in lab, but she agreed that the lecture on groundwater was helpful, especially when Dr. Bower talked about using wells in an investigation. She said reading *A Civil Action* was, "A better part of the class, book isn't half bad…can see it connecting with lab a lot."

When I asked her about what she was getting out of the class, she focused mostly on the awareness she was getting, saying, "Pollution will be more of an awareness for me...factories, I see stuff, I have a little more of an understanding."

Looking back at some of her previous comments, Akira thought the class was less difficult than other sciences class probably were and said, "I enjoy it. I don't mind it that much." She said her game comments no longer applied because even though the simulation was realistic, there was pressure to get work done now.

In general, when I asked Akira what the purpose was of everything she was doing, she said she was, "Still guessing."

November. At our next meeting in early November, Akira was finishing up her report, which was due the next day. She said the maps were complete and she and her partner were still doing interviews with people in the town. She talked me through her theory that Self-Lume dumped tritium illegally, and it had leaked out of the septic tanks near a landfill. However, she was still unclear about where the town well was and what its relevance was. I asked her which town citizens had been helpful. She mentioned Ivana Lede and D.S. Grunti and how it was sometimes difficult to find people. She found the names funny, saying, "I think people don't notice until you're really bored and then you're like, 'Hey that's funny.'" She also mentioned how happy she and her partner were at finding the fire report document to help them figure out if the fire that occurred in the factory was a lead or not (she was still not sure). We talked about using the results of the sediment analysis test and Darcy's Law. It seemed like talking to me helped clear it up for her, as she said, "Now it makes sense," in reference to why they had to determine the flow of a contaminant from the factory to the town's water supply.

Akira commented that the lecture and lab were more connected now, as Dr. Bower was talking about the project more directly. Akira said:

> I get how - like - he talked about what the government is responsible for...Civil Action actually helped a lot...because a lot of the evidence, they had to go through the whole water table...they were trying to prove that the property was contaminated by the company...a good part of what they had to prove was the same.

Speaking of *A Civil Action*, Akira was disappointed in the ending because, "He [Schlictman] didn't win."

I asked her to talk more about writing the report. She said, "It doesn't come together until the last two days...Oh, it's connected." She talked about the process, saying, "Me and my lab partner - we discover things and we're reading things and 'Oh my god look at that'...sadly we get happy." She mentioned reading the latest newspaper article that said there was a problem with the town's water supply as an example. She also said that even though the bedrock lab was a struggle, she now understands its relevance to the flow of water underground. Akira also added that she used the quizzes in her report writing.

I asked her again what she was gaining from this process. Akira had some new thoughts, as she said:

> After writing the report it could help you if you were going into environmental law. The point of it is that things are all intertwined. If you're an environmentalist or even if you're a business or whatever and you want to buy a property you have to watch these things, and government regulations.

She went to on to talk about economics and health and pointed out that, "The people in Moraine, they don't know what's going on, they're clueless, it's kind of like a big deal but they don't understand."

She also said that lately, Brownfield Action, "Felt more like a game because we were focusing more on the project doing more interviews, getting more into it, more captivating."

<u>December.</u> Akira and I started off talking about her report when we met in early December. She was happy with her grade, and when I asked her what her report's strengths were, she said, "I was pretty much on point with where the contamination was, you know the tanks and tests and stuff and I had a good understanding of where the tritium was."

She said she and her partner were trying to figure out how to stay together the next semester, and they wanted to stay in Joe's lab because they had gotten used to him and get along with him. She thought this would be true for most of the people in the lab.

Thinking about Phase Two, Akira thought it was definitely necessary to continue, and she was glad the whole lab shared the work since there were a lot of places to test. She was not surprised they had to continue working, but she felt like some of the momentum the class had earlier in the semester had been lost. Still, regarding the last lab, she commented, "The last one was a lot of fun. We're just kind of like, I don't know – it was snowing outside – we could have left early but we didn't." She was not convinced that reviewing the characters as a group was helpful since they had already turned in the Phase One report, and that she and her partner had done something similar as part of their work for their reports anyway.

We moved on to talking about the lecture, which Akira said was going well. Her only real complaint was that the study questions disturbed the reading process for her because she used the strategy of picking through the books looking for the answers instead of reading the text first. She did this to save time. She said *Silent Spring* was, "More of an attack," than *A Civil Action*. She saw the value of reading it and agreed it made sense to have it at the end of the semester.

Looking more broadly at the whole semester, Akira felt she got what she expected, saying, "I am more aware of - like I don't know - groundwater and - like you know like - how things can spread - you know - how a contaminant can go from one place to another." She added, "I really didn't know what Brownfield Action was at the beginning. I was really confused." She was concerned at the magnitude of the project because she was:

> ...so used to labs being one set thing and then you're over with it....As a student you're like you don't want a long term thing because you know you're going to have to remember things from last lab, have all these papers in front of you and stuff, but it's a good thing because usually when I think of labs, you do a hands on thing and then it's done and you forget about it, so I guess it's a learning experience.

I asked her if the class contributed to the development of scientific thinking. Her response was:

> Yeah, I definitely think more like a scientist because I mean in high school when you took a science course it's like you don't feel like you took a course...you know it's a general course. I definitely feel like I'm more of a scientist...if I were to see something out there, I wouldn't just pass by, I would think about it.

Her caveat was that she still thought scientists understand things more quickly that she does and that environmental science still seemed easier than her experiences with other sciences because there was less memorization. I suggested that Dr. Bower could have made his class much more fact driven and included a lot more memorization. Akira said the way this class worked was different in this way:

> You understand things and there's a connection...you end up memorizing it but like it's on your way to process your understanding...like the fact that the course didn't have a textbook...when you have a textbook it's so much more dry and boring.

She also talked about environmental science being easier because it is connected to real life issues but that doing a real situation was harder.

I asked her about using a simulation to have students experience a real situation. She went back to her point about the labs connecting, saying, "It (the simulation) ties everything together. It's not just a random science class." I asked why it was good to tie everything together. Akira responded:

> You learn more because...there's basics and then you use the basics to look for other things...sometimes when labs aren't connected. With Brownfield Action you have to remember everything and you have to, you know, make sure you understood so you're not lost in the middle.

She added that it was harder, but then qualified her statement that the individual tasks in lab were not difficult, but the task of hooking everything together over time was a challenge.

Akira had no trouble using the computer over the semester and was pleased that the computer was not instructing her, but instead was a place for her to hunt for information. She went on to describe a distinction between what students want that will make things easy for them and what is good for students for their own good. She described how students want traditional learning because they are good at that style, but that for her own good, the design of this course was most effective.

We closed out the session talking about what she would take away from the experience. Akira said, "Even though it was kind of a game, it was close to home, because I'm sure this happens a lot of places," and later, "The point of it was to make you more aware…you never think about groundwater as a source of contamination." She continued talking about the dangers of septic tanks and added that the main message of the course was that everyone should be more aware. I asked her what skills she would take away from the class. She said:

> I guess more of a not really researching but finding out things yourself - you know - and it was more like in Phase One, you have to dig for your own good…if you want to find the contamination and write the report well.

She hopes she can use this skill in other courses regardless of how they are taught. Her last comment could be taken as good advice for next year's group of Brownfield Action students. She said students will perform better by, "Making sure you have a good grasp of what you're learning," and that there are no off-days.

<u>Reflecting on Akira's Case</u>

Akira was the lone first-year student in a Joe lab included in the study, and she is a good example of someone who came into course somewhat fearful of science, but with an open mind about what she would get out of the course. She did not need the extra guidance that a Diane lab might have provided and through Joe's lab came to understand that it was really up to her to figure out what she was doing and put everything from the course together. In fact, that seemed to be the signature take-away for Akira. This course seemed to have contributed to her understanding of what it means to be a self-motivated college student.

Akira did not get into a lot of specifics when it came to talking about the connection between lecture and lab because it seemed so obvious to her. Even though she was a first-year student, she could articulate how students prefer the traditional learning experience that is chunked into small parts and easily managed versus a complex system experience such as Brownfield Action. She articulated the benefits of a cumulative assignment and would look forward to more similar experiences.

Akira believes she became a better scientific thinker due to this course. She also saw how a course connected to real-life situations and relevant examples can make retention easier.

Akira was one of the few students in the study to report no problems with her lab partner. In fact, they were making plans to stay together in the second semester.

As with Victoria in Diane's lab, Akira really seemed to be at home in a Joe-style lab. She figured out fairly early that is was up to her to make decisions and drive the project forward, and she had the maturity to identify this as a major component of what college should be about. As I alluded to in my story about my former high school chemistry teacher, knowing what to do when you do not know what to do next is perhaps the key to not only being a good scientist, but also to getting through life with your feet firmly on the ground. If Akira took nothing away from this course but this one life lesson, she should consider this course among the most valuable set of experiences she has had to date.

<u>Student 6: Emily</u>

<u>September.</u> Emily is a third-year economics major at Barnard in one of Joe's labs. She is interested in a career in business as either a financial analyst or market researcher. She is a transfer student who spent her first year of college at a large school in the Midwest. She came to Barnard to be a part of a more diverse student community and to live in New York City. Emily took a course over the summer at Biosphere, so this environmental science course satisfies the remainder of her science requirement. When I asked Emily if she considers herself a scientific person, she said:

> I'm more of a mathematical analytical person…organized, able to see how different components piece into a whole, able to take different routes to get to a final end as opposed to one route, in terms of finding alternative solutions, not doing cookie cutter work…having math background allows me to step back and conceptualize what I'm learning so I can understand it in my own way and maybe not necessarily the same way a teacher is explaining it to me.

She added that scientific thinking requires a logical progression of thought that is rational, concrete, and follows certain rules. She distinguished this from economics, which she sees as more interpretative.

Emily had a general sense of the Brownfield Action assignment. I asked her what she thought the experience would be like. Her response was, "It's like starting something you've never done before. You don't know what's important you don't know what's not. You don't know what things should stick out to you, what things should really hit you in the face." She understood that the lack of guidelines early on was intended, and she pointed out that she had done a similar project at Biosphere, where she had to design a conservation plan for an ecosystem. There were no computers involved in that project, and Emily admitted she was not accustomed to using them as part of her educational experience. Still, she seemed optimistic about having computers in the classroom, saying, "It's good because it gives you more stimuli and more access to resources." At the same time, she was concerned about backup plans because in her experience technology fails, and people typically become very dependent on it.

Emily had never done a simulation before, but she had positive comments about the potential for learning with one. She said:

> The particular assignment, the computer simulation is probably the best way to do it, because you know it's constant, everybody is starting at the same point…everybody can chose to go where they want…the computer will keep track of where you're going, in that sense it makes it easier.

Later she added:

> I think that it benefits you because it's very true to life, you're not given answers in life and you're not necessarily given a method to finish a project and for you it gives you a sense that you need to choose your priorities and use your skills in a very demanding way, especially analytical skills.

I asked Emily about working in groups or with a partner. She said she usually struggles in groups because she has a hard time trusting people she does not know, and she wants the other people she works with to be as competent as she is. Her main comment was, "I don't want to be hindered by anybody." She needed more time to evaluate her partner for this project.

Emily was not overwhelmed by the introduction to the project and thought the introductory video was funny, although she was the lone student to suggest Dr. Bower not be the character they report to because it emphasizes that they are doing the work for the professor more than for its own sake.

When I asked her about the connection between lecture and lab, she said, "I can see a relationship, and I think it will be strengthened as we go on," and cited examples from the radioactive materials lectures as something that would become more relevant later in the semester. When I asked her what the purpose of the lecture was in terms of completing the project, Emily said, "I think it's giving us the preparation to understand what a problem could be, where potential problems could come from, understanding that is crucial to progressing."

She sees most of the work for the class as busywork but prefers the weekly quiz format to midterms or larger exams, which she sees as generally more stressful. She appreciated the real-world perspective of *A Civil Action*, saying, "You're not like, 'How I could ever use this in real life?'" Still, she was concerned, as she said:

> A lot of girls in the class don't have as much confidence in science related and math related, their abilities - intimidated and unnecessarily fearful - and it actually makes me worry because…'did you get that?'…Are you joking, nearly a high school course [level of difficulty]."

I asked her if she thought the pace of the course was starting out too slow. She said, no but, "If they [instructors] slowed down to explain these things I'd be very upset…I'd almost be insulted." She wished the other young women in the class would be more confident and did not want any of the instructors caving in and giving away anything more about the class or the project.

I asked her what she thought she might walk away with from this course. Emily said:

> I think I'm going to have even more of a sense of conservation and care for existing environmental problems that exist now…I think Biosphere changed a lot of the ways of how I think about things, and going to Biosphere, and learning…economists think that markets rule the world, it's the be all and end of everything….the earth is the be all end all, not Wall Street, not the stock market…it's actually really funny the way things are explained in economic turns, economic reasoning with complete disregard for human psychological compassionate sort of…just doesn't play.

She also thought, "Anybody who's taking an environmental related course has some sort of sense of compassion or responsibility," and went on to describe a story where her parents had cleared an area in the woods and built a house. Lately her father had been planting rhododendrons, and he could not understand why the deer kept coming by to eat them, even though Emily pointed out that the deer were there first. The big message Emily assumed would be pushed throughout the course was the power of humans to destroy the environment versus the need for compassion.

October. When we met in October, Emily was growing frustrated with the mapmaking process. I asked her to describe the source of the problem. She said it was, "A function of assignment and the way we have to go about it and the restrictions about the computer program." She had brought in some notes she had written down about her frustrations. She wanted to be able to sign in two people to the same account at once to collect points more quickly and had trouble justifying to herself why they had to collect the points off the computers instead of having the data handed to them to use. She said, "I understand the point of what we're supposed to do; understand the significance...completely ridiculous to copy."

I asked her about the theory that having students spend the first few weeks getting comfortable with the dataset and doing the painstaking process of map construction allowed students the chance to process the purpose of the larger project and the various inputs they were getting from lecture, the readings, and the lab instructors. Emily said she thought the delay might be intentional and pointed out that students did not have enough knowledge about the process to do anything else yet. This discussion seemed to calm her down a bit.

Emily was also one of the few students to be frustrated by the technology, saying that it was difficult to put the testing points in exactly the right place. Emily agreed that having a mouse for each lab computer would solve most of this type of computer problem. She offered that perhaps this struggle was also intentional to give students a sense of the tediousness of real data collecting, but I assured her that this was not the case. She commented that the important concept to get from the datasets was an understanding of the contour lines that one generates from the data, which would suggest which way groundwater would be flowing. I asked Emily if she thought making the maps point-by-point would help her get to know the map better, as other students had indicated. She said that might be true to some extent, but she expected to use the maps doing some analysis later on, and she would get to know the maps very well then. I explained to Emily that we had cut down on the number of points each group had to gather by having lab teams share data. Her response was that she was used to looking at data that she collected in her own way, so it was frustrating to have to incorporate other people's findings because some of the data was incorrect and she had to check it herself and ask them questions.

Emily had no substantial comments about Joe, saying he did not give a lot of straight answers, but that it was not a problem. As with many students, Emily felt the lab quizzes were helpful for directing students to important information, but in general she thought the class was a lot of work and not very difficult. She expected the class would, "Get a little more interesting…once you starting analyzing the maps." She was growing impatient waiting for the opportunity to start the analysis process, saying, "I feel like the lab doesn't allow for it [analysis]…going to be the most important part of the procedure." At this point, she felt like she was still following orders and could not head off in her own direction yet.

Our discussion moved to the lecture. Emily said, "The groundwater lecture helped us prepare for lab this week and how we are going to analyze the bedrock layers and how to analyze the area where the pumps and wells are." Regarding *A Civil Action*, she said, "Seeing the scientific side of the book helps gives you background if you find something, what that could imply." She claimed to like the book because, "It's clear that it's relevant - you're not reading and going, 'What is this?' It makes perfect sense plus it's really interesting." With Dr. Bower's lecture style, Emily pointed out that his general tactic was, "Trying to make us scared of everything…obviously it's an awareness class so I understand that you have to do that to make people aware." She noticed his enthusiasm about the material but was somewhat concerned that some of his scare tactics might be exaggerated and that the less confident students were taking him too much at face value. She did think the difficulty of the lecture material had stepped up, so she was less concerned with the class being too easy than the last time we met.

November. Emily was finishing up her Phase One report when we met in early November. She was frustrated on several counts, one being her partner had lost some key data that she had to re-collect, and another being that she had paid for interviews in the computer lab but did not have headphones, so she could not hear the key people whose interviews were audio/video-based. She suggested a text transcription for each video be provided in addition to the audio. Still, she was able to talk me through the relevance of the sediment analysis they had done in class and how it correlated to the visual reconnaissance. She said she still had more interviews to do before she could complete the report, but she felt good about her bedrock map, which she felt she could explain better than most people. Emily was also disturbed by the cost structure for visiting people in Pleistocene Court, which seemed unrealistic in how it charged per visit each time even though the houses were right next door to each other.

I asked how the guidance had been in lab recently. In reference to Joe, she said, "If he's been teaching for thirty years, I'll give him the benefit of the doubt…once I figured out how to approach him, my relationship with him has been great." When I asked what his style was like, she said, "He hovers and asks questions and tries to get people to think about things…a lot of people have poor relationships with him and he won't give him the information they need." I asked her how she got to where she is with Joe. She said, "The questions I'm asking let him know that I'm on top of it and…they're not dumb questions." As an example, she described a problem she was having with the bedrock map in trying to figure out whether contour lines can meet and then separate again, which she knew to be mathematically possible, but seemed unlikely on a contour map. She presented this problem to Joe and he said that while it was theoretically possible, she should consider the possibility that there were parallel lines running very close to each other instead. When she looked at the problem, she realized that he was correct.

When I asked Emily if she had any new thoughts on what she might be taking away from the project, she said, "I think I'm going to walk away with knowing how to take a lot of scientific information and a lot of more personal information from the interviewees and kind of put them together into one conclusion." Later she said, "I feel like I'm doing Civil Action. I mean I feel like I'm a lawyer….I think it's kind of cool." She described how she had done a summer internship where she had to do a lot of interviews for a corporation, and that she did not have to concern herself with evaluating the credibility of the information she was receiving, whereas with Brownfield Action that was a primary concern. She said:

> I guess I'm doing something new in that I've done all this before I find when I write the more scientific stuff...I know how to explain data and from this summer I know how to explain interviews and no this isn't that hard for me but this is the first time I did A-B-C-D-E and put it all in one paper.

The tie between lecture and lab was obvious for Emily. She was uneasy about how certain subtleties of the class were being overtly explained that she was used to picking up and having as an advantage over other students. She gave the example of looking at density of plant growth as a clue to where something might have been placed underground. She said:

> The nice thing about his project is everything makes sense…it's just nice that everything is designed to work out. If you do your stuff correctly, like I was looking at the handouts, looking at the septic handouts before lab, before anything, and then looking at the map, 'Wait that's disturbed land, and hey, isn't that where the septic system is, and well, isn't that nice.'

She had noticed this on her own and did not want this type of secret given away to others who had not taken the time to notice.

As for the quizzes, Emily said she puts down extra information to cover her bets on questions that she knew would get graded on more than what the question asks for. Her one concern with this strategy was time, as there was not a standard amount of time allowed for each quiz, so putting down extra info carried the risk of not finishing.

As was typical of several other students, Emily was upset at the resolution of *A Civil Action*, saying, "I was so angry…I mean I watched the movie the same day I finished it. I was a little upset to read so much at the end, but I just went to library and finished it." Later she added, "The court is not the truth, justice, what is this?" in clear frustration at the outcome. Still, she felt the book was valuable to read on its own and relevant to Brownfield Action in that, "Reading the book is your guideline to how to do the report."

<u>December.</u> At our December meeting, Emily started out by telling me the strengths of her Phase One report, saying, "I think I explained the bedrock map pretty well and I think that I analyzed each component to why." She expressed a concern that perhaps the grading was too lenient since so many people she knew did well, which seemed to take away from her accomplishment.

However, in private, Joe had specifically mentioned to her that her report was one of the best that he had read. She said Joe had remained consistent through the end of the semester, and that they still had a good relationship.

In speaking about Phase Two, Emily was concerned that the groups in her lab did not find the underground storage tanks that were supposed to be present on the Self-Lume site, but in general she was less stressed out about writing the Phase Two memo. She had a clear idea about the plumes they had discovered and was in the process of analyzing what they found at both the gas station and the Self-Lume site. She thought the mapping of the story's characters in lab was helpful for everyone in putting together the key points, and was happy that occurred after the Phase One was turned in so people were not let off the hook entirely if they had not done any work on the interviews.

In her comments about lecture, Emily focused on *Silent Spring*. She was satisfied at having it at the end of the semester, saying, "It's easier for us to learn about the injustice of everything of it and the consequences. You've introduced to the whole idea of contamination through Civil Action…then you get a little more specific." She went to explain how reading *Silent Spring* at this point in the semester was important, saying, "You understand the consequences of everything she's [Rachel Carson] talking about." In general, she was more interested in lecture, saying, "I think I like it better because it's more policy oriented. The information we're learning now makes you think about problems we're encountering today," and later, "If you're going to be an environmental activist, these are some of the things you're going to have to deal with."

Emily said the outcome of this class was predictable for her, but the class still surprised her. She said she got the course evaluation form and was filling out the questions when she realized, "It's been a very good class and I haven't given it credit for being a good class." In fact, she said, "It was one of the best classes I've taken, aside from Biosphere, because you do learn something from it." She realized that comment did not say a whole lot, so she compared it to a course in linear algebra. She said she worked with abstract ideas in linear algebra, but she did not think about them outside of class. However, she added, "When you're eating grapes at a dinner party and you're like yeah… pesticides, grapes…I think I've talked about that video [shown in lecture] four times since I saw it with different friends." In other words, the information and ideas from Dr. Bower's course stuck in her head. She reiterated Dr. Bower's comments about education being what you remember six weeks or six months after your formal education is over, and said, "I'll have a lot more to say from this class after 6 months than I would taking other courses." When I asked her what the nature of these things she would remember were, she said they were mostly awareness issues, but that the report writing was also valuable. She said, "Practicing the whole method that you are going through when you are writing the reports…putting A-B-C-D-E together…the more you practice at it the better you'll get."

When I asked her about the cumulative building effect of the class, Emily said:

> The fact that its built reinforces everything you've learned, reinforces that this is important, and it is important because you can't forget about it, and you have to use it in everything else. Therefore you have to be aware of it.

When I asked her if this teaching strategy was essential to this type of course, she said it was not essential to get something out of the course, but that it contributed greatly to the depth she got.

In talking about the simulation, Emily said the computer's role in Brownfield Action was appropriate, and that in general the best role for a computer in learning is, "By being able to supply you with all the data you need," so that students do not have to waste time hunting and getting frustrated. She questioned my inquiry about having the computer instruct students in this course, saying, "Wouldn't that defeat the purpose?" She said the burden for working through the material is on the student, and that there was plenty of guidance. She mentioned that Joe had suggested students who were struggling set aside thirty minutes each week to reflect on what they had done in the course and review. In Emily's opinion, if students chose not to heed that advice, it was their fault. This solidified for me that Emily would not have survived the additional handholding that went on in a Diane lab.

I asked Emily what the main message of Brownfield Action and the course was. She went back to her awareness comments, saying for example, "It's the large sense of you know when you go to the gas station, and you see monitoring wells you know what they are for."

When I asked her about how the course changed or added to her views of environmental science, she said, "People tend to think that they're individual impact on the environment doesn't make any difference, whereas in the great scheme of things it does, but if everybody thinks that way, we're in trouble." She admitted she already felt this way after her experience from Biosphere, but added that this course expanded her thinking because, "It gives you a sense of you have to think about the consequences of your actions because if you do it without thinking sometimes you can cause more harm than you ever would have imagined."

<u>Reflecting on Emily's Case</u>

Emily was the most mature and thoughtful student in the study. She had the most consistent well-articulated comments and came into the class with the most background and skills as a student. She is an example of how a top-notch student can benefit from the course if placed in a Joe-style lab. Michelle and Janet, who are similar in their strengths as students and in their backgrounds to Emily, but had Diane labs, struggled to maintain engagement. Emily acknowledged this course to be one of the best she had experienced.

Emily did not seem to benefit from the humor in Brownfield Action as it was *rarely* mentioned. She apparently did not need it as she was confident and not overwhelmed from the start. She overcame obstacles with her partner and her lab to incorporate other people's work into her own. She clearly predicted and articulated the benefits she received from the connection between lab and lecture, and understood the purpose behind the strategies being employed to keep students motivated and engaged.

Emily was hard-edged in her criticisms of details that could improve the experience. She was also hard-nosed about the burden placed on the student and about not giving students more than necessary to succeed. It was these comments that made it clear that a Diane lab would have sent her reeling (as it did Janet). As it was, Emily did grow impatient with portions of the project process and with other students. However, in the end, Emily acknowledged that the course expanded both her knowledge about environmental science and her skill set as a writer and in integrating many of her disparate skills as a researcher into a large project.

Emily's case serves as a reminder that students of varying levels can benefit from the same simulation experience. Even though all students were given the same set of learning opportunities and the same objectives were in place for everyone, Emily was an example of how a strong student approached the challenges as opposed to some of the more naïve students. In fact, Emily showed evidence of being another level past Michelle in her development. She clearly realized the game of college and how one can take the easy route and get by, and yet, she had no intention of following that easy road. She showed clear frustration when easy roads were presented to other students and they took advantage of them. She openly criticized curricular decisions that gave away too much information or provided easy access to a solution. Emily saw the integrated whole of the experience, could step out of it to reflect, and could see how its design was affecting decisions by other students. She also made many more suggestions about how to improve the experience than any of the other students. Yet still, at her level of development, she still benefited from going through it, and in fact, claimed it was one of the best educational experiences of her life.

Student 7: Angela

September. Angela is a second-year music major at Barnard in one of Joe's labs. She is taking the class pass/no pass and is clearly the most fearful about taking this course of all the students who participated in the study. She believed environmental science would be easier than any of the other science options (she polled her friends before deciding) and her only goal in taking the class is to, "Get rid of this horrible lab requirement." Several times early on during our conversation she said, "I don't know," or, "I don't care," and it was often difficult to prod information from her. I asked her about her high school experience with science. Angela said science was especially challenging for her in high school. She recalled having a good biology teacher and bad chemistry and physics teachers. I asked her if deciding to take the course pass/no pass would affect the amount of effort she put into the course and her attendance. She said attendance would not be affected but effort and time spent out of class would definitely be affected. She described scientists as analytical, mathematical, concise, organized, and decisive.

She sees herself as, "Definitely not analytical…I'm very literal…I don't feel a need to explore," although she did admit to being good at math. I suggested this was not surprising as many people with skills in music also show high mathematical abilities. She agreed she had heard that statement before, but responded that she did not like math or science, and repeated that she was just looking for the easiest class to take.

I asked Angela what she thought she might get out of the class, if anything. She responded:

> I think I can be more analytical…the thing I like about what Peter Bower said about what you remember six months after. I like the practical experience. I'm very practical. If I can't relate it to my own life, then it's of no use, but I think I can definitely learn something from this class.

I asked her if she thought this *something* would be more content-oriented or more skill-oriented. Although Angela said she thought content would carry over better into her life, as an example she talked about her love for maps. She said, "I like topography…always been into geography…the whole thing…I just like that kind of stuff," and later, "I love maps…I'm a very visual person." It seemed she was engaged in both the skill of map using and the content area of geography and maps.

I asked Angela if anything in the lab had been any fun so far, and she mentioned the introductory video being, "Hilarious." I asked her if this was important, and she said, "Oh God, yes. My best teachers were very engaging and made me laugh," and later, "I definitely think humor is a big part of my life, part of my education…it makes me see the person as a human." I asked her what her concerns about lab were at this point. She talked about her dislike for ambiguity, how her literal side wants everything made as explicit as possible. I asked her if Joe had been helpful. She said he reminded her of a bad math teacher she had in high school who was always over her shoulder making her feel uncomfortable.

Angela did not have much more to say about lab, so we moved on to the lecture. I asked her if the lecture and lab were connected in any way. Her response was, "I guess they could be connected…I don't know…I see lab as an extension of lecture." When I asked for an example, Angela mentioned that Dr. Bower had brought up the lab project in lecture. When she could not get any more specific, she apologized, saying, "I zone out sometimes." I asked her if Dr. Bower was a good instructor. Angela said, "The thing I like about him is he is straightforward...not like he's my favorite professor."

Again, Angela seemed uncomfortable continuing down that discussion path, so I asked her about her experience using computers in a learning context. She described that she did the *Oregon Trail* program (a popular edutainment software package), which she thought was a lot of fun. She claimed to have not learned anything from it. I asked her if she thought Brownfield Action would be similar. Angela said, "It's going to be interesting, reminds me of *Oregon Trail*...my partner was so frugal...I'm going to be like that. I want to be the cheap one."

I asked her how she planned to study for the course, and she said she was the ultimate procrastinator. She said she is unable to do assignments early, that she need the deadline to be pending, and then she can, "Work very well under pressure."

I asked Angela if there were any particular concerns she had about environmental science. Initially she said no, but then suggested that she had a fascination with water since a fourth grade science experiment. All the students in her class had to bring a sample of tap water from their home to class and her inner city water was the worst. We went on to talk about how *A Civil Action* has water as a big topic, and she said, "It's a good read." She added that she normally does not like reading for school, and that, "English is not my strong suit." I asked her what it was about reading that made it difficult. She said she was always struggled to perform analysis on books she had read because she was only focusing on the plot.

I asked Angela to name the academic skills she had that she felt most proud of. Angela said she was good at memorization and had, "Been blessed with a talent," for music (in fact she claimed to have a song in her head at the time but would not sing it for me). I asked her if she had any other academic interests, and she said history. When I asked why, she said, "I'm good at memorization, can relate it [history] to my own life...always watch TLC and The History Channel."

Angela clearly was going to be a difficult case to win over with any project, no matter how well-conceived.

<u>October.</u> Angela and I met for the second time in early October. She and her partner were working on the bedrock map, but she could not remember the name of the test or how it worked. She said her partner was good, that, "We do the work, but we do the minimum," and later, "I'll do whatever but luckily she's in the same boat," meaning she was happy that her partner was not a real go-getter who would try to motivate her to excel. I asked her what the point of mapping was, and she said, "It's a task…is there a point to this?" I asked her if Joe has provided any guidance as to why they were doing these tasks each week. Angela said, "He's good…not outstanding," but could not (or chose not to) give me any specifics on his behavior or where the project was headed.

Because many of the other students had said the lab quizzes helped them orient to the important material, I asked Angela how they were going for her. She said the Visual Reconnaissance quiz they had was hard and she did not do well. I asked her if this helped her to know what to pay attention to. Her response was, "We took the quiz. It's over. We can move on. I haven't really retained."

I moved on to asking her about using the computer. Angela said it was straightforward to use but agreed that a mouse would help with some of the pointing and clicking.

I asked her what her and her partner's strategy was each time they came to lab. She said they wait for Joe to get them going. I asked why this was the case, and she suggested that while some people are more independent learners, "I would like to have some clue, don't like the unpredictability." I asked if it would be helpful to have a more structured outline of the lab. She agreed, "It would be nice to have - not like - I guess an outline."

Based on her decision to take the class pass/no pass, I asked Angela how concerned she was about her performance to date. She said she worried about this course more than others because she got tested weekly, which at this point, she said she preferred to larger exams even though it felt like high school. I asked her if the lecture quizzes forced her to go to lecture, and she agreed, saying that she would be skipping lecture otherwise. While on the subject of lecture, she mentioned, "I noticed yesterday he talked about Brownfield Action. He was talking about what was going to happen next week." She said this was tough for her because he was referring to them starting to interview people in the town, and that it was recommended that people get started on that. However, she had not had lab yet for the current week. Angela's point-of-view was, "I need to take it - like - one thing at a time," and this was another obstacle she had to overcome. Still, she was looking forward to the interview portion of the investigation, as she said, "I'm sort of excited about that. There's a face to this...there's actually people you can talk to." Still, she had missed the crucial lecture on groundwater, so she was in the dark still about the main purpose behind the tasks they were performing in lab.

One positive area for Angela was the book *A Civil Action*. She said, "I really like it because Brownfield is like a mini Civil Action or Brownfield is something that could...actually did happen in Civil Action, so that's really cool, the connection." She said the study questions were tedious but plot-related, so she did not mind them. When I asked Angela if she had any new thoughts about what she would take away from the class, she said it would be this book because of the correlation between it and the lab experience, no matter how unclear that seemed to be.

Looking back at some of her past comments she was still convinced, "This was the best class for me to take...I just know, it's not that bad, it's sort of annoying how it's structured, but...." When asked if it was better than the alternatives, she agreed. She also still wanted the practical experience out of this course, and she claimed to have not given up, citing better relations with Joe and the overlap (she called it, "More mingling,") between lab and lecture.

<u>November.</u> When we got together in early November, Angela was visibly distressed. Her Phase One report was due the next day and she and her partner, "Of course, haven't started." She was dreading being up all night, and did not know how they were going to begin. She claimed to have lost her sense of purpose, but said, "I'm going to get it within the next twelve hours," and again later, "The purpose will be found by nine am tomorrow." When I asked her about the tasks she had been doing in lab, Angela complained, "I do these maps and - like - what's the point? I feel like I'm drawing." She also let me know that her partner failed to show up for lab even though she had the maps they had been working on.

Since the maps were clearly a sore point, I asked her about the sediment analysis test they had done. Angela was positive about that, saying, "I liked that, felt I was doing something, instead of - like - drawing maps. I was seeing it. I wasn't just plotting points." However, when I asked her what she learned from this lab that would help her writing the report tonight, she said it was better because it was fun and that she did not learn anything. I was not convinced, so I prompted her with some hints about discovering the soil type, but she still failed to relate it to the Brownfield Action investigation.

Angela changed the subject, complaining that her home computer was not working, so she could not log in to the project. She also was concerned about the interviews because she was having trouble understanding what the people were saying. One problem was that she interpreted Mal Sangre, the character who died from radiation exposure, to mean "Bad blood," the literal Spanish translation, and did not catch on that it was a person.

I asked her if Joe's guidance had been of any help. She said he just laid out the tasks and, "Doesn't apply what we're learning." I asked her if she might have been better off in Diane's lab based on what she's heard from other students. Angela agreed, saying, "I would care a little bit more about the class…I feel very lost."

We returned to the one positive note in the course, *A Civil Action*, to which she said, "It was a quick read and a good read…I feel like we're doing *A Civil Action*. This thing could happen." But then she switched tracks, saying that she was not gaining anything from the experience any more, that it had, "Gotten more and more pointless," and the amount of busywork had turned her interest off. Her main goal now was to survive the remainder of the semester. I asked Angela how she got into her current conundrum. She admitted she had been missing lectures, saying, "I can sit in the lecture and still not understand what he's saying…I haven't been in a while," and that this could explain why she was missing the point of everything in the course. I asked her if she preferred lab to lecture, and she said, "I always liked lab better because I feel like we're doing something," where with lecture, she said, "It's over my head…when you start to get technical…" and then trailed off in frustration. I asked her if Joe was any help in clarifying the lecture material, as Diane had been for Victoria, but she said indicated otherwise.

At this point, I felt like I had to ask Angela why she agreed to participate in this study. She said, "I'm unique in a lot of things when it comes to academics." She wanted to make sure her experience was represented. She said she was not prepared for the chemistry and formulas involved in the course. She reminded me that she did not do well in high school chemistry, and that she expected this course to be more abstract.

One glimmer of hope for her was that she was considering a visit to a tutor and that it was not just this course, but several of her courses that were giving her trouble. For Angela, there appeared to be larger issues than just this course that were contributing to her academic struggles.

<u>December.</u> Angela started out our December meeting talking about her long night writing the report. She said it was painful, "Probably one of the worst experiences of my life. It was horrible." I asked her what made it bad. She said, "I didn't know what to do....I was really frustrated...didn't know where to start." She talked about how her partner offered to allow her to paraphrase her paper, but she felt unethical about doing that, so she declined. Still, when I asked her where the words for the report came from, Angela said, "I was writing from - you know - air."

I asked Angela if she was satisfied with the assessment she received, and she said she had done badly and was not surprised. Apparently she had left out a section of the report in her haste. I asked her if there was anything positive about her report. She said the interviews worked out fine and they did well on their maps. Where she struggled was in figuring out Darcy's Law and how it related to the project.

When I asked her about the Phase Two work that had been going on recently, Angela said, "It just gets more and more pointless. Today I was like, 'Oh my God, I'm so glad this is over,'" and went on talking about how she wished she did not have a morning lab since she was not a morning person. I asked her if there was any sense of accomplishment in finding some contamination and if she knew how she was going to write the Phase Two memo. She was, "Sort of excited," to have found something and was not clear how she was going to write the memo. Her only comment on phase two was that she wished it was worth more than six percent, thinking if she did well that it might help her reach the pass level for her grade, which she was not confident she had achieved.

I moved on to questions about the lecture. Angela said her attendance had improved, and that she was enjoying *Silent Spring*, saying, "It's compelling. It's eye opening, makes you think." She pointed out that the two books were the only things she liked about the course and said, "I'm glad I was forced to read them." She did not mind the related study questions, especially with *Silent Spring*, which she saw as more textbook-like, and thus a better fit for study questions.

Looking back at some of her previous comments, she said her partner had been better over the last month and that in general the Phase Two group work was better because, "I don't really have to pay attention." This was not to say she was not doing any work, though in the example she described a situation where she and Joe had an altercation because:

> He was making fun of me because I was not doing anything but so was a lot of people, so I don't know why I was singled out… I don't like it when teachers say that I don't do anything, I do something, give me credit for that…someone asks me to do something, I'm going to do it.

I asked Angela if she had followed through on her intention to go to a tutor. She said no, that it was more important for her to rest than seek out a tutor when she had the free time available. In addition, her problems in her other classes had resolved themselves to her satisfaction, so this course had become the main obstacle to overcome in these last remaining weeks of the semester.

When I asked her if she was surprised by the way this course turned out, Angela said:

> I thought it would be easier, more manageable. This whole semester I had a lot of expectations for things and they just didn't work out, or it ended up that I couldn't handle all this load, having a heavy class load, and then work and then activities, just been very overwhelming.

She admitted this course was not the source of the problem, and that she should not have arranged her schedule the way she did and gotten herself as busy as she was. She remembered that she hoped to get some practical experience about the environment and to become more aware. She thought she did achieve some of that, thanks to her reading of *A Civil Action* and *Silent Spring*. When I asked her if she got any skills benefits out of the course, she said she felt some of them had deteriorated, such as her ability to manage her time.

I asked her about the prospects for learning from simulations given her experience. She said:

> It depends how much you put into it…I thought I was going to get something out of it but when I realized it was just a lot of calculating and stuff like that I just…I didn't think it was going to be so much…I don't know…scientific.

She said she expected the project to have more social aspects but that the interviews came along too late in the process, when she had already turned off to the experience. She did admit, "I know environmental science is science and there's going to be measurements and stuff, but I didn't think it was going to be *all* [italics added] that." I asked her if starting the interviews earlier and easing into the science would have helped her and she said yes, but that in general:

> I'd rather be instructed, I don't like being left to my own devices, and that's what I was, left to my own devices, and I didn't really know what to do in the first place, so I totally just came to lab expecting to be told what to do and you'll do well.

I asked her if she was an independent person in her approach to her daily life. Her response was, "I'm a very independent person…but not in an academic setting." She described how she was more self-motivated at her place of work, where it was, "More like a democracy and less like a republic." She meant that people cooperated better and there was a better sense of community with the group than the way Joe ran the lab. Again, I mentioned this was perhaps more evidence that she might have been better served by a Diane lab. She agreed and said she was trying to find out what labs Diane taught so she could be sure to sign up for the right section for the next semester.

Ultimately, she said she would be taking what she learned from the books with her as she proceeded with her schooling. She again mentioned her desire to know more about water and how *A Civil Action* fulfilled that for her. She admitted that knowing something about chemicals would make her more aware as well.

Her summary comments focused about the course were that, "Lecture and lab were not together," that it was, "Annoying to go from lecture to lab within a very short amount of time, hard to like try to find a connection if there was a connection." As a last resort, she suggested a combined small class where the lecture and lab were taught together. Again, this was more evidence that Angela might have survived had she been in a Diane lab.

<u>Reflecting on Angela's Case</u>

Angela clearly did not engage in this course, and yet she still received some benefits. Some would argue that her attitude suggests she does not belong in college, especially not in an elite liberal arts school. Some might suggest she would be better served by a fine arts school in music that would allow her to focus on her musical talents without the distractions of other subjects.

However, one must wonder how this type of student would do in a Diane-style lab, and how many other students like Angela there are in this course and in the college? In past large-scale evaluations, very few students reported such negative feelings about the course, but there were always a handful out of the approximately 120 students each year. How many of this type of student are saved by a more nurturing lab experience? What is a professor's and lab instructor's responsibility towards this type of student?

Angela did not see the lecture and lab connection because she did not consistently attend lecture. She did benefit from the readings because she made the effort to get through them. She did not benefit from the report writing because she did not make the effort to figure out the project's goals or to understand what was happening in the class as it proceeded. She did find the opening sequence humorous, but that alone did not keep her motivated for long, and Joe's style did not encourage her to engage as Diane's might have.

Is it the job of this course and its instructors to make students feel good about what they learned, no matter how little learning there actually is? Or is it to present students with a larger learning opportunity befitting of college-level credit that some will achieve and others may fail short of? I would argue that it is the latter, and that Angela represents a case of the type of student that does not measure up to the standards expected of an undergraduate.

Still these students exist, and I see it as important that Angela chose to participate in this study. She stated that she wanted her point-of-view represented. I see Angela's act of participating in the study as a realization on her part (conscious or not) that she is not in the right place for where is she in her life. One might call it a cry for help, but what she fails to understand is that she has to help herself. She has to dig herself out of her insecurities and step up and take some responsibility for her own learning. She rejected Brownfield Action and this course's approach because it did not lay out a clear path for her follow. Angela is very attached to the traditional spoon-fed regurgitation method of instruction, and so fearful of her own abilities to construct meaning out of her experiences (recall her desire to avoid symbolism in her reading).

Angela is a surface dweller. She has not yet learned how to learn, how to engage in material in a deep and meaningful way. In a complex simulation, staying on the surface is the easiest way to fail. There is no wrong path except to not take a path, and that is exactly what Angela did with Brownfield Action.

Student 8: Megan

September. Megan is a second-year political science major interested in a career in politics. She is interested in campaign finance reform as a vehicle for fostering policy change, including but not limited to environmental legislation. She has work experience in campaign finance reform and sees environmental science as very intertwined with politics. She is not necessarily an advocate of what she calls, "Hardcore environmental protectionism," that places unrealistic expectations on people, but she detailed her hatred of sport-utility vehicles and excessive pollution to me. Megan describes herself as scientific-minded in that she thinks she is mathematical, straightforward, analytical, and objective. She is taking this course to fulfill her science requirement but also because she sees the legislation angle on environmental science tying in nicely with her career goals. Diane is Megan's lab instructor.

Megan described how she and her lab partner were getting along very well initially, but that she was quickly losing her patience with Diane's teaching strategies in the lab. She believed the lab was taking at least twice as long as necessary because Diane had her, "Head in the clouds," and was flustered and out of control. Megan insisted that if she could just have the list of tasks for each lab, she and her partner could figure out what to do on their own and finish the work in the time it took Diane to explain what they were supposed to do. Megan's biggest concern was the wasted time coming back to haunt her later in the semester. She said, "It's one of those exponential growth things. I'm afraid we're going to have to work like mad in November." When I asked what had been accomplished so far in lab, she said they had barely started working on the site map, and indicated there was nothing more to say because they simply had not achieved anything of significance yet.

I asked Megan about using simulations for learning. She said she took several science courses in high school that had smaller, simpler simulated environments involved. She said in those cases the computer was easier to use than looking under a microscope, and that good computer simulations were typically straightforward and easy to use. As an example, she mentioned an enzyme lab she did in high school that used a computer. She wanted to hold back her judgment of Brownfield Action until later on.

When I asked her about mapping, Megan said she was not a fan of maps (she prefers written directions when traveling) and found the contouring process frustrating.

In terms of the lecture/lab connection, Megan said, "At first I thought they were connected but now I don't see them as connected." As an example, she said the mapping in lab and the lectures on radioactivity seemed totally different.

She was concerned about the weekly quizzing format because she knew that some weeks in other courses were going to be very busy and she could see herself struggling to keep up in this class. In general, it seemed Megan was easily stressed out and that weekly quizzes would be a consistent source of anxiety.

When I asked Megan what she might get out of the class, she said:

> I haven't gotten everything from it yet, but to see more of the environmental issues is what I'm trying to get out of it…but it's not something that's really going to affect my life…more interested in more broader issues.

She was less interested in the scientific background and was hoping for more issues that she could become knowledgeable in. She was very pleased with *A Civil Action* to this point and was hoping it would be connected to Brownfield Action in order to make the lab work easier.

At this early meeting, Megan was clearly withholding much of her judgment until she had more information.

<u>October.</u> Megan's frustration had grown further by the time we met in October. She and her partner were still getting along fine, but they were running into technical problems logging in to Brownfield Action in both the lab and in their dorms. They were wasting a lot of time trying to figure out the problem, and both she and Diane got very frustrated trying to solve it. Now Megan and her partner were behind schedule, but they were not about to give up. Megan simply said, "We'll survive."

I asked her if she had any more to say about Diane's guidance in the lab. Megan's response was:

> The instruction is generally more confusing than if I sat there at the computer and tried to figure it out on my own…to say she gets flustered is a vast understatement…and I think her mind is very uni-planar.

What Megan meant was that Diane seemed to struggle to multi-task, and Megan thought this was an important skill for a lab instructor to have working on this type of project. Because Megan had one of the first labs of the week, I asked her if perhaps that could explain why Diane was having more of a hard time than had been reported to me by other students. However, Megan said that her friend who had a Wednesday lab reported similar problems to her. It is not that Megan did not appreciate Diane's strengths, saying, "She's really nice and caring." However, at the same time, it was clear, "It'd be much easier if we could just get a list of tasks to do," and later, "When she talks she completely loses me." Because Megan had to miss a lab, she was going to go to Joe's lab to make it up later in the week, so she suggested she might be able to contribute some unique perspective on the difference between the lab instructors' strategies at our next meeting.

In terms of the actual work going on in the lab, Megan saw it as tedious and just as a set of tasks to get done. She said this was in part because she and her partner were behind and felt rushed. She was also upset, as other students were, at groups who were not systematic with their data collection. When I asked her about the lab quizzes, Megan said the contract quiz did not have much value because Diane went over the contract so thoroughly whereas the Visual Reconnaissance quiz had some benefit. She said, "I think it [Visual Reconnaissance quiz] just makes yourself go through it, gives you sense of who you're going to talk to."

In general, Megan felt like she should have more control of the project and where it was headed. She said, "I'm very much of a long term project person…you can look toward what you have to do…can't do that here because I don't really have a sense of where I'm going." She repeated her wish to get a list of the tasks for the whole semester. She wished she could get ahead when she had extra time since she knew he schedule would get tight later in the semester. She also complained about the lab always starting late and how that contributed to her stress. Megan talked about, "Getting worked up," and how that made it difficult for her to concentrate.

I asked her how lecture and lab were working together. She said they were, "More connected than they were in the beginning," due mostly to the lecture on groundwater that had taken place earlier in the week. She was enjoying *A Civil Action* and its connection to Brownfield Action, saying, "They're sort of doing the same thing, but Civil Action focuses on the legal aspect." However, she found the study questions childish and unnecessary since she was motivated to read the book for its own sake. I asked her what she was taking away from the lectures. She said, "I'm more interested in the environmental law aspect, so I'm looking more toward the policy, like what's going on, how do we deal with this stuff." She expressed frustration that Dr. Bower often raised potential policy problems that she was interested in, such as how to deal with excess garbage, but that he did not always provide solutions to these problems. The policy person inside her wanted the best options to solve the problem, and he did not always resolve them for her.

<u>November.</u> When me met in early November, Megan had resigned herself to completing the project on her own. Her report was due the following Monday, and she was in the process of completing it without any input from her partner. Her partner suggested that since her computer did not work that Megan should do all the interview work. Megan quoted her partner as saying, "'Why don't you just do everything and print it out for me' and somehow I was - like - ok." I asked her why she allowed this division of labor. Megan replied, "I don't like her at all so I would have to do it any way so I could do it on my own and remain sane or work with her and have to do it anyway."

Megan claimed to have spent between seven or eight hours performing all the interviews. Based on the information she gathered, she talked me through her theory about the tritium being dumped somewhere on the Self-Lume site. She suspected one of the underground storage tanks. I asked her where she got her theory, and she said that Self-Lume had cut down on their tritium waste without reducing or changing their production process, so the excess tritium had to be somewhere. She also said, "Not to mention it's the exact same thing as Civil Action…same idea." She also had a clear sense from the sediment analysis lab of how contamination could flow to the town well from Self-Lume in a time frame that made sense with the story.

In general, she said the labs where computers were not used went smoothly and were not stressful. Because she and her partner were still having technical problems and because she felt like there was always much more work to be accomplished whenever the computer were involved, she still found those labs highly stressful.

I asked her about working on the project at home. She said she still had trouble from time to time maintaining her Internet connection, but that she got through it. I asked her if any of this was any fun. She said, "I liked the actual figuring it out," referring to the analysis portion of the Phase One report. She then went on to describe the annoyances of writing all the data out for the report, saying:

> Writing the thing [Phase One report] is kind of odd because its basically like writing data, I'm just not comfortable with it. I feel like I should be analyzing something. When I got to part seven it was good: the rationale.

She said her report would be between ten and twelve pages and that it would probably amount to thirty to thirty-five hours of total work time. When I asked if her if this amount of effort was reasonable, she said, "It's a different kind of effort because a lot of the work was busy work, not that I don't see it as important now." She suggested that the report writing was time-intensive but not energy-intensive.

She then reminded me that she had gone to one Joe lab. "It was so peaceful," she said. "I did my work. He didn't bother me, didn't try to give me instruction." She compared this to a Diane lab, where, "I'm always trying to calm her down, not just me, the whole lab." Still she said, Diane had her strong points, and told me a story about a student who lost their complete map set. Diane was very understanding and calmed the student down, whereas Megan expected that Joe would have been *much* less sympathetic. Megan said she liked the nurturing aspect of Diane's personality but that it was difficult to deal with when there was a lot of work to be done.

As for lecture, she said it was more tied into the project than ever. She wished Dr. Bower would have given some of the lectures sooner, saying, "If we would have got some of this stuff earlier, we would have known what to look for." She then referred to the newspaper articles, which later on clued me into her way of thinking about the project. She was not in this simulated environment in real-time. She was imagining it as an historical event, where even though the news articles came out chronologically at key points over the semester, she thought that this whole story took place a few years earlier.

As was the case with most students, Megan was annoyed at the ending of *A Civil Action*, though she was more critical than most about the way the reading assignment ended. She was convinced that the last 160 pages of the book were unnecessary and suggested that next year's students just skip to the last chapter.

I asked Megan if she thought the class was worthwhile. She said, "Yeah because I have a better sense of basically - like - how it all works...basically the class has helped me understand the whole water issue." She then repeated that she appreciated emphasis on the legislative elements of topics presented in lecture. I asked her if she would be taking away any skills from the course. She said that she had gained mapping skills. She talked about how she had hung all the maps in her room and was, "Putting five maps together...looking at all the same stuff," and using three of them to determine which way chemicals move. I asked her if she thought she could generalize this skill outside of environmental science, and we talked about urban planning and other relevant topics where maps might be useful for solving problems. She agreed that these skills would be useful in other areas.

We talked a bit more about her technical problems. Megan said she had used plenty of technology in educational situations without incident, but that this was just a case of bad luck.

December. In mid-December, Megan seemed much more relaxed. She was happy with how her Phase One report had been evaluated and had a clear understanding of what was expected for Phase Two. In fact, she had already completed the memo assignment. I asked her what she liked best about her report. She said, "I probably liked the part where I saying something of interest, the more analysis part."

She found the Phase Two work somewhat redundant because, in her mind, all it did was provide concrete evidence for the theory that nearly everyone came up with. I suggested that finding evidence was not insignificant, and she clarified that the writing of the memo was somewhat redundant because she said she repeated much of her previous report and just added the physical evidence.

She was happy with how the Phase Two labs had worked, with a student in charge and everyone working as a group. She said the work was done earlier and was much more relaxed. In general, it seemed that people calmed down after the pressure of the Phase One report. I asked her if her relationship with her partner had improved at all. Megan was positive about her partner but said that it was mostly due to the level of work diminishing in the lab. She added she did not have to expect much from her partner recently, whereas before they were, "At each other's throats." Megan did not find the character mapping group activity in lab of any help because she had done every interview herself. I asked her if Phase Two was any fun. She said the students became better friends towards the last few weeks and she was not dreading going each week, again mostly because the pressure and workload had diminished and she knew Diane would not try to be as controlling. Because of holidays, her lab was no longer one of the first labs that Diane taught in a given week. I asked if this might have helped as well, but Megan disagreed, citing the improvement came before the calendar change went into effect.

As for the lecture, Megan's first response was that reading *Silent Spring* made her think, "I'm going to die so soon." Later she said, "Clearly people need to recognize the fact that there are consequences from contaminating the environment." She went on to talk about how she saw this book more as an historical artifact. She commented that the arguments seemed obvious, but were clearly important at the time the book was written. She reiterated that the study questions were of no help and made her feel like a sixth grader. As with some other students, she agreed that the questions disturbed her normal reading process in a negative way because they caused her to struggle to maintain the bigger perspective of the book because she was focusing on so many details.

Looking back over the whole semester, Megan said, "I expected to get much more science out of this class. I'm not really judging whether that's good or bad, but I got much less [science] out of it." She indicated that she was comfortable with the approach the class took, saying:

> It was nice to be working on something all semester, I have one other project like that…usually when you finish it you feel more accomplishment to your semester, than if you do lots of little lab reports because you don't it all in one, like when you hand in a thirty page paper you're like this is the work of eight weeks of research and whatnot, so that was nice because you could sort of sum up your whole semester and you didn't feel like you wasted time but by the same token it was not like a whole semester project because it was so broken down into little pieces.

I asked if the fact that the lab was so structured caused her to lose a sense of the whole while she was in the middle of the project. She agreed, saying, "Yeah until - like - the night before I did it [report]. I would have liked it to be a more unifying." She talked about how having projects less chunked into pieces was more valuable to her, but might not work for everyone. At one point she said:

> I like to do research, and I get more out of it when I have room to do more analysis versus like if you do lots of five to seven page papers you get really good at not getting anything out of them and you can just produce an 'A' paper and not really get anything out of it, but when you're doing a full semester project you get more out of it because you can't just make it up, twenty or thirty pages, so you have to devote yourself to it.

I mentioned that a couple students I was interviewing who were also in Diane's labs seemed to have not engaged and perhaps gotten away with it because Diane gave them so much guidance. Megan did not think people could legitimately avoid engaging the project and write a good report. She said:

> When it came to the analysis, in order to do, in my opinion, a good analysis of this, you couldn't just talk about the data, you actually had to know what you were going to say before you started typing or you couldn't really go anywhere.

Megan suggested that perhaps she just tuned Diane out and did the project more or less independently. She even said, "Maybe I just subconsciously had a Joe lab." I asked her if she was going to switch to Joe for second semester. She said her schedule might not allow it, but she was not too concerned because she had gotten used to Diane over time.

Overall Megan was pleased with the course as a whole. She repeated that her expectations about learning more actual science did not come true, but since she was not looking to go into that area she was not concerned. She said, "The way the class was structured I got a lot out of it. It was just different than what I expected." Even though she had rampant technology difficulties, she still said she would opt for more courses with similar simulated learning environments and figured her luck would change in the next instance.

Looking at the lecture and the lab together, Megan tended to group the course into two parts, based on the two main texts, *A Civil Action* and *Silent Spring*. She suggested there be an exam at the end of *A Civil Action* and then a non-cumulative final that covered the *Silent Spring* related material rather than the large exam she was currently studying for.

One last time I asked her what she would be taking away from this class to see if she had anything new to say. She mentioned her knowledge of pesticides and groundwater poisoning in terms of how common it is and how it occurs. She said:

> It's different now because I never saw pesticides as such a huge problem…and also how easy it is to poison the groundwater, how many things poison the groundwater, how that affects you, how you can ingest them, all those issues.

She did not think this new knowledge would change her everyday life all that much because she felt like her parents had already taught her many environmentally sound behaviors (She mentioned using vinegar instead of Drano for a clogged drain as an example). I asked her what she really received from the course in terms of awareness if she already operated in her daily life as a more environmentally conscious person. She said, "Because I was already at the awareness level, I could get more out of the details." Then we talked about the map skills she had gained that she mentioned at our last meeting. She elaborated on her thinking about it, saying:

> My whole room was just like all my maps were taped around, and then you had to be able to look at all the maps so I would go around the room and look at - you know - 1200, 800 on this map and 1200, 800 on this map and figure out what all those numbers meant in your head, so I think that was really helpful because I don't like maps all that much, I don't keep maps in my car or anything…sort of helpful because I was forced to analyze them and understand what they were trying to say.

She also mentioned the use of testimony, saying, "Usually when I do research I don't have to use what people say, but it was interesting…forced me to use interviews as a source of facts."

In Megan it seemed we had an example of a bright student who overcame several obstacles in order to have a positive experience in a Diane lab.

<u>Reflecting on Megan's Case</u>

Megan is the best-case scenario for a bright motivated student in a Diane lab. However, she succeeded mainly by tuning out Diane. Megan saw the obvious lecture and lab connections and appreciated the cumulative nature of the course. She is the rare student who likes long-term major projects. She would have benefited more from a Joe lab, or at least, had less of a struggle getting through the course.

Megan and her partner failed to work well together, as did many of the students in the study. To have that pattern carry so well through the project makes me wonder if this high a percentage of pairs have trouble working on the project, or that was just a peculiarity of the group who participated in the study. Because I did not track any student pairs, it makes it difficult to say much more about this side topic.

Megan considered herself a scientific-minded person before this course, and she mentioned more than once that this course did not give her much additional scientific knowledge. However, she still identified skills that she could generalize including the use of maps to solve problems and incorporating testimonial evidence into argumentation and was not disappointed that there was less science than she expected. She also considered herself to be environmentally conscious, and yet she articulated how she received more detailed information that would be of use to her in her designated career path and life.

Megan was also the lone student to participate who had significant technical problems with Brownfield Action throughout the semester. Yet, this obstacle did not prevent her from having a substantive experience. This should serve as a reminder about the ability of students to forgive errors when there are good intentions and a willingness to be flexible. At first Megan was very distraught that she might be at a disadvantage due to her technical difficulties. However, once it was made apparent to her that these things happen occasionally and were not her fault, she was able to relax and push ahead. Students will trust when given the opportunity. Diane's ability to empathize with Megan's situation allowed her to survive these difficulties even though Diane also brought a lot of additional stress to the lab when difficulties arose. Still, Megan appreciated the peacefulness of Joe's lab the one time she had to make up a lab. She was then able to see how the stress Diane brought was all in Diane's head and not necessary to get through the experience. Joe and Diane's flexibility to allow Megan to make up a lab on a different day demonstrated to her that they cared about her learning and wanted to see her succeed. Megan was then able to run with the project, even in the face of challenges with her partner and a preference for a different style than what Diane offers.

Megan is example of a special student, one who even though she was very task oriented, was able to step out of the experience, see Diane's strengths and weaknesses as an instructor, her partner's limitations as well as the limitations of the technical infrastructure, and adapt her own behavior in order to obtain a positive experience out of her circumstances. In addition to knowing what to do when you do not know what to do, the ability to adapt to bad situations and make the best of them is another enormous life lesson that many people never achieve. Through this experience, Megan is well on her way to having a set of personal tools that will serve her well whether she sticks with her political ambitions or not.

Reflecting on all Eight Cases

Looking at the eight cases as a whole, there are some distinctive findings that did not come out in previous years. Talking to students while in the experience allowed me to gain a well-nuanced understanding of not only what was happening in the course but how all of the various strategies and decisions we had made over the years affected each student in different ways. Following these eight students made it all the more apparent how difficult a task it is to address a large course with an appropriate learning environment. Even at an elite all-women's college, where one might expect a large amount of homogeneity, there were eight entirely different experiences from eight very interesting and unique students.

I will not attempt to categorize these eight students into well-defined groups, but we can look at some general trends. In looking at the four students that had Diane's labs (Victoria, Michelle, Janet, and Megan) versus the students who had Joe (Josephine, Akira, Emily, and Angela) we can say a little more about Diane and Joe's strengths and weaknesses as lab instructors in the context of this course and project. Diane appears to be playing *not to lose*, in that she errors on the side of giving too much guidance and asserting as much control as possible in order to make sure all students in her labs make it through the course successfully. In the case of Victoria, Diane's methods were fortuitous. In the case of Michelle and Janet, these strong students benefited less than they might have because Diane took away learning opportunities by giving them much more than they needed. Megan is also a strong student, and by blocking out as much of Diane as she could, she was able to hang on to more of those learning opportunities than the others. Joe appears to take the opposite approach. He errors on the side of antagonizing students rather than give them too much guidance. For strong students such as Emily and Akira, his strategy paid big dividends because they met his standards and avoided confrontation. However, Josephine, who had an encouraging start to the simulation, lost interest over time (even though she still spoke positively at the end of the project), and Angela had no chance for success with a lack of support from Joe.

It is difficult to say which style is the better approach. In previous years, the student ratings essentially washed out, with students rating the experience of the course equally regardless of the lab. In looking at these eight students, the end results are similar. It is not surprising when you ask students which lab instructor they like better or prefer because that question has multiple factors. As all four students who had Diane pointed out, she has the best of intentions, cares for the students, and tries very hard. However, she is not necessarily doing strong students any favors by giving them as much help as she does. As much as students may like Diane, they may be getting less from the course than they could be. It is complicated to be a student in a non-traditional course, as students such as Michelle, Janet, and Akira pointed out. They all know they have been groomed for the traditional course and there are at an elite college because they know how to work the educational system. This course challenges traditional methods by its very nature. Diane takes some of the heat off by giving significant guidance and assistance. It is very tempting as a strong student to take what she gives, get the good grades, and not concern one's self with the larger learning opportunities that have been presented. Megan was the rare student to take the hard road, wall off that guidance, and dive into the project on her own. It is hard for me to expect the typical college student to do that.

It can be argued that Joe is actually doing more for students through his tough love approach that forces students to think for themselves. However, the harshness with which he treats students who are not living up to his expectations is not something that should just be let go of easily. Strong students such as Emily and Akira had no significant trouble with Joe's style because they met his expectations, and thus avoided conflict. In Angela's case, even if Joe acted perfectly, there is good reason to believe Angela would still have come away from the class with a negative experience solely based on her inability to maintain attendance and concentration. However, Josephine is a good student. She was engaged early on in the process, and Joe's frustration with her combined with a bad partner situation took her out of the experience unnecessarily.

In the end, we want students such as Janet and Michelle to have experience more like Emily and Akira, and we want students like Josephine and Angela to have experiences more like Victoria. If Diane could gain some of Joe's hard edge when it comes to offering too much guidance, and Joe could gain some of Diane's understanding and nurturing behaviors, we could be more confident that a higher percentage of students would walk away more positively and having learned more.

Still, even those students in the middle ground (Josephine, Janet, and Michelle) acknowledged that they got something out of the course and were able to articulate what that was. Because of this, it should be clearly stated that Joe and Diane did not do a poor job. All instructors have strengths and weaknesses. One has to applaud Joe and Diane for their willingness to be subjected to a new type of project after long teaching careers as well as a great deal of scrutiny about their teaching practices. For example, in speaking with Joe after this last semester, he clearly acknowledges his strong points and his weak areas and sees improvement with how he has dealt with students over the years. He expressed a clear desire to me to continue to try to improve, but wants it understood that change is not quick after so many years in front of a classroom.

Year Four Reflections

We must remember that we made no significant design changes from year three to year four in Brownfield Action. In the end, the project went more smoothly than it ever has, according to Dr. Bower. Student reports were better than ever, according to Joe and Diane (and it is these people's opinions that should really matter). Students complained less during the process to Joe, Diane, and Dr. Bower. Students progressed further into the Phase Two portion of the project than ever before. Less technical assistance was required than ever before. A lot can be said for another year of experience implementing a complex project. A lot can be said for the adjustments Dr. Bower continued to make to his lectures. A lot can be said for less significant outside circumstances, such as the terrorist attack on the World Trade Center that occurred during year three's implementation. In the end there are more variables than can be accounted for. As has been stated throughout this study, this project has never been about trying to control variables and producing indisputable evidence that Brownfield Action is a superlative project for undergraduates. We can only talk about what we have observed through experience. This year's observations provide more direct, specific evidence about what makes an environmental simulation work in a large lecture and lab course, what makes simulations work in general, as well as many of the factors required to make any educational technology project move forward in real classrooms.

CHAPTER VI

What We Have Learned

After a year's worth of intense scrutiny on the complete student experience, it is now worthwhile to broaden out to what has been learned over the four years of the Brownfield Action project in an effort to provide findings and recommendations for the future of the project, other similar simulation projects, and the field of educational technology as a whole.

We can start off by looking at the specific questions generated over the years of the project that were used to try to improve it over time to see what we can recommend based on our four years of experience.

Q: In what way does Brownfield Action help connect the lecture and lab components of the course it is used in? What benefits do students receive from a more connected experience?

Simulations are a useful way for students to apply content knowledge from lectures in a lab setting, and thus can be a good strategy for connecting a course with lecture and lab components. Simulations are a useful method for creating a building, accumulating structure to a set of lab experiments that will reinforce previous knowledge and encourage students to make connections between topic areas in a course.

Brownfield Action supports better retention than traditional approaches, integration of concepts into a system, and provides an authentic purposeful experience for students. The cumulative nature of the experience challenges students to break out of traditional surface-level study habits and encourages more complete engagement in the material. With the exception of Angela, who did not consistently attend lecture, and to some extent Josephine, all the students interviewed felt that Brownfield Action connected the lecture and lab in some form, but this connection was interpreted and valued in different ways. Some students found the novel *A Civil Action* to be the main link between lab and lecture. In some way, reading that book informed the lab work and vice-versa for many of the students. Other students clearly engaged the lecture material and saw how it fueled the lab work and vice-versa. It should not be a surprise that different pieces of the course affect different students to varying degrees. Even a student who struggled as much as Angela perceived benefits from the texts.

Perhaps more important than the identification of a connection, all students except Angela identified benefits of a cumulative experience over a traditional lab experience, some earlier in the semester than others. These benefits included the integration of concepts into a related system (Emily and Megan), a real-life practical or work-like experience (Janet and Josephine), better retention of material (Akira, Emily, others), and giving a purpose to the lab work (Michelle).

Some students mentioned downsides to this type of process that focused on how tough it is to avoid the standard college student's *get-by* approach. Michelle, for example, saw that this type of teaching challenges that approach to learning, and it is hard to break that habit with students, especially those that are very concerned about their grades.

Based on the feedback of the students and faculty in each year's version of Brownfield Action, we can say with high confidence that this simulation allowed students to apply content knowledge from lecture in a lab setting. We can also say with high confidence that this simulation has been used effectively to connect an environmental science course with lecture and lab components. Intuitively, it seems this piece of the Brownfield Action framework would hold true for other simulations as well. A class on anatomy that has lab dissections, real or virtual, could be the basis for a simulation. A chemistry class with labs asking students to identify unknown substances could also follow a similar framework. In either case, if the lab problem or experiment is layered with a role for the student and a context for solving the problem, one has a simulation. By bringing this context and role into the lectures, the instructor can encourage students to make links between lecture topics and lab activities. A well-designed simulation provides incentives for students to make links between topics.

In addition to linking from lecture to lab, Brownfield Action has been shown to be an effective way to link up several seemingly disparate topics into one large problem. Students and faculty reported better student retention of previous topics and made linkages in their report writing that were not likely under a traditional teaching framework. Several students identified value in reinforcing previous knowledge, saying that it would contribute to a long-term impact from the project and the course on their lives over time. Faculty also identified added value through their high assessments of student writing. This method of linking labs together could also apply to many contexts outside of environmental science. The hypothetical chemistry lab mentioned earlier could set up a detective or forensics-like simulation with a series of chemicals to be identified using the various experimental methods that would be traditionally taught. Within the simulation, these experiments might be performed by students playing the role of forensic scientist trying to solve a fictional crime. The hypothetical dissection lab could be done similarly. Adding the simulation component groups the isolated lab experiments into a purposeful narrative. If students are assigned to write up their lab experiments in the context of one larger problem, they will be forced to connect what they have learned in one lab to another. This reinforces the knowledge they gained in previous labs and helps them to create a system of connections between the various skills and content knowledge they have gained throughout the course. Students of Brownfield Action identified this type of learning to be more challenging for a busy student who just want good grades, but pointed out it was better for them in the long term, whether or not they planned on being a scientist.

Q: Can students demonstrate growth in their ability to discuss their scientific or analytic thinking processes through the use of the Brownfield Action?

Simulations are a useful method for developing and/or practicing scientific thinking and problem solving skills through the exploration and analysis of a multi-disciplinary complex system.

Brownfield Action supports the development and/or practice of scientific thinking and confidence building surrounding the ability to perform complex tasks that involve problem solving, integrating concepts from different disciplines into a system, and the use of maps. If we look at the students who claimed to be non-science oriented (Victoria, Akira, Angela, Josephine), all but Angela demonstrated confidence with the material by the end of the semester in the way they were able to talk about their recommendation for the factory site. All but Angela received high assessments on their Phase One report and reported value in doing the assignment. Victoria and Akira had very positive views on their complete experience. Josephine claimed to have done a fair amount of *get-by*, but still was able to articulate her strategy for determining the problem presented by Brownfield Action. Looking at the four students who identified themselves as analytical or more comfortable with science, it is more difficult to make such strong claims. Emily and Megan perceived that this course expanded their scientific thinking skills, either in terms of integrating concepts or using maps to solve problems. Janet and Michelle had more difficulty identifying how the project helped them scientifically. Again, all four performed well on their Phase One reports, but they may have already had many of those skills coming into the course.

Brownfield Action is a complex system. Students had to demonstrate problem-solving skills in order to write the Phase One report. Some students claimed to have developed analytic or scientific skills of one kind or another (Victoria, Akira, Megan), while others determined it was more puzzle-working and not much science. Earlier evaluations of the project made this claim each time on the basis of the report-writing, but it is difficult to say if the scientific thinking evidenced in the reports was already developed in the students prior to their use of the simulation or if the process of Brownfield Action caused or led to the development of those skills. Since we are not in the business of pre-testing students and/or dividing them into control groups, we may never gain a definitive answer on this claim. However, again, it does seem others could benefit from the knowledge that simulations, as complex systems, are a useful sandbox where students can gain and/or practice problem-solving skills. In addition, some students may develop analytic and/or other scientific thinking skills through their use. The point about the system being "multi-disciplinary" should be emphasized. Brownfield Action incorporates geology, civics, human health, chemistry, mathematics, social networks, and engineering, among others. To complete the project, students had to dabble in each of these areas and interrelate them in their reports. Other simulations could benefit from following the same strategy.

Q: What are the essential characteristics of effective guidance and support for Brownfield Action at its introductory, middle, and ending stages?

Guidance is a crucial element in the use of simulations. Too much guidance limits discovery. Too little guidance generates frustration and resentment.

Brownfield Action requires a range of guidance strategies for different students. Stronger students benefit most from a hands-off independent approach, while weaker or more intimidated students benefit most from a more hands-on nurturing approach. Instructors using a more hands-off approach should be cautious about creating resentment in students while instructors using a more hands-on approach should be cautious about taking away learning opportunities for students.

Guidance was an enormously important topic amongst the eight students and was discussed at length in Chapter V. Effective guidance appears to be a balance of Diane and Joe's strategies, but again, it depends on the student. Some students, especially those who are more fearful and intimidated coming into the course, respond better to more of a Diane approach, and all students *like* her strategies, but may be let off the hook too much from a challenge point-of-view. Stronger students tend to get more out of Joe's *tough love* style, and some less strong students will survive it. Others will balk at his confrontational style, as did Josephine and Angela.

In looking at the introduction of the project, students such as Emily and Janet dealt well with how the project was introduced. Other more nervous students wanted things laid out more clearly, but much of this can be attributed to their habit of getting into the "What do I need to do to *get by* mode?" that they are used to. Giving more concrete information up front may push more students into the *get-by* strategy. By keeping it somewhat vague, perhaps more students are willing to buy into the simulation and engage before the clear end goals are laid out and students slip into *get-by*. Too much guidance pushes strong students that way, as evidenced by Michelle and Janet's experience in Diane's lab. Megan's ability to wall off Diane's assistance was a rare exception that should not be expected of the typical college student.

In the middle of the project, students such as Josephine and Angela, lost sight of the end goal, and may have benefited from more small victories along the way from Joe to let them know they were on the right track. Students in Diane's labs seemed less likely to be lost, and instead may have benefited from more independence, as seen with Michelle, Janet, and Megan.

In the ending stages of the project, students in both labs reported a loss of momentum, which may be natural the way the project is structured leading up to the first report. This last year was the first time substantial effort could go into the Phase Two portion of the project, so another year of practice for Joe and Diane may be enough to improve the end of the semester guidance that was taking place. On the other hand, much could be done to improve the design of the Phase Two portion of the lab experience through additional multimedia and supporting documents to boost its visibility to students (see recommendations in Chapter VII).

For Diane, in addition, she needs to buy into the Phase Two individual memo assignment (or make an argument for revision next year) because some students (Janet for example) picked up on her lack of enthusiasm.

As has been discussed at length at various points in this study, guidance is a crucial factor in the success or failure of a simulation with any given student. In previous years, on the surface it appeared that Joe's and Diane's strategies washed out in the final analysis. While Joe and Diane used very different strategies, students rated the experience in either lab similarly. However, when one looks at this issue more deeply, as was done in the most recent study, the nuances of each of their techniques come out. It was clear from Diane's students that the weaker and more fearful students had a more positive experience with Diane than with Joe. However, stronger students lost out on some of the challenge in Diane's labs. Joe's students had more of a challenge in general, but his confrontational style alienated some of the less confident students. One could see how an end-of-year rating system would lead to a balancing out of scores between the two styles. Talking to students individually at the end of the year about whom they prefer would tip the balance in favor of Diane because of her nurturing and caring style. Students initially value compassion over learning. Most will take the path of least resistance. Only by talking to students in depth does one discover that many of them do realize that overcoming the challenge of the discovery is what they walk away with at the end and use in their daily life. Some students will seek that out once they articulate it to themselves. Others will not. In the end, we need to do what is best for students, not what makes them feel good. I am not suggesting that instructors should use Joe's confrontational style. Criticizing students personally in public is never a good instructional technique. In addition, as Bruce pointed out in his study, Diane does many things very well in her lab to reinforce concepts and keep students on track. What I am suggesting is that learning should taking precedence over too much caring because ultimately you are not caring for students if they walk away feeling good about learning but having not really learned anything that they can walk away with from this course. In fact, you are doing them a disservice because you are reinforcing to those students that feeling good about learning equals learning, when anyone who has learned a real life lesson knows that real learning is often a painful struggle blocked by many obstacles.

Q: In what way does humor assist novice students in engaging complex content?

Humor in a simulation can be a useful method for engaging less confident students in a seemingly overwhelming activity.

The humor in Brownfield Action helps to relax more intimidated students and keeps many students engaged when tasks become arduous. Humor seemed to have relaxed and engaged some of the students, but was not a factor for everyone. Several students got into the funny character names and nearly every student interviewed mentioned the opening sequence as being humorous. Adding a little light-heartedness to the grind of the project seemed to have hurt no one and helped some students get through it more easily. Only Emily perceived a possible negative side effect of involving Dr. Bower as the real estate developer in the story. She astutely pointed out that students may feel like it is more of an assignment for the professor instead for a fictional person that might make it easier to buy into the student role.

Large complex science problems such as Brownfield Action can be overwhelming to some students, especially those seeking the easy way out of a science requirement. Adding humor to the activity can reduce the pressure some students feel and help them relax and engage in trying to achieve the objective. More confident students do not appear to require this factor to be present, but they do not report any harm. It also makes the building of the simulation more fun for the creator(s). Simulation creation is enough work to merit a little fun when appropriate.

Q: How does the partner dynamic affect the benefits one receives from Brownfield Action? What benefits do students receive from working in pairs? Are pairs the ideal setup for this project?

Working with a partner or team on a simulation adds a real-world element to a complex assignment that is important for students to develop regardless of their chosen career path. Do not be surprised if even great students struggle to work together in groups when doing a simulation.

In the Brownfield Action project, many students require support in order to foster better working relations with their partner. Pairs of students may not be the ideal setup for this project. We have significant evidence that pairing does not work well for several students, but we do not have any evidence to suggest that larger teams would be an improvement. Resources are not available to allow students to complete the project individually.

The partner dynamic was a major obstacle for many of the students interviewed. Only Michelle, Janet, and Akira managed to avoid substantial partner problems. Many of the students in the study had to make up for partners who did not work as hard as they did (Emily, Megan, Victoria). The participants could be biased towards more outgoing and motivated students as I asked for volunteers to participate in the study with minimal compensation. Still, there seems to be more work to do in this area in terms of support for students to help them overcome teamwork obstacles and work together better than was demonstrated by the eight students involved the most recent study.

Completing a simulation such as Brownfield Action is more work than should be asked of one student for one semester-long course. Adding partners can reduce the workload if the pair of students work together. If they do not work together, having a partner adds another obstacle. This fundamental concept is an important life lesson that many students experience throughout their schooling. And yet, five of the eight students in the most recent study still struggled with this component. Clearly, students need more support than has been provided to date in Brownfield Action on this factor. Partner and group work has a long literature behind it that is beyond the scope of this study. A future study could expand this point further. One might also consider trying some teams of three next year to see what might be added or subtracted from the experience (see recommendations in Chapter VII).

Q: Do students demonstrate growth in their personal relationship to environmental issues through the use of Brownfield Action and/or the course? How might the experience affect their real-life decision-making and approach to science?

Students who experience a quality simulation activity may apply the experience and/or the content and/or processes they used in that activity to future courses and/or their life.

Brownfield Action supports growth in students' personal relationship to environmental issues and promotes transfer into students' real-life decision-making and approach to science. This growth and transfer will be different for every student based on their background and chosen path in life. Nearly all students were able to expand their articulation of environmental issues through the course. Some students were better able to relate to the pesticide issues, while others felt closer to groundwater issues, but all found something in the content of environmental science that they would take with them. It is difficult to say how much of this finding relates to the structure of the course versus what Dr. Bower's lectures might accomplish isolated from the complete project system.

Victoria gave the best example of how she changed her behavior even while the course was still going with her example of her approach to the use of pharmaceuticals. Other stronger students, such as Janet, felt inspired to move more deeply into the technical or more scientific details of environmental science because she proved to herself through this course that she was up to the challenge of more hard science. Others such as Megan and Emily felt they got more practice at integrating concepts into an argument, and that this could be generalized into many other disciplines. Megan talked about using maps to solve problems. Several students talked about the new kind of writing skill this course helped them develop. All students spoke about awareness and taking note of what was around them in their environment and how precarious the system of the environment is at this point in history. In some way, all students were able to apply something from the course to their daily life.

As was evidenced in the comments by several students in the most recent study, engaging in Brownfield Action provides experience, content, and skills that they plan to apply to their daily life if they have not done so already. From map work, to a new kind of writing, to gaining an eye for detail and confidence about scientific ideas, to coming to a new level of awareness about how science related to the world around them, students identified several generalizable benefits that go beyond the classroom and the lab bench. While it would go beyond the scope of this study to verify that, in fact, these students did use these skills in other courses or in their daily life going forward through the years, we can still say the opportunity to use these newly gained assets has been identified by these students and the burden is on them to put them into play on their path. Other simulations can provide the same opportunity. Again, using the hypothetical chemistry forensics lab simulation, students could gain many of the same benefits when it comes to writing, thinking about details, gaining confidence, and gaining awareness about the role of science in the world around them.

Other Thoughts

Through the act of designing, implementing, and evaluating the project we learned several other pieces of useful knowledge that could also be developed into theories that may not have been explicitly stated as questions at any point in the project. Nonetheless, they are worthwhile to point out.

- *Some ambiguity is good, but students need proper orientation to accept and engage in ambiguous, open-ended learning activities.*

Through this project, we have come to learn that students expect the traditional approach to teaching and learning science. Students at elite colleges will be some of the best in the world at performing the tasks that traditional approaches reinforce, such as textbook memorization, while expending minimal energy engaging content in a meaningful way. Over the years, Dr. Bower, Joe, and Diane learned to forewarn students that they would be discovering how the project is defined and how to complete it over the entire semester. They reminded students to review what they had learned in previous weeks because the burden would be on the students to put everything together in the end. Michelle felt the warnings to be unnecessary given Diane's level of assistance, but even she identified that eventually there was no point in waiting for someone to tell her what to do next.

In order to get students to accept their role in a large project, it is important that enough engagement and explanation occurs to get them to buy into the experience. However, too much orientation will remove the challenge for many students, so some vagueness or ambiguity can be an asset as well. Doing a simulation project well can be a bit of a mystery unfolding. Students likened the beginning of Brownfield Action to *Carmen San Diego* and even *Charlie's Angels*, a game and a show where the intrigue of the stories keeps you hooked. In designing a simulation story, do not feel compelled to over-explain. Instead, give students enough tidbits to get hooked on the concept, then unfold the story enough to point students to the range of directions to go and set them as loose as you can tolerate.

- *Students need incentives in order to pace themselves on large projects that build on previous knowledge.*

In the first years of the project, we discovered that students were cramming the work for the lab with their cramming for lecture midterms. This led to difficulties in completing the project on time and with high standards. By replacing the midterms with weekly exams, students were forced to spread out their work on the project over the semester, which made it easier for them to build their knowledge base as they proceeded.

Simulations by definition do not instruct directly. They teach indirectly as students establish the connections between the actions they take and the effects seen in the simulation. Because of this, students often struggle not knowing if they are on the *right track*. A good simulation does not have just one *right track*, but several, and students should have ways to find out if whatever course they are on is reasonable. In our case, weekly quizzes in lab and lecture helped considerably, but any number of techniques would have done the trick. The important thing is to let students keep exploring within as broad as range of options as possible. Think of the process as a more open-ended slalom ski race. The goal of the simulation is to get to the bottom of hill. There are walls along each side of the racing path indicating the boundaries for the race. Then there are numerous posts for the participants to ski around. The job of the instructor is not to indicate which posts to go around, which way to go around the posts or even which order, but just to provide the outer boundaries for the exploration. Allow the students to find their way down the mountain. If they rub up against and outer boundary, provide guidance to send them back to the nearest marker.

- *Instructors need years of practice at adapting to technology-infused projects and in incorporating more constructivist strategies into their teaching practices. They will progress at different rates and show different strengths and weaknesses.*

This finding has a substantial literature behind it. This project just provides four years of further evidence in support of it (See references to Mandinach & Cline as well as Sandholtz et al. in Chapter I). As I learned the hard way in the early years, didactic training of instructors about to embark on a new open-ended learning activity backfired. Through years of experience, Joe and Diane came to believe that Brownfield Action was a good idea for students to experience. Slow but noticeable improvements in their teaching followed. In implementing a simulation, allow instructor mistakes and motivate them to reflect and foster self-improvement over time.

- *Accept that all students are different, no matter how homogeneous the group appears on the surface. Each student will react to complex learning opportunities in projects such as Brownfield Action in a different way.*

Perhaps most important out of all the findings, it became clear through this project work that even at an elite women's college, the variety of student experience, motivation, energy, aptitude, and external pressures in a large non-majors science course is so vast that it is impossible to try to quantify the bottom line added value of this project for every student. Each student interviewed came away with something valuable from this experience. For Angela, it was the texts. For Megan, it was using maps to solve problems. For Victoria, it was gaining confidence in her ability to use scientific details to make a big picture argument. For several students, it was simply greater awareness about environmental issues. Furthermore, it is likely that the eight who participated do not represent all of the 120 students who took the course this year nor the 120 students who took the course each of the previous three years. But there are limits on what one can do to try to gain an understanding in any one instance. Interviewing more students may have led to greater breadth but less depth into each student's individual perspective, which at this point, I would not trade.

In designing methods for assessing the benefits of a simulation, do not limit yourself to pre- and post-experience interventions. Instead, get deep engagement in the experience with the people involved while they are in it. In other words, follow your own beliefs about learning.

Surveys and interviews outside of the actual experience are only on the surface of the experience and will only give you a general texture of what is happening on the ground. Imagine yourself as a war correspondent. Do not just report on the war from your desk at the news bureau where the wire reports trickle in. Go out into the field with the troops. Look at what they are looking at. Ask a variety of participants to describe their challenges and their decision-making processes. Stay with them through the battles, and see how they come out on the other side. You will learn so much more nuance about the impact of the experience. This information may make it more difficult to make overarching headlines that apply to everyone, but it will give you the detail to improve the experience you are engaged in over time and more confidence that the experience is having a real impact.

Reflecting on the Project's History

From the most general perspective, one can look at the project's history to see what can be recommended in terms of project processes and design techniques that would be applicable to many educational technology projects.

It is interesting to look back at our implicit assumptions when we began the Brownfield Action project. Dr. Bower and I generated this project out of our beliefs and intuitions for what students should be able to do after completing the project and the course. In the second year, we stated these beliefs, saying that students who experienced Brownfield Action should be able to explain their approach to the solution of a scientific problem by:

- Describing the strategy used to discover contamination sites Brownfield Action
- Identifying and explaining the outcomes of the environmental tests they conduct and related information, making recommendations and demonstrating awareness of the consequences of their decisions
- Drawing inferences from data about structures that contribute to environmental contamination

We also wanted to state more indirectly our hope that students would:

- Read articles on ecology with different understanding, interest, and personal commitment
- Appreciate that real world decision-making about ecology involves ambiguity rather than certainty

These statements arose out of our implicit beliefs when the project began. When Dr. Bower and I originally got together, we did not talk about these needs explicitly, but I can now look back and reconstruct the challenges he and his course faced when the project began and some of our initial ideas about how to address those challenges. The initial challenges included:

- The lecture and lab portions of the course needed to be more connected than they were in order to motivate students to engage the content and to give the content purpose and practical application.
- Non-majors students would benefit from a cumulative experience to relate all the aspects of the course together.
- It was important to maintain some of hands-on lab activities to provide students with real practice at carrying out experiments and performing active manual activities.

Some of out initial hypotheses to the above challenges included:

- If the cumulative experience was a hypothetical but realistic story that could be connected to real-life examples, students would better achieve the course objectives by actively performing aspects of the story through solving a large problem with many components.
- Lecturing on these components would motivate students to integrate lecture content into their lab work and allow the elimination of the textbook-driven, surface level, traditional

science instructional method. In general, the detailed facts of the course were less important to students of this course and should be de-emphasized.

- An engaging and fun story would motivate students to engage in the problem, and thus the content, much as they might engage in a game.
- It was important to maintain many of the hands-on lab work including contour mapping and sediment analysis but if these concepts could be integrated into the story and the problem, students would be more likely to retain the purpose of this work and perhaps the basic skill, if not all the details.

In a more evolved project process, we would have set laid these thoughts out as best we could on paper before any design work began. We would have set processes in place to capture the key decision points of the project as we proceeded from design choice to design choice. These documented choices could then evolve into theories that would be tested in each implementation and then refined and funneled into any redesign that was done. As was stated in Chapter I, we intuitively followed this logic, but did not have a refined process we were following. As it was for this study, I spent many weeks reconstructing how and why we did what we did in the earlier years by foraging through old notes and specifications, which thankfully were fairly complete. With a more evolved process, we may have been able to address more of the challenges we faced with this project more quickly because problems that we did not pick up on may have surfaced earlier through the use of more systematic evaluations. While we may have made most if not all the same design decisions, the key choices would have been documented as we proceeded through the project rather than me reconstructing them years later. This would have allowed for simpler theory development earlier in the process and perhaps more dramatic improvements from year to year.

Still, CCNMTL as well as Dr. Bower and I were learning together as we proceeded with this project. We were learning in the act of designing, building, and implementing. We were not doing thought experiments or hypothetical environments that were tested with volunteers outside the context of any real situation. We were learning while doing work that was real, in that it was used with a real course with real college students with a *range* of experiences. Some might say these factors were constraints that placed limits on our ability to find out what our learning environment quantifiably does for students. I believe these constraints are the realities of the world that our work must learn to deal with, and we are not in a position to wait for the controlled lab results to come in. Plus, many of the theories and findings generated would not have arisen outside the context of a real classroom. One of the single best examples is the concept of beating the system or *get-by* that college students use to avoid real engagement with material. To see that this project and method of teaching discourages that kind of tactic is a very useful finding that would mostly likely not have arisen through the use of volunteers in a controlled study. Volunteers, through the act of showing up for a study that is not mandatory, already misrepresent the population of students we are trying to address. Even using a real classroom of students, but with no grading attached to a study in order to allow a division of the class into a control group and one or more test groups would not have generated this type of finding because of the lack of pressure of any consequences.

Design Research

Going forward, CCNMTL has developed a Design Research Project Process to encourage the very recommendations listed above in the context of doing educational technology projects on any scale for real classrooms.

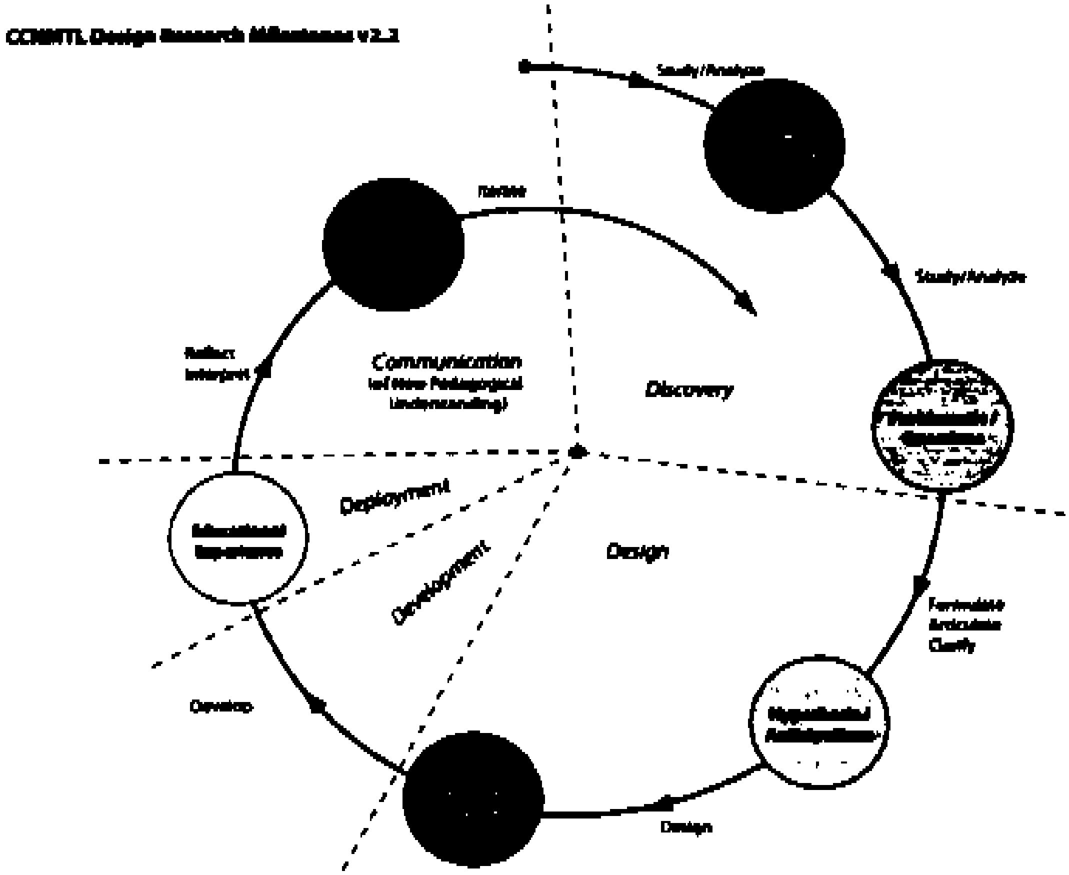

Figure 19. CCNMTL's Design Research Process Spiral

As show in Figure 19, the phases of CCNMTL's Design Research process represent a design and development cycle that can be iterated many times with any project. It is also a set of guidelines, not hard and fast rules, based on the experience of projects such as Brownfield Action and others. In its short history, CCNMTL has achieved good success at building many beautifully designed projects and getting them done on time with good project management. Several projects have also had evaluations done to determine their success. However, many times, as was the case with early Brownfield Action evaluations, they often failed to capture the nuances of the project necessary to glean generalizable knowledge for the benefit of future projects, both similar and dissimilar. In order to get to the next level of the Center's work, a knowledge base, founded on the theories developed from its projects is needed. The goal of the Design Research process is to generate shareable knowledge from real project experience. This sharing will take place on many levels. Some knowledge will be of most use to other designers and builders of educational technology projects. Other findings should be made public to faculty to help them gain a better sense of our expertise and value added to their classrooms. Design findings become CCNMTL's ever-growing toolkit of strategies for addressing various challenges. When a particular set of challenges arises with a new partner, a visit to the toolkit will show demonstrable solutions to challenges that are general enough to apply to multiple contexts.

Recommendations

Beyond the project process, some of the most general methodological findings of Brownfield Action may be useful for anyone working on an education technology project. Following these recommendations will lead to improved designs and better implementations, which will lead to more valuable shareable knowledge.

- *Get all key instructors involved as early in the design process as possible.*

The single biggest constraint on the success of the Brownfield Action project is its implementation in the lab by Joe and Diane. They are the gatekeepers to this world for the students, and we did not involve them in the design process at all in the beginning, and only to a limited degree in future years. There are reasons this occurred. They often both had other commitments in the summers, when most of the development took place. They did not see it as their role to get involved in the design, and thus did not express interest. Still, if we had found a way to have them present at key meetings, they would have felt some ownership of the project earlier in the process. They could have practiced the techniques that were going to be asked of them. Ultimately, the early years of the project may have went more smoothly in the lab, and they may have progressed either more quickly to where they are now and/or farther in their teaching practices with the project.

Any project designer can learn from this finding. If you are building an educational technology project for a course, involving the implementers of the project in the design process will lead to a better project. It may sound just like common sense, but over and over again, one will find examples of projects where the designer builds what appears to be a beautiful project, but because the implementer was not a part of it, the project is never used as intended, if at all. If the project is never used as intended, one cannot generate new knowledge about the design because there is no true feedback on the design choices that were made for the intended audience. Thus, the project becomes a monument or *demo-ware* that can only spin in theory-land about what it might be able to do for a class somewhere, someday. If you think about this for a moment, it makes sense. Would a good teacher put something into their curriculum that they did not understand how to use or have intended goals for including it in the course? No way.

This recommendation does suggest the possible problem of how one uses projects built for one context in another context. For example, one of the future goals of Brownfield Action is to use it at other schools, either other colleges or even high schools. How do we get the project to a point where another institution could use it as packaged environment given the above recommendation? The answer is, get a group of sample instructors from different situations to come to Columbia University and Barnard College and work with us on that package. In this way, it almost becomes a new project intended for instructors instead of students (see Chapter VII for more).

- *Do not be afraid to use real students with your projects, even in the prototype stage. They will understand and appreciate that you are actively working on improving the experience for them and future students.*

Brownfield Action has demonstrated success using students in real classroom settings who knew we were studying their learning in a new experience. Most students have no issues with this approach because they see the instructors caring about the quality of what the students are experiencing. They see active decision-making on the part of the instructor based on their feedback that may not impact them, but will impact students who take the course in future iterations. When compared to taking courses where the faculty member who has not changed a word of the instruction given for several years, a course that is self-reflective by its very nature has an attractive energy to it.

The main drawback to this technique is the institutional constraints of assigning traditional grades to students. Some students may be upset that the grading for a course in active development is not articulated well enough, that their grades are somehow up for grabs. I would argue that this points to the inadequacy of institutional grading systems and need for new assessment procedures, but this track goes beyond the scope of this study.

- *No matter how homogenous you think your student population is, every student is different. Every student will have a different reaction to a given learning opportunity and walk away with a different piece of the experience. Therefore, talk to students in your intended audience before you complete your design, while they are in the experience, and afterwards to find out what is really happening on the ground.*

This statement has been discussed at length, but it should be emphasized that being convinced of this truth can lift some barriers in the heads of the project team. It is only human nature for me to expect that everyone sees the world as I do. The truth is, only I see the world the way I do, and no one else has my view. Designers and faculty members fall into this trap over and over again. A faculty member expects that all students *got* what he or she told them in one of his or her better lectures. A graphic designer cannot imagine that a student would mistake a beautifully placed Quit Button for decoration. It happens over and over again.

Talking to a range of students that are a part of the intended audience at different phases in the project process can provide a lot of perspective. Designers and faculty members can see the broad range of experience that students will be bringing to a project. They will be more likely to see the range of possible outcomes from different design choices. Then while the project is in use, talking to students will give anecdotal evidence for successes and improvements that often cannot be captured on a form or after significant time has passed. Talking to students after an experience can also be helpful, and it is probably the most common approach because it takes the least effort and someone not involved in the design can fairly easily carry it out. However, it will usually give you broad strokes on what you accomplished, but rarely the details needed to deduce which decisions you made were essential and which ones need to be revisited. Real improvement comes in the details found while in the experience.

- *Allow structure for your work to emerge and do not over do it.*

Rather than taking all of these recommendations and applying them to another situation in a recipe-like fashion, this study and this project demonstrate the benefits of allowing a structure of work to emerge from the people involved. This should not be taken lightly. Using each of the project participants' intuitions in this project's early stages, we got Brownfield Action off the ground and running. Over time we realized we needed to begin putting structures in place to ground ourselves to where we had been and where we were headed. We realized we should be sharing our work with others and have been developing a process for communicating new knowledge that is still in formation today because it will be formed out of real examples, just as our designs were made for real work by students. We did not co-opt anyone else's strategy. We made our own based on our successes and failures. One might say the design of CCNMTL's project process was a Design Research project itself, with Brownfield Action as one of the prototypes that fueled the initial designs.

I say, "Do not overdo it," because inherent in whatever structure emerges should be the means to knock down structures and rebuild. Do not allow the rules that are laid down to govern the work in a rigid dictatorship. Those people doing the designing and building must be allowed to break rules when they have good reason to. If that was not allowed in the case of Brownfield Action, the project never would have happened at all because a full-semester student project immersed in technology is not supposed to be doable in three to four months with no user testing the first year, but it was done, and done well.

In the end, good project work is about taking calculated risks and learning from the consequences as quickly as possible. CCNMTL took many risks early on its life. Brownfield Action was one of the risks that paid huge dividends.

CHAPTER VII

What Lies Ahead

The Future of Brownfield Action

Brownfield Action will continue to be used in Dr. Bower's course for the foreseeable future. Based on the 2001 and 2002 findings, we are seeking funding to do at least one more development cycle to move the project to version 3.0. The hope is that version 3.0 would be at a stage where other institutions could test its efficacy in their contexts and work with us to refine the project for a possible commercial release. Possible new areas for new development include:

- Addition of more Phase Two multimedia to keep the momentum going after the Phase One report is turned in, including additional documents and video to resolve the story of the town once the contamination is discovered (currently this is all done verbally by instructors)
- Revision of the cost structure and additional budget functions for easier transfer to the phase one report (currently students have to copy it manually)
- Additional data to represent pesticides that would most likely be present at the vineyard and nursery and a tri-chloro-ethylene (TCE) plume that would most likely be present at the junkyard (this would allow more direct ties with data to *A Civil Action*, which focuses on TCE and *Silent Spring*, with its focus on pesticides
- Additional functions to make data collection quicker and easier in the testing area (the place where most students found the tediousness at its worst)
- Additional testing tool for radiation detection
- Ability for teams to share data they have collected over the internet (currently students share data by hand)
- Adding a mouse to each laptop in the lab
- Improved server application so that instructors could manage student accounts (current version does not have an intuitive interface for a non-programmer)

- Improved server functionality for low speed connections (currently only high-speed connections can log in to Brownfield Action)
- Transferring the server to Barnard technology administrators (to demonstrate how CCNMTL can complete a "passing off" of the complete project)
- Non-internet version for local labs or individuals to do the project without being online and for demonstrations

There is still much that could be learned from continued study of this project, both at Barnard and at other institutions. Possible areas for further design and study include:

- Trying larger teams of students working together and/or adding additional partner support to assist students in working together more effectively, including the design of a study to follow teams through the project to test the value and nuances of teamwork in Brownfield Action
- Having a new instructor teach one or more of the Barnard labs to test our ability to train a new instructor and to see if a more balanced teaching approach based on our findings would add value for students in the project
- Involve another institution in trying all or a portion of the project in one of their courses to test our ability to transfer the project to another context

There are likely many more nuances on simulation as a design framework that can be gleaned from further study of Brownfield Action. The work at the University of Twente by Swaak et al and de Jong et al referred to in Chapter I points to an area of tacit or intuitive knowledge that students gain from simulation that is very difficult to capture in students. Rather than a controlled study as they typically do, it might be useful to try to design a means for capturing similar findings from students in Brownfield Action.

Leutner and Veenman et al, also referred to in Chapter I, look at different styles of guidance in more controlled studies. It might be useful to apply some of their findings by having an instructor other than Joe or Diane teach one or more labs.

One could also experiment with larger teams and study the partner or group dynamic more closely by tracking lab partners either together or separately to learn more about the this factor in the use of simulations.

Both Barnard College and CCNMTL are also actively seeking funding support to carry Brownfield Action outside the boundaries of Columbia and Barnard to other institutions. In April 2003, a weekend seminar for interested colleges took place at Barnard, sponsored by the Andrew Mellon foundation. This seminar walked interested instructors and administrators through the Brownfield Action experience in an effort to communicate what we have learned and to try to spark interest in sharing this project and in developing similar projects in other areas. Preliminary feedback was very positive.

New Simulation Projects Benefiting From the Lessons of Brownfield Action

There are a significant number of CCNMTL simulation projects that have already benefited from some of the lessons learned from Brownfield Action.

ReliefSim

The most direct benefits from Brownfield Action can be seen in the ReliefSim project (http://ccnmtl.columbia.edu/projects/reliefsim/). ReliefSim is a simulation for training in decision-making in humanitarian emergencies at Columbia's School for Public Health as well as non-profit organizations and other governmental institutions. Students are placed in the role of director of a relief operation at a refugee camp. They must make use of their limited resources as best they can to minimize loss of life.

ReliefSim is designed with the framework in mind that simulations are a good strategy for having students interact with a complex multidisciplinary system. Students of humanitarian relief are traditionally taught the different elements of the system in isolation. For example, students in the standard Columbia course receive two lectures on nutrition followed by a lecture on water needs. Then they receive a set of three lectures on common diseases. However, in a real emergency setting, each of these factors is highly dependent on the others and managers must place priorities on which elements will be monitored for dangers, which elements will receive assistance, and which solutions will be implemented to accomplish the selected assistance. These choices cannot be effectively made by people in the field with training in only one area of expertise or by people trained in each element, but in isolation from one another. Through multiple interactive scenarios, the ReliefSim project hopes to give students practice at this type of decision-making.

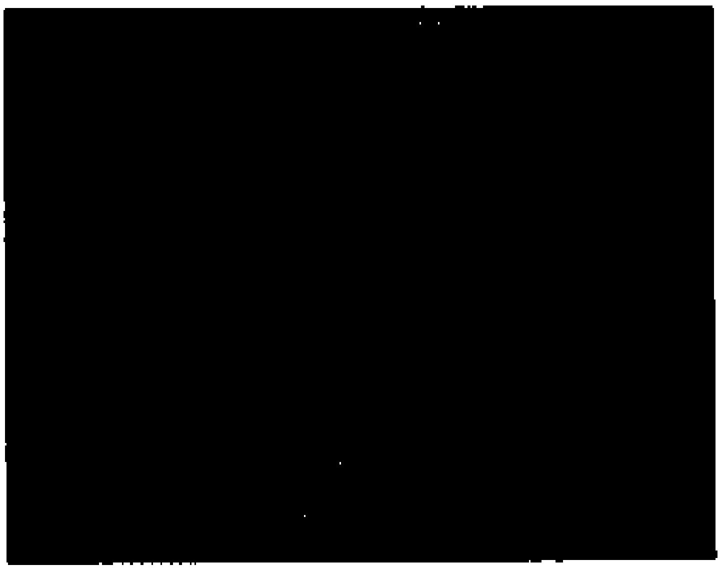

Figure 20. Screenshot of the ReliefSim prototype.

Currently, this project is at the prototype stage. As can be seen in Figure 20, ReliefSim is a text-only interface that might remind someone of something built in the early 1980s. For the prototype, we focused solely on the simulator, or model, knowing that we can add an interface at a later point (In fact, we worked on interface designs in parallel to building the prototype but have not implemented a design yet). We chose this strategy in part because of knowledge about the effort involved in building Brownfield Action. In the first year of that project, approximately ninety percent of the effort went into the data model. Once that was accomplished, laying an interface on the Brownfield Action model was not trivial, but it was done very quickly. We learned a lot from that first use of the project, and then spent the majority of the resources in year two developing a better interface, adding networking capability, along with all the character work. ReliefSim will travel down that same road pending additional funding support.

Heart Simulator

This project takes advantage of the distinction between simulator and simulation laid out in Chapter I. The Heart Simulator is not a simulation. Students do not have a role and a context in which to solve a problem. Instead, the project is the simulator model on its own. The students who use it are primarily first-year medical and dental students at Columbia University. The goal is to have students become experts in the model itself. A simulation would hide the model and ask students to infer what was happening to develop problem-solving skills. These students need to internalize the model first, so we present the model's inputs and outputs in various forms and give students the opportunity to control specific parameters and see the effects of their input (see Figure 21).

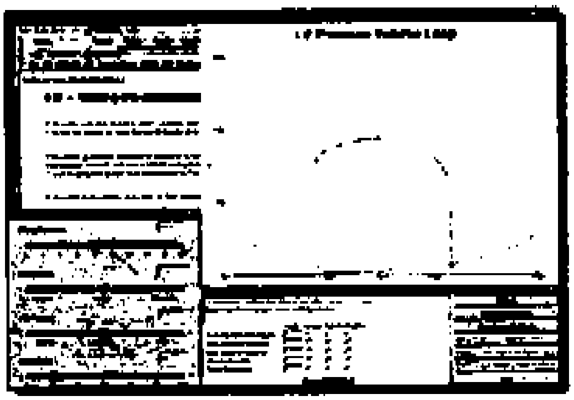

Figure 21. Screenshot of the Heart Simulator.

At a later stage, CCNMTL may choose to layer a simulation of an emergency room around this model for more advanced students who already have the model internalized in order to practice the real-world skills of quick diagnosis and treatment planning in cardiology.

News Reporting Simulation

The Journalism School and CCNMTL (led by Kristen Sosulski) worked together to create an online simulation of a fire scenario for beginning students to learn to basic reporting skills (Figure 22). Students are given a beat and tools to cover the story of a fire in a fictional town. They conduct virtual interviews similar to those in Brownfield Action in order to file a lead and then a story covering the fire.

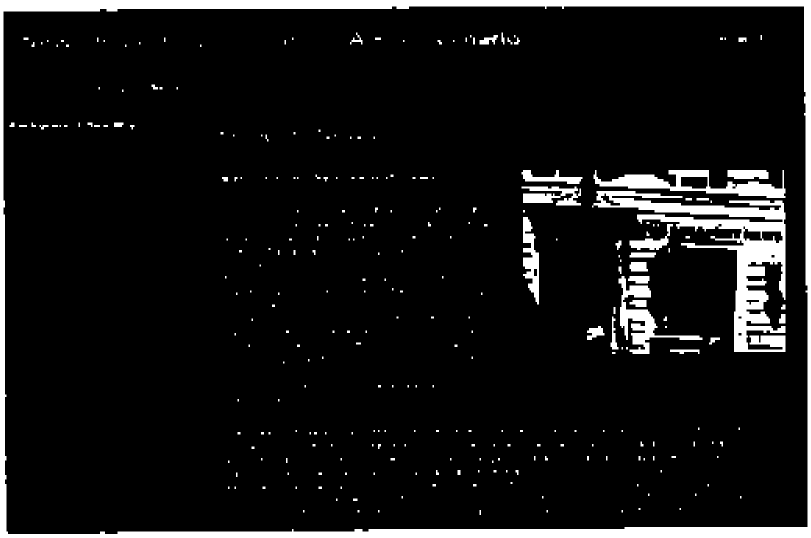

Figure 22. Screenshot of News Reporting Simulation

Epiville

Columbia's School of Public Health worked with CCNMTL (led by David Van Esselstyn) to develop a simulation of a disease outbreak for an epidemiology course. Students play the role of a epidemiologist, gathering facts and deciding actions to curb an outbreak that has struck the fictitious town of "Epiville" (Figure 23). The simulation uses digital video newscasts and interviews and municipal Web sites provide information about commerce and diseases in an attempt to mirror real-life situations. Three different simulations map onto three different types of epidemiology study designs – case control, ecological, and cohort studies. Interactive, multiple-choice examination allows students to test hypotheses about these cases.

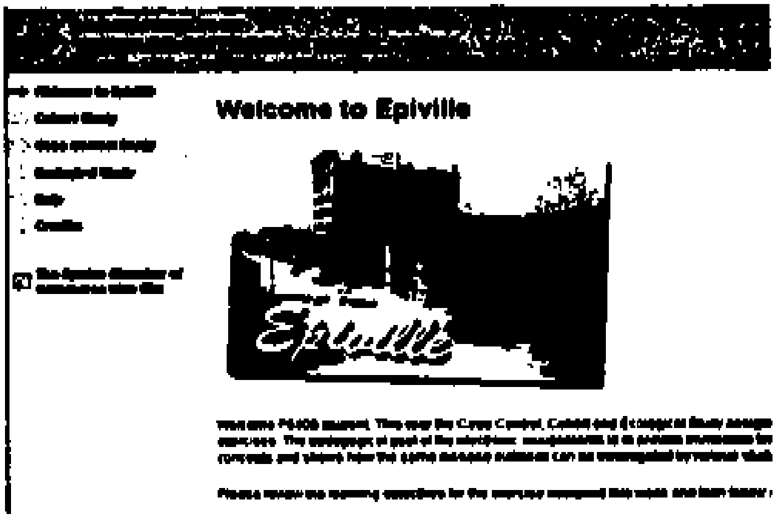

Figure 23. Screenshot of Epiville simulation.

The Future of Educational Technology and CCNMTL

CCNMTL will continue to refine its processes, take risks with innovative projects, and mature into a knowledge creation organization for the world in the field of educational technology. Its rules have been made to be broken. Projects will continue to be created for real classrooms in order to study hypotheses and techniques in authentic environments. CCNMTL is on its way to generating a shared knowledge base of its findings on many levels, from domain-specific theories to broader frameworks. The method for how that will be accomplished is still in progress, and the only thing that is certain is that this concept will continue to evolve and change as more projects are taken on, more data is collected, and more theories are shaped. Brownfield Action has taught many lessons, but it is just one project. CCNMTL's projects now number in the hundreds.

Centers such as CCNMTL are still the early settlements on the frontier of education with new media. Projects such as Brownfield Action are windows into the future of what education *could be* in this new millennium. We are the colonists in this new frontier. We have only scratched the surface of what can be discovered in this field through the act of designing, building, implementing, evaluating, and sharing. It is still up to us to keep striving to determine what education *should be* in this new millennium. The experience of doing it should certainly be an education.

Your experience can be an education, but only if you make it so.

R.K.

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APPENDIX A

STA Proposal

Peter Bower, Ph.D.
Senior Lecturer
[redacted]
Department of Environmental Science
Barnard College
[redacted]

2. Title
"The Groundwater Project"

3. Principle Educational Goal
The Groundwater Project (GWP) has been part of the Introductory Environmental Science course taught at Barnard for the last five years. Six laboratory sessions are required to complete the GWP. There are also ancillary laboratories and coordinated lectures and readings.

The basic premise of the GWP is the need for a corporation to assess groundwater contamination on a site which they are planning to purchase in order to develop a shopping center. Because they become legally responsible for any pollution on the site once they purchase it they hire an environmental firm to make a site investigation. Each environmental company consists of two students. The company is given a budget by the development corporation. Each student company then competes with the other student companies to see who can find the groundwater contamination on the site while spending the least amount of money.

Students purchase information using various means and technologies, such as: workers to find information at the municipal building or to interview local residents, ground penetrating radar to search for underground disturbances (pits, tanks, etc.), topographic data, or drilling to mention just a few. Some information is much more expensive to obtain, so that the company attempts to locate possible sources of contamination in other ways before embarking on drilling and sampling operations.

Students eventually compile a surface map showing topography and present and past human alterations (buildings, pits, pipes, roads, etc.), a water table map, a bedrock surface map, and maps of contamination. They must keep an accounting of their expenditures and make several reports to the development corporation describing their results and current strategies before making their final report.

All of the information which students seek to obtain is stored in folders in file cabinets or on computer programs. Student make written requests for information citing the technology to be used and grid box numbers corresponding to the specific location on the surface map. These requests require the instructor to find the specific information and give it to the student or the student to access the information by making requests of a computer which has the basic parameters of the site stored as a database.

The main goal is to upgrade this project by:

a) Creation of a new database for surface topography, depth to water table, subsurface regolith, and depth to bedrock. Each of these databases allow the creation of a three-dimensional (3D) surface. At present students acquire data at a limited number of grid locations and draw contour maps by hand.

b) Creation of a 3D database for groundwater contamination. At present the database is 2D and contamination is indicated only by general types (floating, dissolved, sinking) with concentrations indicated by a range of numbers (0-10, 10-100, etc.). The creation of the 3D groundwater contamination database will also include specific, real-life chemicals and concentrations.
c) Selection and/or creation of software to visualize 3D surfaces and 3D plumes of groundwater contamination. This software should allow the student to visualize the entire site under investigation much like the computer games "SIM CITY" and "SIM ANT". Individual grid boxes may be entered and explored as well.
d) Selection and creation of software to interface with the decision-making and economic (accounting) aspects of the GWP.
e) Creation of interactive, educational software to teach students about the groundwater technologies they utilize, such as: ground penetrating radar, seismic profiling, soil gas, the drilling, monitoring, and sampling of wells.
f) Creation of a web-site to guide students outside the classroom through all aspects of the GWP. This would include the newly written history, the socio-political and legal framework in which the GWP takes place.

4. Measurable Project Objectives

In order to achieve the goals stated above the databases must be created and the software must be in place so that they can be utilized in the Introductory Environmental Science class in the fall of 1999. The measuring stick is the extent to which the stated objectives can be actually incorporated into the curriculum this coming fall.

5. Development Milestones

a) Creation of a database for a new surface grid map including human alterations, history, present vegetation and surface topography.
b) Creation of databases for: water table, subsurface regolith, and bedrock.
c) Creation of a 3D database for groundwater contamination.
d) Development of interactive software allowing students to learn about the site, make decisions, spend money to acquire resources, information, and data, and visualize their information and data as 3D views of surfaces and plumes.
e) Creation of interactive, educational software and a web-site to support the above.

6. STA's Summer Work Responsibilities

The STA must become familiar with groundwater and groundwater contamination as well as the existing GWP. The STA will assist in the search for case studies of groundwater contamination useful in the formation of a the databases. The STA will assist in the inputting of this information into the selected database software. The STA will work with Frank Moretti and his staff on the above as well as the creation of the 3D interactive software which utilizes the databases.

7. Technology/Information Components Needed

The information required for the GWP is the fictitious, but real-life information to be included in the databases. This already exists on paper and has been gleaned from actual case studies modified for pedagogical purposes. This needs to be renewed and is my arae of expertise. Software must be chosen as the receptacle of all this information.

The databases can then be accessed interactively using other 3D software. These software and hardware components are the expertise of Frank Moretti and his staff upon which I will rely and upon which the collaboration for this project rests.

8. Continuing Support

Contact with Frank Moretti and his staff will certainly be needed and useful when the new GWP goes into service in its test-phase. Only in the actual use of the product with the problems encountered and with the student and instructor response will changes and fine-tunings be realized. It is hoped that with this testing and the subsequent changes that the product become commercially available.

9. Assessment Strategy

Independent assessment of the project, of students, and of instructors by individuals and organizations at Teachers College would be sought during and after the testing phase.

10. STA Candidate

If possible, I would like to use a brilliant high school senior, a National Merit Scholar, who will be attending Dartmouth this fall majoring in Environmental Science. He is a perfect match but I am not sure if he qualifies for the program. He has not applied as a STA candidate.

APPENDIX B

Brownfield Action Contract Text

An AGREEMENT made as of the __________ day of ______________________ , 1999.

by and between Malls-R-Us, Inc. represented by Seymour Buckmeister, President and

______________________________________, represented by

______________________________________, and

______________________________________, Principals, (hereinafter referred to as the "Contractor").

Now, therefore, in consideration of mutual agreements and covenants herein contained, the parties hereto agree as follows:

1. As used herein, "Contractor" shall mean the party contracting with Malls-R-Us, Inc., and shall include any subcontractor.

2. The Contractor agrees to provide the material and to perform all the work required in a substantial, businesslike, and first-class manner, and in conformity with the general provisions and specifications attached below, and, if applicable, in strict obedience to the directions which may from time to time be given by Seymour Buckmeister or other authorized representative of Malls-R-Us, Inc.

3. Malls-R-Us, Inc., agrees to pay to the Contractor, for the work performed as aforesaid, $75,000. An initial payment of $60,000 will be made upon the signing of this contract. A final payment of $15,000 will be made subject to the provisions of Section 4 below.

4. The Contractor agrees that the sum of money received for the work performed and for all materials provided herein shall be received as full compensation for all claims of the Contractor against Malls-R-Us, Inc., under this Contract or otherwise, including but not limited to the furnishing of materials, labor and tools used to complete the Contract in accordance with the specifications. All loss or damage arising out of this Contract due to the action of the elements or any unforeseen obstruction, defect or difficulty that may be encountered, shall be borne by the Contractor. The Contractor shall be responsible for all expenses incurred by or resulting from the suspension or discontinuance of this Contract, and shall be responsible for the faithful completion of this Contract in the manner set forth in the specifications, plans and general requirements, and to the thorough and entire satisfaction of Malls-R-Us, Inc. Prior to receiving final payment, the Contractor shall execute an affidavit prepared by Malls-R-Us, Inc. wherein it acknowledges that all debts and liabilities arising from this Contract have been properly satisfied or discharged.

5. The Contractor agrees to indemnify and save harmless Malls-R-Us, Inc., its agents, servants and employees, from any and all claims arising out of injury, death or property damage which may occur in connection with the Contractor's performance of this contract. The Contractor has furnished to Malls-R-Us, Inc., at the time of the signing of this Contract, a Certificate of Insurance which includes the following: (I) a provision holding harmless the Malls-R-Us, Inc., its agents, servants and employees; (II) liability limits of not less than $1,000,000 for bodily injury and $100,000 for property damage; and (III) a provision that Malls-R-Us, Inc. be given ten days prior written notice in the events of cancellation of the aforementioned Certificate.

6. Malls-R-Us, Inc. agrees that the Contractor may sublet any part of the work required to be performed by this Contract, and that it may assign or transfer this contract or any part thereof without the written consent of Malls-R-Us, Inc.

7. The Contractor stipulates and agrees that time is to be considered as an element and of the essence of this Contract, and that said Contractor has so considered it and figured upon it in agreeing to the aforementioned $75,000 payment. The Contractor agrees that it will commence and continue said work in an uninterrupted manner, according to the terms of the specifications, and shall complete such work, complete every detail, within eight (8) weeks or forty (40) working days) after the date that this Contract is signed under the penalty in form and terms set forth in the specifications.

8. The Contractor hereby states and declares that she/he (or if a corporation, its duly authorized officer) has read each and every clause in this Contract and has thoroughly and fully examined the specifications and provisions for said Phase One Investigation and that, in all aspects, she/he fully understands the same.

9. It is further agreed that no certificate or payment made under this Contract shall be deemed conclusive evidence of the proper performance by the Contractor, either wholly or in part, and that no payment by Malls-R-Us, Inc. shall be construed as an acceptance of defective work or improper materials; and any mistake made in any aspect of this Phase One Investigation, either partial or final, or in any payment, shall be immediately rectified as soon after the discovery of same as possible.

10. The Contractor further agrees and warrants that all labor, materials and methods shall be in strict accordance and compliance with the specifications attached hereto.

11. The Contractor hereby covenants and agrees with Malls-R-Us, Inc. that all workers employed for the purpose of this Contract will be paid an amount not less than that prescribed by the Commissioner of Labor and Industry, pursuant to the Drumlin State Prevailing Wage Act.

12. The parties agree that the mandatory language required by Subsection 3.4(a) of the Regulations promulgated by the Drumlin Department of the Treasury, Affirmative Action Office, pursuant to Public Law 1975, c. 127, as same may from time to time be supplemented and amended, is incorporated herein by reference as if fully set forth, and the Contractor agrees to comply fully with the terms, provisions and obligations of said Subsection.

13. In the event that the Contractor fails to satisfactorily complete or timely perform the work required of it, under this Contract, or fails to comply with any governmental rule, law or regulation relevant to this Contract, Malls-R-Us, Inc., at its option and without any liability to the Contractor or otherwise, may terminate this Contract, and the Contractor shall be liable for any and all expenses incurred by Malls-R-Us, Inc. by reason thereof.

Provisions and Specifications

14. The Contractor agrees that it will conduct a Phase One Environmental Site Assessment (ESA) in conformance with existing (ASTM) standards and produce a Phase One report including:

a. site topographic contour map;

b. site bedrock contour map;

c. site map showing locations and addresses of surrounding properties;

d. physical description and site topographic contour map of the Self-Lume property;

e. physical description of the subsurface at the Self-Lume property and to the extent possible the site as a whole including but not limited to: sediment type, sediment size analysis, porosity, and permeabilty;

d. physical description of the aquifer under the Self-Lume property and to the extent possible under the site as a whole including but not limited to: groundwater table elevation and direction of flow;

f. description, location, and preliminary analysis of any interior or exterior condition or contamination on the Self-Lume property requiring a Phase Two ESA;

g. description, location, and preliminary analysis of any condition or contamination on a surrounding property impacting on the Self-Lume property and requiring a Phase Two ESA;

h. rationale for or against any Phase Two ESA;

i. budget summary for all expenditures.

15. Contractor agrees that the site consists of the Self-Lume property and any surrounding properties included on the Malls-R-Us, Inc. site grid map with dimensions of 2000 feet by 3200 feet attached hereto.

16. Malls-R-Us, Inc. agrees to provide the Contractor with any and all information concerning the site that Malls-R-Us has available to it including but not limited to:

a. plat of Self-Lume property;

b. topographic survey data for Self-Lume site

c. site grid map (2000 feet x 3200 feet);

d. information concerning the industrial process and operations of Self-Lume.

e. an Environmental Site Assessment Checklist;

f. ASTM Phase One ESA standards;

IN WITNESS WHEREOF, Malls-R-Us, Inc. has caused this Agreement to be signed by Seymour Buckmeister, President, and attested by Benjamin Pennypacker, Secretary, Malls-R-Us, Inc., seal affixed thereto, and the Contractor has hereunto set his hand and seal, the day and year first above written.

By: Seymour Buckmeister
Seymour Buckmeister, President

Malls-R-Us, Inc.

Attest: Benjamin Pennypacker
Secretary

Contractor: ______________________________

By: ______________________________,
Principal

By: ______________________________,
Principal

APPENDIX C

Brownfield Action Visual Reconnaissance

8:00 AM — Visited Building Department of the Moraine Municipal Government Complex and obtained maps of all properties in the vicinity of the Self-Lume property.

8:30 AM - Began drive-through at intersection of Pitch Pine Lane and Boulder Boulevard (aka Route 66E) - drove NE on Boulder Blvd. - "No Hunting / Property of Moraine Township" signs posted on both sides of the road - both sides of road have "pine barrens" vegetation (dominated by scrub oak and pine) with light-colored or beige soils that are visibly sandy and gravelly. About 0.3 mile further down the road is a narrow clearing on both sides of the road, ~20 feet wide extending NW-SE; stopped car on side of road; there is little vegetation in these cleared strips except for low, scraggly weeds; to the NE 40-50 feet from road is a brick building (20 ft. square) sitting in the middle of the clearing; on the building is a sign stating "No Trespassing/ Township of Moraine/ Division of Water Supply" - the building is possibly a pumping station because the clearing runs straight up hill all the way to the water tower (clearly labeled "Township of Moraine"); the clearing on the other side extends straight downhill (about two football fields away) to another brick building which (with my binoculars) looks to be several times the size of the first building; I'll try to check this building out when I close my loop at the end of the day.

9:10 AM - Back in the car - 150 yards further up the road is a BTEX gas station - where I pull in for a full tank of regular gasoline - the address is 21-172a Boulder Boulevard (aka Rt. 66E) - the E is for Esker County as this is a county road and the 21 is the 21st segment from the road's origin in Assininboine 23 miles to the SW (this as told to me by Al Milankovitch, the brother of Tillie Terrain who owns both the diner next door and the gas station) - this I find out when I go get a cup of coffee and a buttered roll from Tillie's Diner (21-172b) - the only 24 hour diner in Moraine. Tillie - very friendly and chatty, pushing 60 (?) - told me that the property and the diner were bought by her parents back in 1958 - that the diner was renamed Tillie's at that time - that she has worked there ever since - that the gas station was built in 1968 - and that she purchased the property in 1971 after her husband died in 1970. Her brother Al runs the gas station. The Firn Freeze across the road she says was opened in 1979 - it closes down at the end of September and reopens every April Fool's Day.

9:40 AM - From the diner I pull across the street into Firn Freeze (22-11 Boulder Blvd.), a local "Dairy Queen" type operation - a bit run down, dusty gravel parking lot - the property sits on a triangle formed at the intersection of Rt. 66E and Loess Lane. Directly S across Loess Lane is what appears to be more Township property that ran all along the E side of Rt. 66E on my way up to BTEX - however, the vegetation has changed to a deciduous forest (second or third growth) with the older trees maybe 50 to 75 years old - the soils are visually finer and dark brown in color.

9:45 AM - As I proceed E on Loess Lane there is a small strip of land with a few trees that appears distinct from the asphalt parking lot of Kilroy's Bar (7 Loess Lane) - the frontage of this bar is about 200 feet - just beyond the bar is another open area with more trees and undergrowth (~100 feet of frontage) - directly across from this open space is a large asphalt driveway /entrance to the parking lot for the Wedging Nursery (at 10 Loess Lane) - as I pull into the parking lot I find it to be a bustling place with the small trucks and vans of local landscapers loading sod, dirt, chips, etc. There are three long greenhouses on the W side of the Wedging parking lot (i.e., directly across from Kilroy's Bar) and one large and two smaller buildings around the lot - outback (to the S) from what I could see from the lot was a large sod farm with other growing areas for trees and shrubs (somewhere between 5 & 10 acres); just at the S end of the parking lot is a small square shed (a well?) with old hose, pipe, and other irrigation equipment laying around - there are several large trees interspersed on the site and many trees and low growth bordering the site. Just before leaving the nursery I picked up a business card in the main office which says "Wedging Nursery/ serving landscapers and gardeners since 1980/ Flora Blume, Proprietor."

10:05 AM - Turning right onto Loess Lane heading E again - about 100 yds. down on the N side is a paved entrance to Plucker's Scrap Metal (15 Loess Lane), an auto wrecker and scrap metal business - there is a large fence surrounding the property - the front gate was open - the paved road extends straight in to the N ending about 150 yds. in the distance in a 30 ft. high pile of scrap metal (fenders, hoods, doors, etc.) - on the right is a long building with stalls containing cars in various stages of being stripped - on the left is a small office building - there are cars everywhere, some piled on each other - a dirt road extends to the W between more piles of parts, barrels, tires, etc. - a crane is operating off behind the office building lifting metal into a compactor - a real junkyard complete with yelping junkyard dogs that have announced my now unwelcome presence.

10:25 AM - I leave Plucker's turning left onto Loess Lane. Directly across from Plucker's is (according to the name on the mailbox) the Wedging family homestead (12 Loess Lane), a large 2 1/2 story edifice with mansard roof, two chimneys and eight gables - a paved driveway leads to a two car garage. The site is nicely landscaped with numerous shrubs and several large trees. Just 100 ft. or so down from the Wedging family driveway on other (N) side of Loess Lane is a dirt road leading back into the junkyard but a metal gate blocks the way though it does not completely obscure the many cars and piles of sorted (and sordid?) debris.

10:30 - I've finally arrived at the front entrance to the abandoned, Self-Lume factory site Lane (20 Loess Lane) which is about a football field away from the Wedging driveway and also on the S side of Loess. My key to the building itself is for the padlocked door in the rear parking lot but I also have keys for the chain link gates at both entrances. The property is surrounded by an eight-foot chain link fence. The 200 ft. entrance driveway extends straight to the S and is surrounded by dense deciduous forest with many large and intermediate trees and heavy undergrowth especially along the sides of the road. Coming down the road I can see part of a water (?) tank on the roof. The foilage is the same around the parking lot. Both the road and the parking lot are littered with twigs, leaves and the like. The parking lot is about 150 ft. wide and 300 ft. long with a rectangular island (approx. 30 x 200 ft.) of trees and undergrowth right in the middle of the parking lot. From the S end of the lot are two sidewalks about 100 ft. apart, the W one leading to the main entrance (with a slightly rusted "Self-Lume, Inc." sign still in place over the entrance portico) and the E sidewalk leading to a smaller less imposing entrance probably for workers. Nothing seems unusual - single story, cinder block construction, a flat roof not visible from the ground level, the windows are all still intact and closed - the tan paint is weathered and peeling in places - empty office rooms (no furniture, no debris) are all one can see through the dirty windows. Large weeds, overgrown shrubs, and several young, invading trees now surround the building at the front and along the W wall; however, at the SE corner of the parking lot is a cleared area about 40 ft. wide running along the E wall of the factory - all that is growing here are weeds and grasses - the substrate consists of 3/4 inch diameter gravel with some dirt in the pore spaces - it looks like an old access road but it is inaccessible to vehicles because seven large glacial erratic boulders have been moved into place at the edge of the parking lot in front of the cleared area. With binoculars I can see that this old road extends to the rear parking lot where I will have a better look.

11:05 AM - Leaving the Self-Lume site and turning right onto Loess Lane heading E. On the N side of the road about 200 ft. down from the Self-Lume entrance is a road running straight to a large red barn then another 150 ft. down the road is a driveway and a garage followed by a large two story red sandstone home. There is a sign near the mailbox that indicates that this home is an Esker County historic site and was built in 1837 as part of the Fallow Farm. The mailbox also says Meredith and James Fallow (25 Loess Lane) so I presume that some part of the family continues to live here. The home sits on the NW corner of Loess Lane and Erratic Avenue and is nicely landscaped with several very large elegant oaks. On the NE corner there is a second or third growth forest with dense undergrowth and many intermediate trees. The same can be seen on the SE corner but older trees dominate the SW corner which is the NE corner of the Self-Lume site.

11:15 AM - Turning S on Erratic Avenue - about 220 ft. down on the E side of the road is a relatively new condominium development (16, 20, 24, 28, and 32 Erratic Avenue) - these are two story, wood frame, rather ordinary - the development is under the aegis of the so-called Kame Kondo Association - there are five units, each with driveway and garage under the second story - landscaping is severe at present with a few sparse planting of trees along the edges of the property.

11:30 AM - About 100 ft. down from Kame Kondos on the W side of Erratic Avenue is the factory (delivery) entrance to the Self-Lume site. After unlocking the padlock and opening the gate and driving down the long (300-400 ft.), wide (50 ft.) road I enter a large, rectangular paved area (about 200 x 300 ft.). Both sides of the entrance road are guarded by the same forest and undergrowth as the other entranceway. I drive in straight ahead at the W end of the lot where I find a concrete pier (about 10x30 ft.) on which are two gas pumps (old, rusted, no hoses or nozzles, and no markings, seemingly empty metal shells). There are two steel caps, almost certainly the covers for refueling pipes of the UST for these fuel pumps, visible in the asphalt. Both of them are about 7 1/2' to the E of the concrete pier and 5' down from the N end and S end of the pier. Most of the lot is bordered by the same forest and undergrowth previously mentioned. There was once a cleared zone (lawn?) about 40 ft. wide along the W side of the building which I can see from the old pumps but this is now replaced with considerably new growth, weeds and small, invading trees, etc.- I'll walk this area after lunch. Just to the S of the old fuel pumps at the edge of the parking lot is a wide area (about 100 x 100 ft., but irregularly shaped), once cleared (there is no old growth), with similar vegetation to that along the W wall of the factory - this disturbed area extends out into the older forest. Upon closer inspection the substrate of this area is dirt and gravel mixed with chunks of concrete, pieces of cinder block, asphalt, and other debris (a piece of 2 by 4, metal flashing, an old pail, a half-buried bucket of tar) - this is a fairly recent landfill of some sort. I return to the car by the pumps and drive to two old trailers (rusting, rodent infested with flat, rotting tires) in the far SE corner of the lot - they are empty except for piles of flattened, bundled, and now rotted cardboard boxes that the animals seem to love. I return to the car and drive to the back entrance after passing the two loading docks in the right rear (facing N) of the building. The large metal back door is in the center of the building close to westernmost loading dock. Rather than begin an interior inspection I decide to have lunch.

12:15 PM - Retrace (Erratic to Loess and back to Boulder) to Tillie's Diner for lunch. When I inquired about Kilroy's Bar, Tillie told me that Jack Kilroy was the former Chief of Police and that he bought the former PAL building and converted it into a bar and grill about ten years ago - it's now a popular place for locals, especially Moraine's uniformed services. She also told me that Hector Fowler, the owner of Plucker's, and Jack Kilroy go way back and are regulars early in the morning — and that Plucker's was established in 1962 the year she graduated from Moraine High. Good food and good stories at Tillie's Diner that I am now leaving in order to return to the back entrance of Self-Lume.

1:10 PM - I decide to finish examining the exterior before entering the building - along the west wall which I inspected by walking from back to front and back again I confirmed the initial observation of a 40 ft. cleared zone (now overgrown) extending from the W wall outward. Now, however, I have found in addition a much larger area that was once cleared (not visible to me before). This area is about 100 ft. wide centered on the middle of the W wall and extends out from the building 120-140 ft. to the W. Thus, there is an additional cleared zone 100 x 80-100 ft. jutting into the forest from the cleared zone mentioned before. Again the vegetation in the once-cleared but now overgrown area is about ten years old (based on the age of the oldest invading trees) and is about 50 ft. lower in height than the canopy of the surrounding forest. Closer inspection of the surface of this zone reveals that the soil structure has been disturbed compared to the surrounding forest (which has a surface silt loess layer 1-3 feet thick) which is missing or mixed with sand and gravel in the cleared zone; other than this there is nothing else to report on the W side of the building.

1:50 PM - After retracing my steps I walked along the E wall of the building noting again the probable access road. The first significant find on the E side of the building is the soot that stains the cinder block above a section of six consecutive windows. These windows begin about 100 ft. from the NE corner of the building and extend down another 50 ft. from there. The windows are missing and a brief look inside indicates a significant fire (which from outside seems confined to one room inside). There is a gaping hole (about 4 x 7 ft.) visible in the partially collapsed roof as well. At the S end of these six windows is an exterior pipe only a couple of inches from the wall extending vertically about 2 ft. from the ground - this is a pipe used to refill an oil fuel tank probably underground here. Also, about 100 ft. from the SE corner of the factory is a stone wall (that has largely collapsed into a pile of stones) beginning about 10 ft. from the edge of the gravel access road along the side of the building and running to the E another 250 ft. The wall is broken in two spots for about 15 ft. dividing the wall into three roughly equal sections. There are no obvious changes in vegetation. I did find an old rusted tire rim along the wall and about 150 ft. out found several concrete footings but the brush and the poison ivy were so bad I turned back to concentrate the rest of my time on the interior of the building.

2:35 PM - Except in three instances the interior of the building is largely unremarkable. I inspected every room shown on the floor map and, without the exceptions noted below, each room was empty and clean except for dust and some soot especially closer to the fire. By empty I mean walls, floor, and ceiling - no furniture, no benches, no fixtures; where there had been sinks, drains, etc. all that remained were pipes jutting from the concrete floor that were capped off. Other pipes extend down from overhead (also capped off) that would not be visible except for the fact that all of the dropped ceilings had been removed. The room with the fire has been marked with a * on the map. There is a charred hole in the roof but the room itself, except for stains of smoke and charring has been cleaned like the others and all debris from the fire as well as furniture, fixtures, etc., has been removed. There is a considerable pile of leaves, twigs, and decaying organic matter beneath the hole in the roof as well as standing water on the floor. The room itself appears to have been the boiler and utility room. I see no evidence of gas lines. There is no obvious oil storage tank so there must be a UST here. The second item, marked on the floor plan with an "X" in a very small room, is a capped well with a concrete pier, a capped pipe, rusty valves, an old well pump, and the faded words painted on the concrete wall "main water feed"; clearly the tank on the roof is a water tank. The third items (marked on the map with a small triangle) are the triangular "danger radioactive materials" signs on two doors in the main hallway. Both of these doors lead into similar empty rooms containing several smaller rooms each with the same "danger radioactive materials" signs on the doors. Again, except for overhead pipes and capped pipes coming up through the concrete floor, everything has been removed from these rooms including the dropped ceilings.

3:15 PM - Exiting the factory entrance to the Self-Lume property after locking the gates - turning right on Erratic Avenue. About 300 ft. down on the W side of Erratic is the end of the Self-Lume property where the chain link fence makes a ninety-degree turn to the W. On the S side of the Self-Lume property is a well-groomed vineyard operation clearly demarcated from the Self-Lume property by the chain link fence and the dense wild vegetation behind it to the N. On the left (E side of Erratic Ave.) are four homes (at 90, 92, 94, and 96 Erratic Avenue); they are all the same layout (two-story wood frame with paved driveways and detached garages on lots approx. 100 ft. x 150? ft.); these were probably all built at the same time. 96 Erratic Ave. is at the NE corner of the intersection of Erratic Ave. and Pitch Pine Lane. Directly across from the driveway of #92 is a dirt road guarded by a padlocked metal gate. The dirt road extends into the grape vineyards; the vineyards property extends on the W side of Erratic Ave. for about 500 ft. N of the Erratic-Pitch Pine intersection right up to the S boundary of the Self-Lume site.

3:20 PM -Turning right (E) on Pitch Pine Lane - there is another dirt road and padlocked metal gate about 200 ft. down on the N side of Pitch Pine; another 400 ft. down there is the paved entrance to the Roche Moutonnee Vineyards (47 Pitch Pine Lane). The entrance road leads to the winery, a large, two-story brick building (~200 ft. long x 100 ft. wide) surrounded by asphalt on all sides; there is another ~150 long maintenance/equipment shed to the E of the main building; there is a shop and sales office - tours and wine tastings are by appointment. In the main office I literally ran into the owner, Tom Verde, very friendly, mid-fifties, a hands-on person — he said that the vineyards are fifty years old next year for which he is planning some big celebrations/promotions. More significantly, there are two brick sheds, one to the E and one to the W of the main building, both with pipes and hoses and irrigation equipment attached and nearby. These are probably both active wells.

3:35 PM - Exiting the vineyard and turning right (W) on Pitch Pine Lane - about 300 ft. down on the N side of the road is another dirt road into the vineyard with a closed metal gate. Another 250 ft. past this dirt road is Pleistocene Court, an entrance to Eolian Acres, a development of 24 private homes. Each of these home is split level with interior garage. Pleistocene Court is a "U" with the other end of the "U" meeting Pitch Pine Lane about 200 ft. down from the other entrance. On the E side of one arm of the "U" are 10 homes, 5 on one side and 5 on the other exactly opposite each other and exactly alike (#'s 2,6,10,14, 18 on the east & 3, 7, 11, 15, & 19 on the west); the same situation is to be found on the W arm of the " & "U" (#'s 38,42,46,50,54 on the east & 39,43,47,51,55 on the west); four homes are located in the top of the "U" (#'s 57,56,21, & 20) with #'s 57 & 20 (located in the W & E corners of the "U") being much larger homes. The property line of these last four homes is next to a portion of the Wedging Nursery that can be seen through the backyards of these homes.

3:50 PM - Exiting Eolian Acres and turning right (W) on Pitch Pine Lane - about 500 ft. on the N side of the road is Scrub Oak Street, a paved road leading to Township Well #4 (as it says on the door), which is housed in a 40 ft. x 40 ft. brick building with a sign reading "Township of Moraine, Division of Water Supply". Surrounding Scrub Oak Street and the building is sandy soil and scrub oak and pine vegetation. Out behind the building is a cleared path through the vegetation about 20 ft. wide extending uphill (and with my binoculars) all the way to the water tower (previously mentioned).

4:10 PM — Leaving Scrub Oak Street and turning right onto Pitch Pine Lane. The land on the other (S) side of Pitch Pine Lane (from Erratic Ave.) all the way back to Rt. 66E (Boulder Boulevard) is undeveloped Drumlin State land; the only remarkable feature here is the change in vegetation about midway along this stretch from dense deciduous growth (much like that around the Self-Lume site to scrub oak and pine like that around the Township Well. At this point I have completed the loop around the roads circling the Self-Lume Site.

APPENDIX D

Sample Interview Questions

- Please state your name and year in school and major and which lab you are in and who your lab instructor is
- Tell me a little bit about your background, why you chose to come to Barnard?
- Do you have career goals yet? Know what you want to be when you grow up?

- What made you choose env sci over other science options?
- If you were going to tell someone the 1 or 2 or 3 most important things about env sci, what you would you say those things would be?
- Can you give me any examples of current issues related to the environment – maybe in the news or that you've heard about from someone else - that bother you?
- Can you give any examples of how environmental issues are connected to your life experience, either growing up, or in your family – either now or in the past?

- Going to take more science courses?
- Would you describe yourself as a scientific person?
- Could you define scientific thinking for me?
- What kind of a person is a scientist? What traits come to mind?
- I'm going to read off some traits – tell me if you think you would characterize yourself as any of the following: Problem solver? Methodical? Persistent? Curious? Mathematical? Analytical? A planner? Thoughtful? Jump to Conclusions? Cautious? Optimistic? Skeptical? A thinker?

- How did lab go this week/last week?
- Lab partner ok?
- Other students in the lab?
- Lab instructor?
- Have you had other lab science courses? How have those been in comparison?

- What are your expectations about BFA?
- What do you think the goal of the project is? What are you supposed to get from the experience?
- Experience with simulations/games/computers?
- Importance of simulations?
- Do you think simulations can help people learn? How?
- What needs to be present for a simulation to work well?
- Maps are going to be an important part of the project. Do you like using maps? When you're traveling around the city, do you use maps?

- How would you describe your study habits? How do you study for your classes?
- What do you hope to get out of this course? Knowledge on particular issues? Besides a passing grade?
- Do you have any general thoughts about your college experience so far that I should know about?

- What were your expectations about BFA?
- What do you think the goal of the project was? What were you supposed to get from the experience? What did you actually end up getting?
- Awareness: has your awareness of env issues changed due to this course? How so?

- Going to take more science courses? This course have anything to do with that? Looking forward to semester 2?
- Would you describe yourself as a scientific person now?
- Could you define scientific thinking for me?
- What kind of a person is a scientist? What traits come to mind?
- I'm going to read off some traits – tell me if you think you would characterize yourself as any of the following: Problem solver? Methodical? Persistent? Curious? Mathematical? Analytical? A planner? Thoughtful? Jump to Conclusions? Cautious? Optimistic? Skeptical? A thinker?

- Comment about the value of simulations/games/computers based on this experience?
- Do you think simulations can help people learn? How?
- What needs to be present for a simulation to work well?

- Comment on the value of mapmaking and using maps for analysis

- What is the signature message/theme from brownfield action? From the course?

- If you were going to tell someone the 2 or 3 most important things about env sci, what you would you say those things would be?

- Has this course impacted the way you study in general or the way you go thru your day-to-day activities?

APPENDIX E

Instruction Manual
for

Brownfield Action $_{2.1}$

Ryan Kelsey
Project Manager
CCNMTL

Peter Bower
Dept. of Environmental Science
Barnard College

COLUMBIA
CNMTL

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Columbia University

Brownfield 2.1 Instruction Manual

First-Time Users: This manual can serve as a walk-through tour of the software so feel free to follow along on your computer while reading this guide. By the end, you will be completely oriented to all aspects of the Brownfield Action software.

Returning Users: Use the Table of Contents below to find the section(s) you need to refer to.

Table of Contents

Introduction

Welcome to *Brownfield Action 2.1*! You and a partner are about to enter a simulated town where you will play the role of an environmental site investigation company. Your job will be to investigate a potentially contaminated land site in the fictional township of Moraine and report in detail on what you find (if anything) to a real estate developer.

Installation: How to install Brownfield on your computer

System Requirements: 64MB RAM; 200 MB free space on your hard drive
Windows 95, 98, ME, 2000, or Mac OS 9

Installing Brownfield Action 2.1 using the cd rom

Windows Users:

1. Place the cd rom Brownfield Action 2.1 in your computer. Open My Computer. Open the drive with the cd rom icon labeled Brownfield. Open the folder on the cd rom labeled BFWindows.
2. Brownfield Action requires Quicktime 4.0 or higher. If you have Quicktime, proceed to step 3. If you do not have Quicktime, doubleclick on the Quicktime Installer in the BFWindows folder and follow the on-screen instructions.
3. To install Brownfield Action, doubleclick on the bfinstallwin.exe file in the BFWindows folder and follow the on-screen instructions.
4. Once installation is complete, to login, doubleclick on the shortcut Brownfield Action on your desktop, then type in your Company Name and Password.

Mac Users:

1. Place the cd rom Brownfield Action 2.1 in your computer. Open the cd rom icon on your desktop labeled Brownfield. Open the folder on the cd rom labeled BFMac.
2. Brownfield Action requires Quicktime 4.0 or higher. If you have Quicktime, proceed to step 3. If you do not have Quicktime, doubleclick on the Quicktime Installer in the BFMac folder and follow the on-screen instructions.
3. To install Brownfield Action, doubleclick on the bfinstallmac file in the BFMac folder and follow the on-screen instructions.
4. Once installation is complete, to login, doubleclick on the alias Brownfield Action on your desktop, then type in your Company Name and Password.

Important Note: Once installation is complete, you no longer need the cd rom to play Brownfield Action. The complete program will be stored on your computer.

Installing using the Web Download

Windows and Mac Users:

Visit the Web Resources section of your course website:

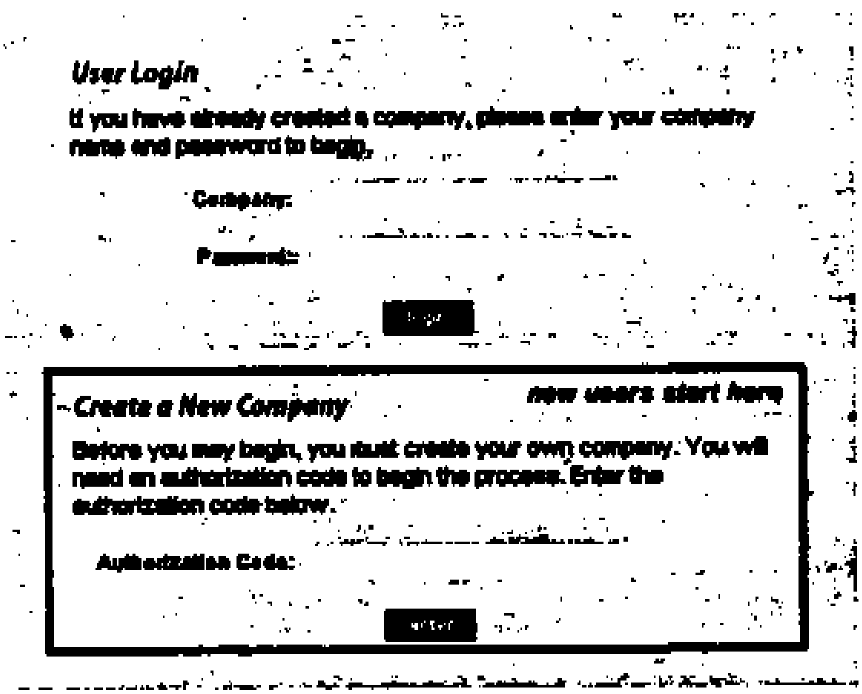
http://www.columbia.edu/itc/barnard/envsci/bc1001/

Click on the link to Download Brownfield Action Software and follow the instructions.

Beginning Brownfield Action: How to Login

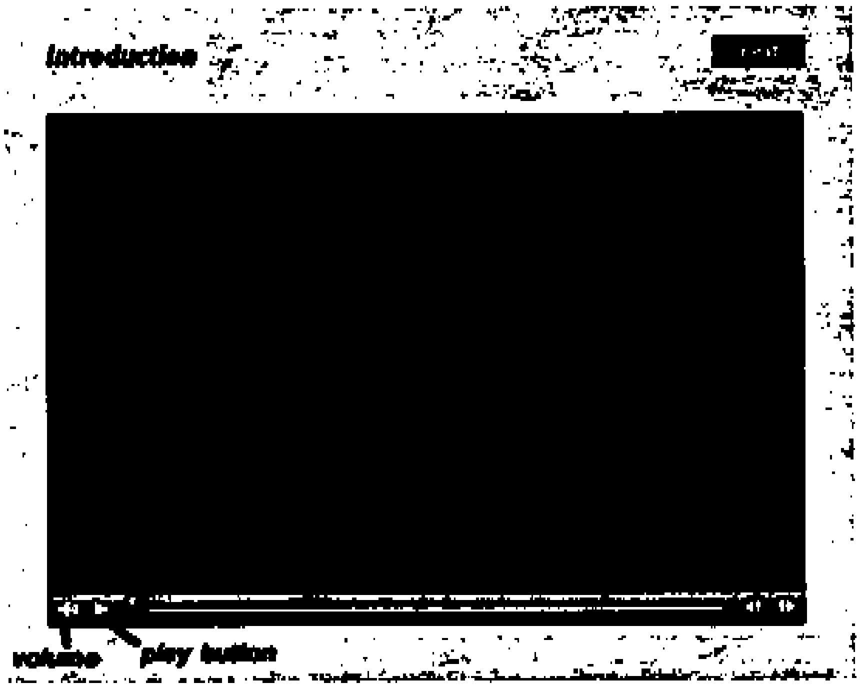
To begin, make sure your computer is connected to the Internet with a fast connection (do not attempt to use with a modem). Doubleclick on the icon *Brownfield Action* on your desktop or select the shortcut in the Start Menu under Programs (Windows users only). If you've deleted or can't find the shortcuts or alias, open the Brownfield Action folder in your Program Files folder and doubleclick on the *brownfield.exe* file (Mac users should find and click on a file called *brownfield* in the Brownfield Action folder in the Applications folder.

If you've already been playing *Brownfield Action* you will need to enter in a name and password as shown below, and then you will be able to continue from where you last left off. If this is your first time playing, you will create your company's name and password shortly.



For now, new users should begin by entering the authorization code you have been given by your instructor into the **Authorization Code** field near the bottom of the screen. Then click on the **enter** button. You will see a list of supplies you need. Check those over. Then click next to see a clip of a television show that will give you a sense of the problem you will need to solve.

Introductory Movie

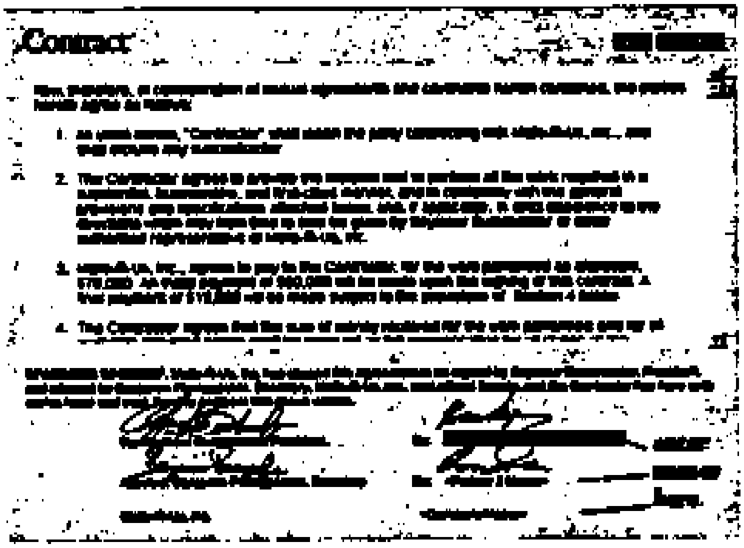


To play the show, click the triangle-shaped play button in the lower left portion of the movie screen. You can pause the show by clicking the play button again (it will change to a pause symbol after you hit play). You can also scroll back and forth through the show by sliding the bar along the bottom of the movie. When you are done, click next to move on to the contract.

Use the Volume control as necessary to adjust the audio. If you are having trouble with the audio, check your computer's volume control.

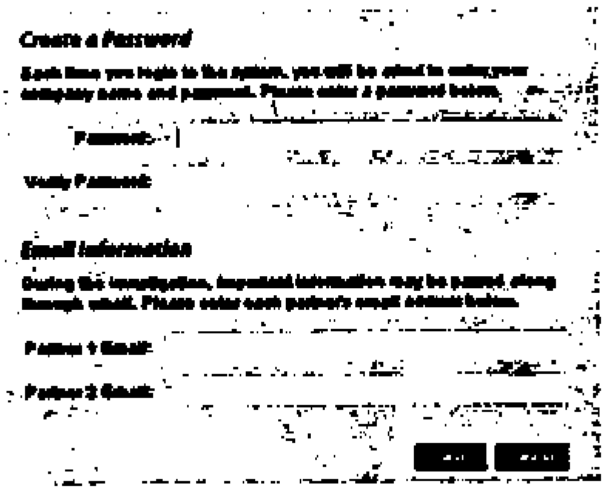
Contract

The contract is an agreement between you and the real estate developer you saw in the television show. **Read it carefully as it outlines exactly what your company will need to do to complete your investigation.**



When you have finished reading, enter your names in under the signatures on the bottom right and enter a name for your company name that you will use to login with from now on. **Think carefully about your company name – keep it simple so it easy for you and your partner to remember and type in.** When you are done, click on **sign contract** in the upper right.

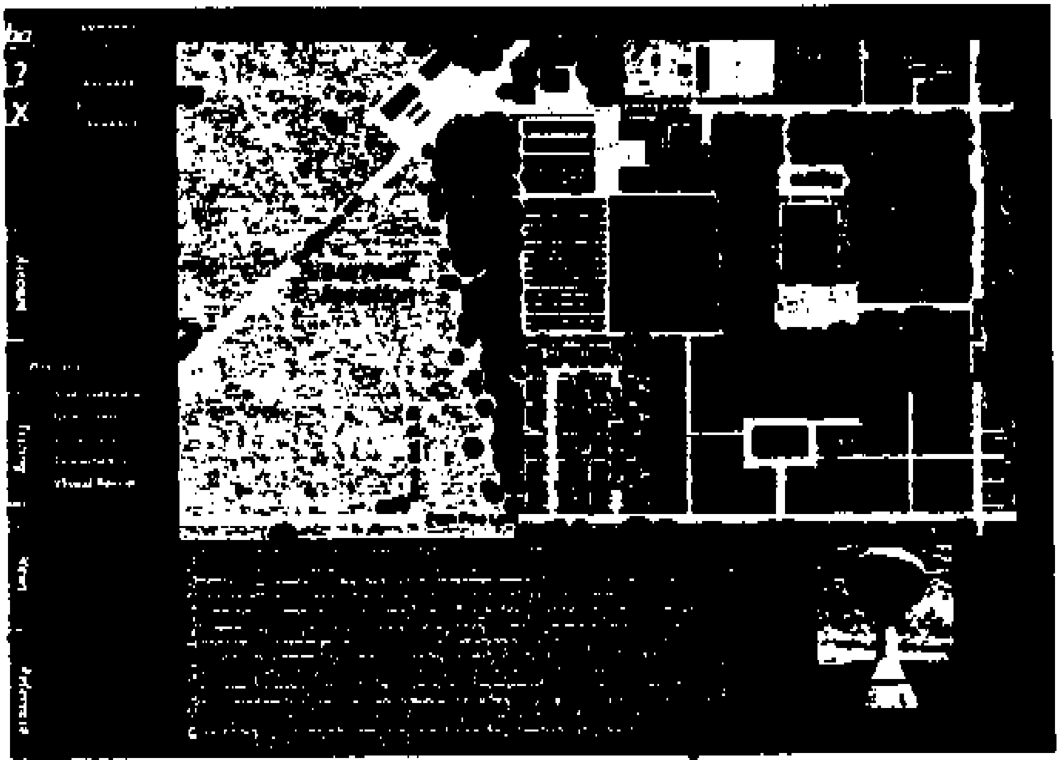
Next, you will need to enter in a password as well as your school email addresses in the boxes below. **Write down your company name and password, as you will need them to login next time you want to play.** Names and passwords are case-sensitive.



When you are done, click **next**.

Visual Reconnaissance

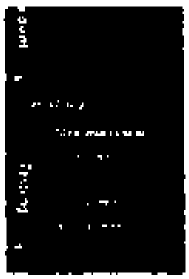
Upon entering Brownfield Action for the first time, you'll be taken on a tour of the Site Map. This tour is called the Visual Reconnaissance and it will cost your company $100. Visual Reconnaissance gives you a chance to learn a wealth of information about the site you must investigate as your assistant drives around and reports about the areas surrounding and including the Self-Lume factory site. Take your time in this section to find out clues that will lead you towards a successful investigation. **Take Notes!**



scrollbar *tour controls*

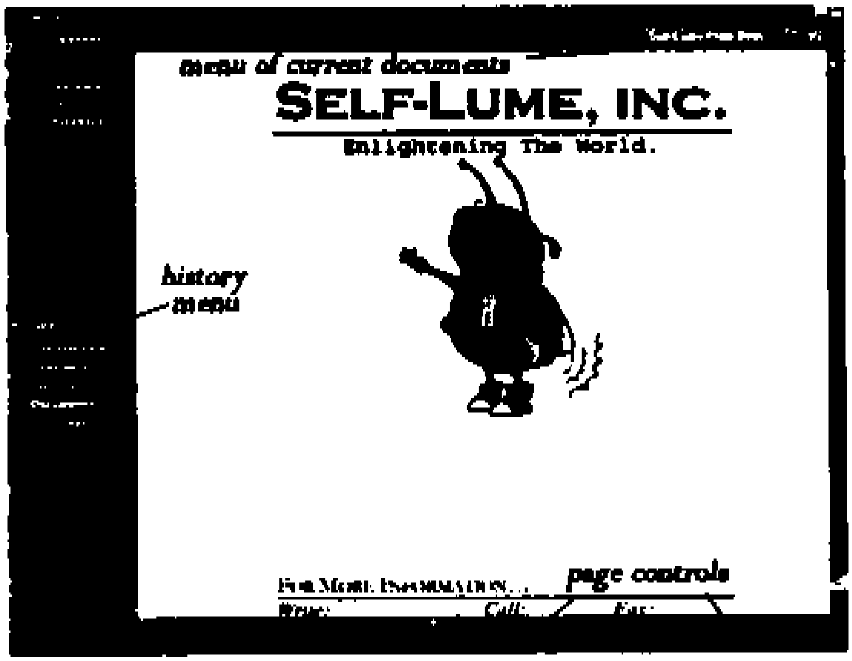
To navigate through the Visual Reconnaissance use the **next** and **prev** tour control buttons on the bottom right portion of the screen. Read the information listed in the info box for each spot carefully. Sometimes the information will exceed what can be shown on the screen. Use the scrollbar to the right of the text to control the text window.

When the Visual Reconnaissance ends, select Documents from the History Menu.



Documents

The Documents section is where you can view the initial packet of documents that have been provided for you. Some documents will contain useful information for your investigation while others are records of documents you've already seen, such as the Contract and the Visual Reconnaissance report.

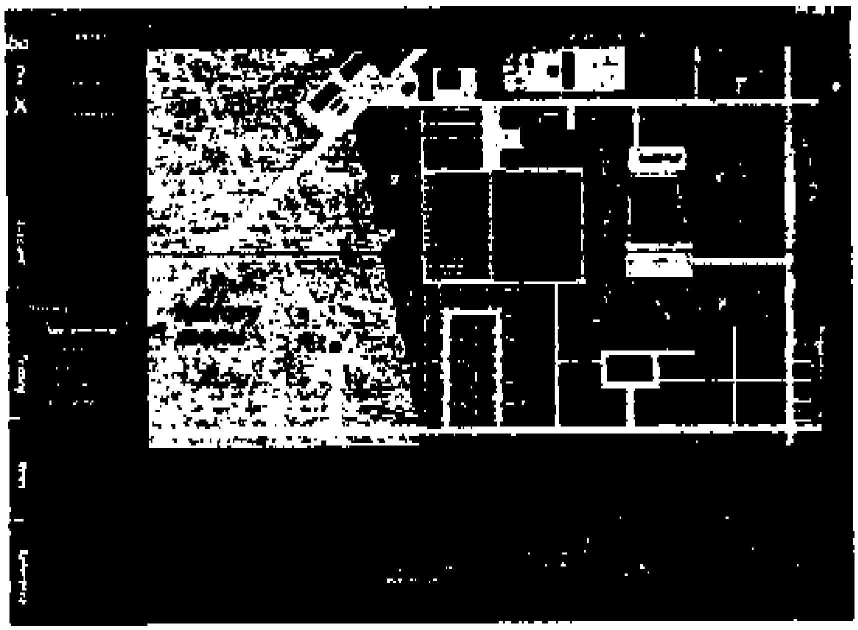


To see a list of your current documents, use the menu in the upper right. To view a document, select from the menu. Some documents have more than one page. To move through the pages, use the page controls on the bottom of the screen.

At this point, there is no further direction from the software about what to do next, but it is suggested that when you are done reviewing the Documents, click on the **Site overview** button in the **history menu** so you can explore the basic navigation.

Basic Navigation

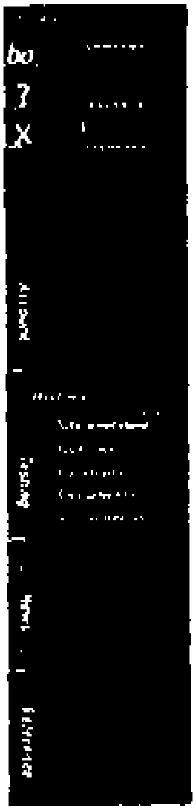
Once the Visual Reconnaissance is complete and you are placed on the **Documents** screen, it is up to you to begin your investigation by clicking on **Site overview** within the **History** menu. Once you do, you will see the following screen:



There will be no direction from the software about what to do next. It is up to you to choose which areas to explore and what tools to use with this interface. The next page describes the basic navigation features for exploring *Brownfield*.

Basic Navigation (cont.)

Brownfield Action 2.1 has a main menu that runs along the left edge of the screen. The main sections are listed by the tabs **Account**, **History**, **Testing**, **News**, and **Reference**. The **X** is to Quit the program. You can also Quit at any time by pressing CRTL Q or ESC (Windows Users) or Apple-Q or ESC (Mac). The *?* is to go to the online help.

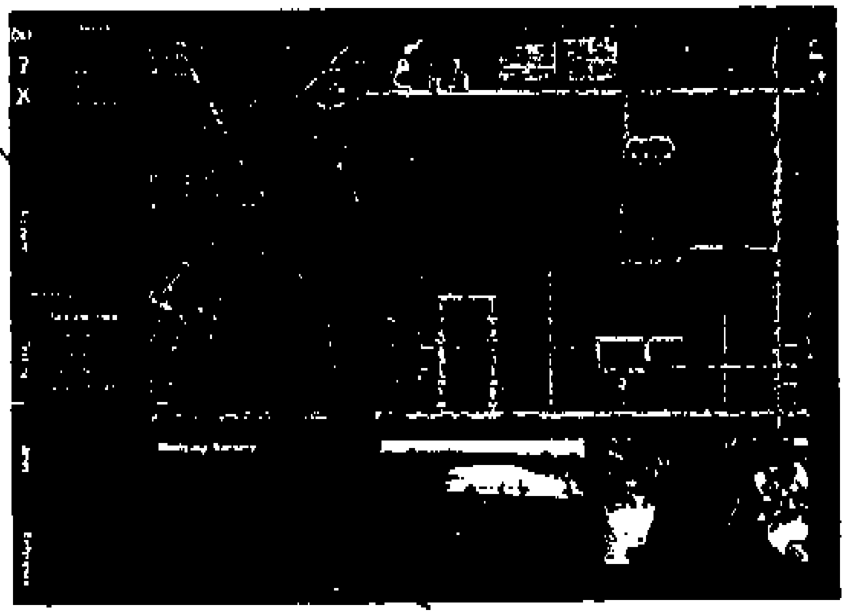


You have several tools at your disposal within these sections and $60,000 in your budget to start off with. Your current balance is always shown in the upper left corner of the screen. What follows is an explanation of each of the main sections.

History

The most important tool your company has is the Site Map. The Site Map appears in both the History Tab and the Testing Tab. When you are in the History section, as your mouse rolls over the map, you will notice that certain areas of the map will highlight. Clicking down on a highlighted area will provide you with information about that location and an opportunity to visit there. In the above below, the Wedging Nursery has been highlighted.

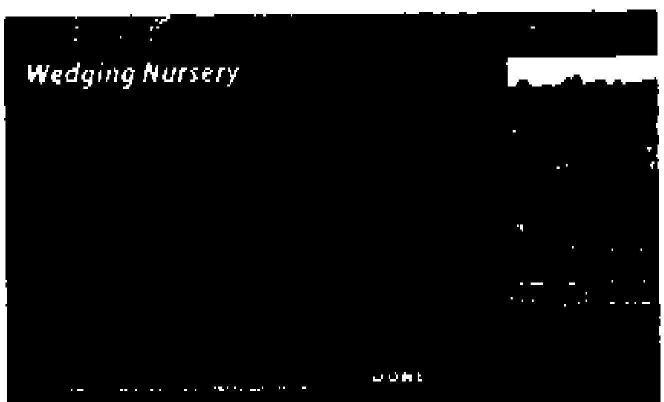
main menu



info box

Plotting XY Coordinates

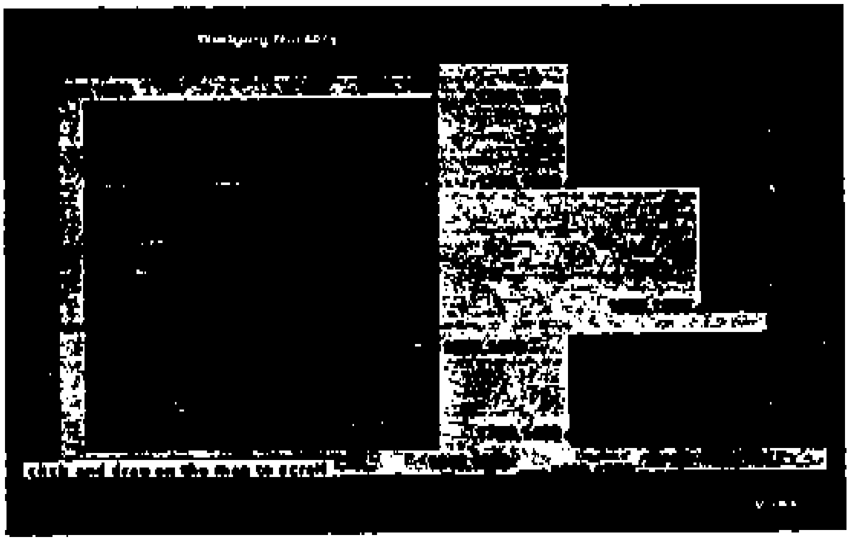
The xy button will provide you with an enlarged map of each location with the coordinate points you need to plot it on your own map.



xy button

Plotting XY Coordinates (cont.)

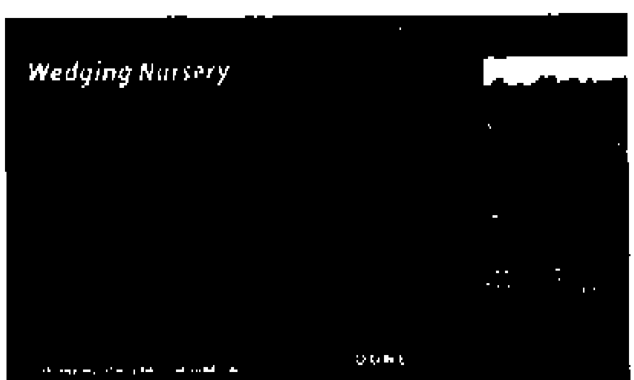
Below is a portion of the coordinate point map for the nursery. To see the rest of the map, click down on the map and drag your mouse to slide the map in any direction.



Note also that as you move your cursor around the regular Site Map, the coordinates on the top of the screen will change to show the cursor's current position. This feature may also help in the plotting your own map.

Visits

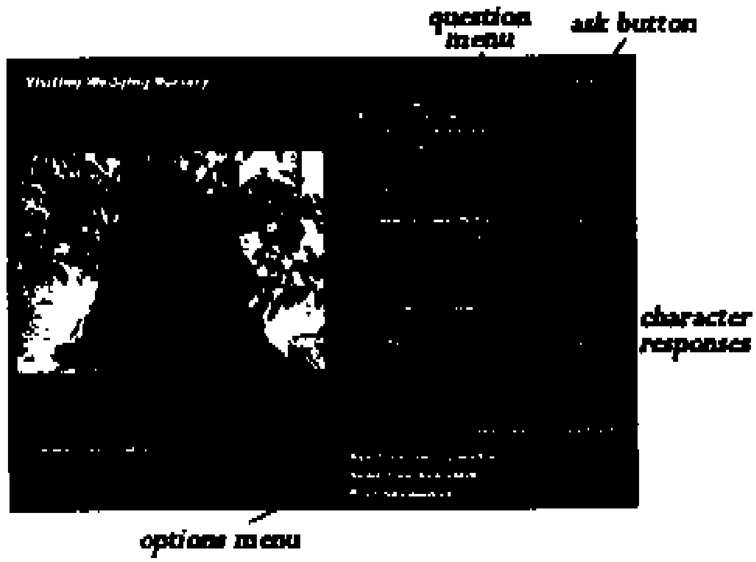
The **visit** button will take you to the location you've clicked and provide you with an opportunity to talk to a person at that location. Each visit costs your company $25. If you decide you don't want to do a visit, you can click **done** to reactivate the map and you will not be charged. If you do want to visit, click **visit**. You will see your balance in the upper left portion of the screen decrease by $25.



visit button

Visits (cont.)

While on a visit, some questions are provided for you. Simply click on a question, then select **ask** and the character at that location will provide you with an answer. Each question costs your company only $1, so ask lots of questions.

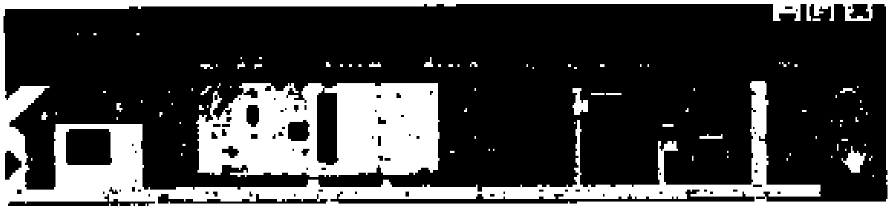


You can also type in your own questions by selecting **Ask Your Own Question** in the **options** menu, but these questions cost you $100, so think carefully before asking your own question. Answers to questions you write will arrive in your email. You can also send your assistant on tasks for $100. You do this by selecting **Send Assistant** in the **options** menu. Be sure to provide clear instructions. Your assistant will send you an email with whatever he or she finds out (if anything).

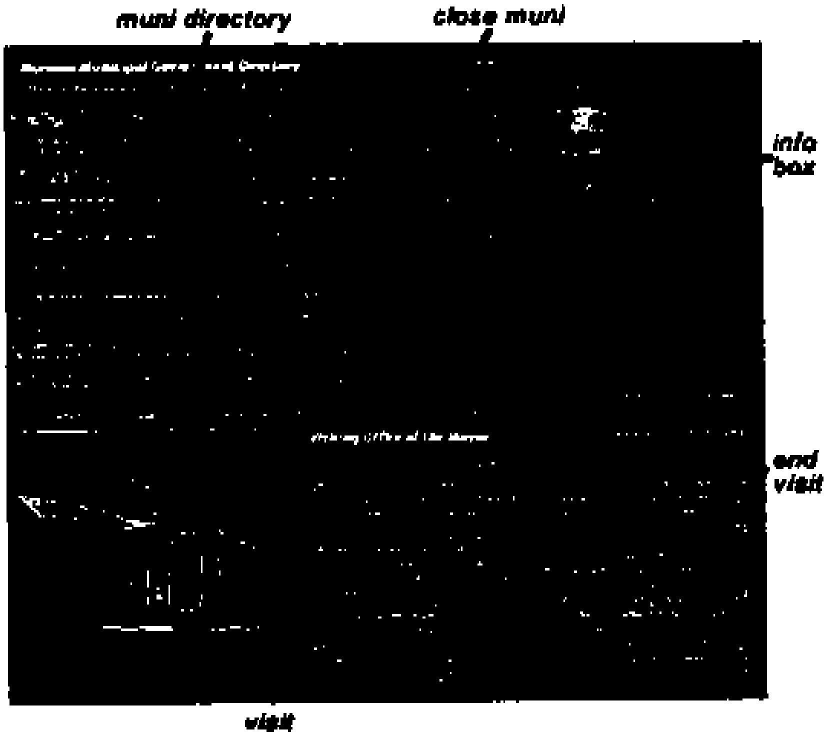
Be aware that some locations don't have a person available, so don't waste money going somewhere where no one is around. Also, *Brownfield Action* does not track the questions your company has asked in the past, so take good notes and/or print out the responses you receive. Otherwise you may have to spend money asking characters the same question twice. When your visit is complete, click on **end visit**.

Municipal Government

Some locations that you will need to visit are not located on the map. Instead, they can be found by clicking on the **muni govt** button near the top right of the screen.



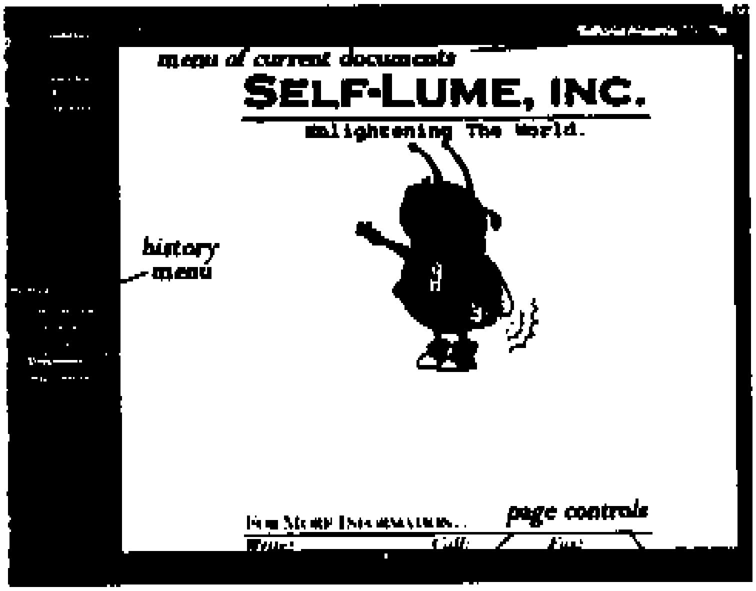
A directory of the municipal government complex will be presented to you, where you can select an office or department. Just as with the locations on the map, when you select a location you will see a description of that office or department and you will be given an opportunity to visit and ask questions.

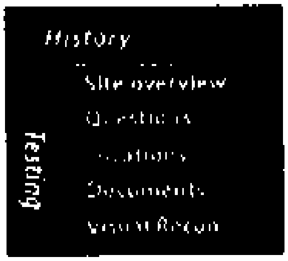


When you have completed your muni visit, select **end visit**. To visit another muni location, click **done**, then click on another location in the directory. To go back to the site map, click **close**. You must choose **end visit** before you can close the muni government window.

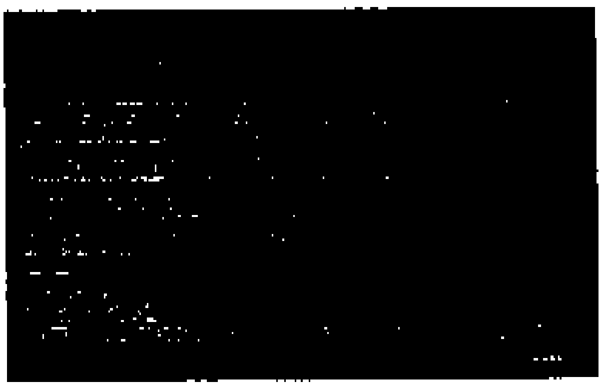
Documents and Other Helpful Screens

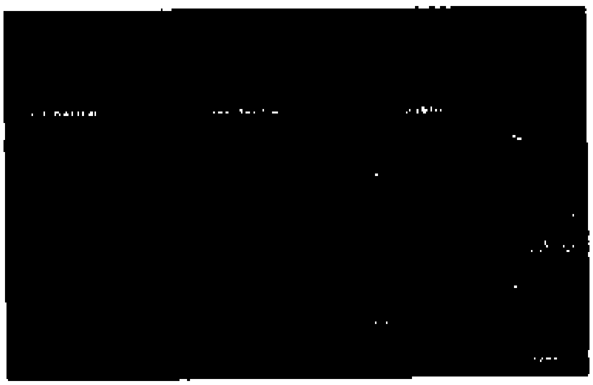
Sometimes when you ask a question, you will receive a document. A list of your current documents can be found by clicking on "Documents" in the **history menu**. Be sure to check there early on as your company starts out with a few useful documents. To see a list of your current documents, use the menu in the upper right. To view a document, select from the menu. Some documents have more than one page. To move through the pages, use the **page controls** on the bottom of the screen.





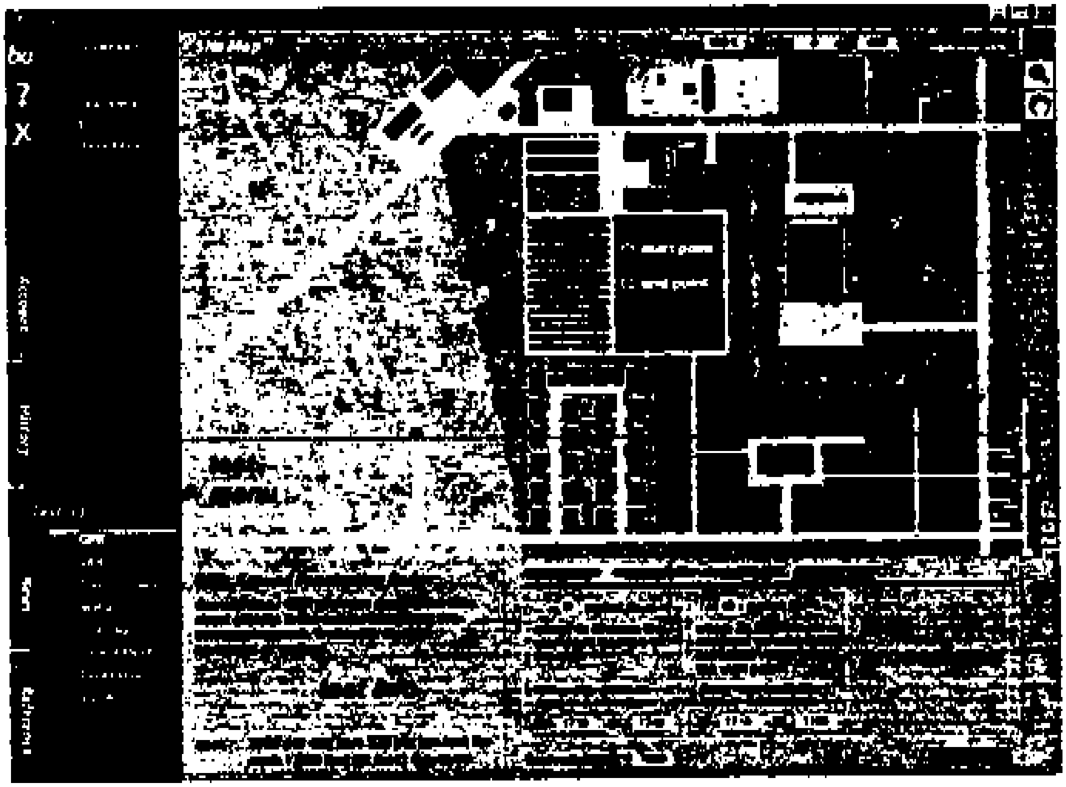
Also in the **history menu**, you can also select **Questions** to see a list of the preset questions that you can ask at each location. In the same area is **Locations**, which helps you find locations on the map. You can also redo the **Visual Reconnaissance** by selecting it from the **history menu**.





Testing

In the Testing section, you will see a test menu with a set of environmental testing tools on the bottom left portion of the screen. Clicking on a test will give you a description of the tool and an opportunity to use it on the map.



Test Certification

Before using a test, you should become certified to use the tool. Using the tool at the inappropriate time or using it incorrectly could cost your company a lot of money, so read the reference material and pass the certification exam before using a tool on the map.

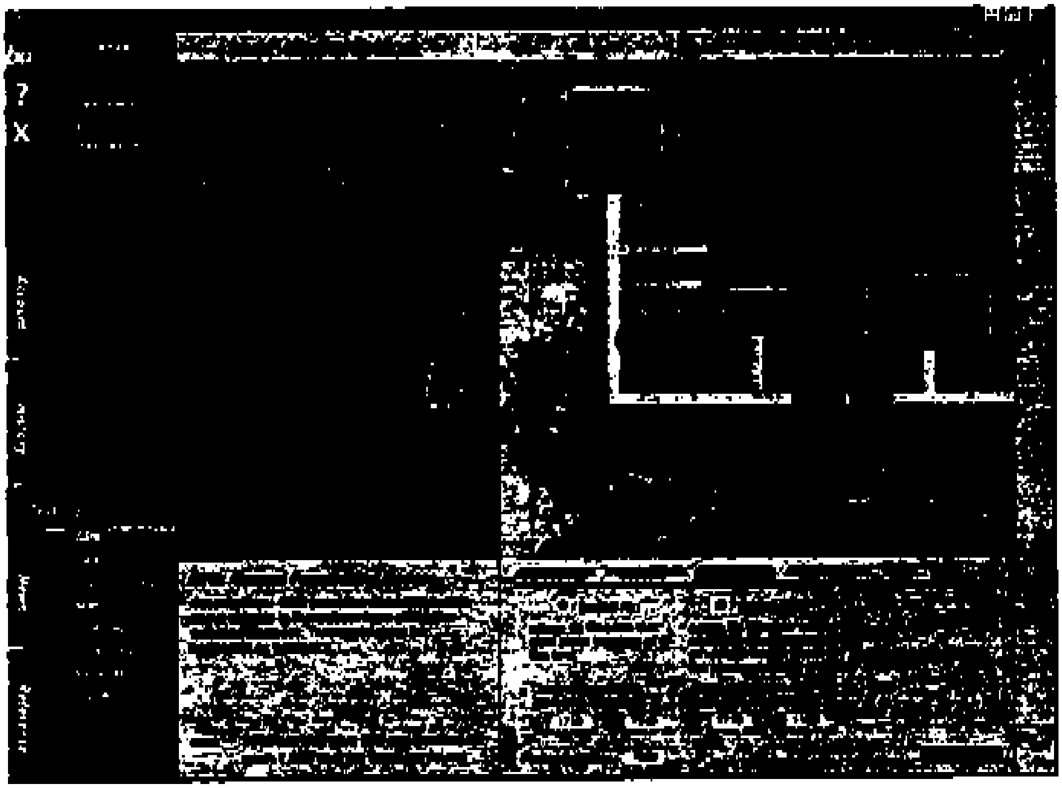
Certification involves answering a set of multiple choice and true/false questions about each test. You will have to visit the Brownfield Action Reference website in order to learn about each test and to take the associated exam. The URL is:

http://www.columbia.edu/itc/barnard/envsci/bc1001/bfaref/

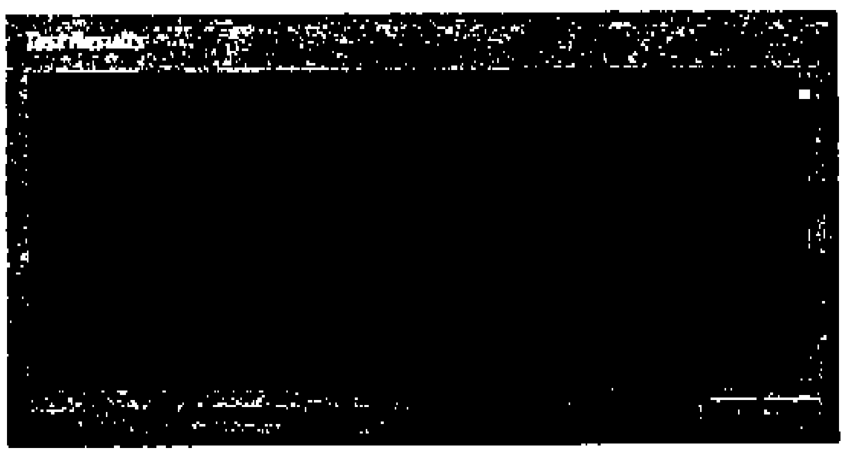
Note that there is a **Reference** button in the Testing section that will display a link to the Reference website if you click it or you can visit the course website and go to the Web Resources section, where you will find the link as well.

Practicing with Testing Tools

After you have been certified to use a test, take advantage of the **Practice Map** to practice using the test before you use it in your investigation. Follow the instructions for each test to learn how to use it. The practice area gives you a chance to use the test without being charged, so take advantage of the opportunity and perform as many tests as you want. Pay attention to the cost structure for each test, as each of them are different.



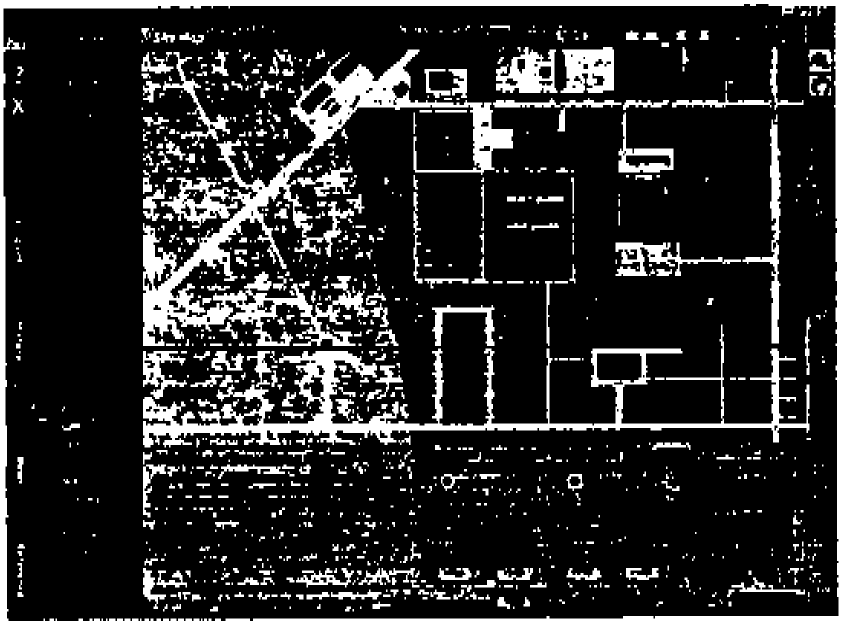
Each test will produce a results screen something like this:



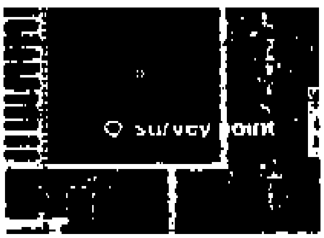
which you can use to note down data you've collected.

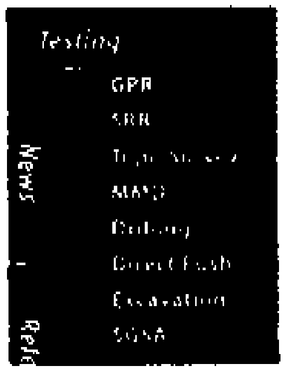
Performing Tests

Once you are done practicing and you are ready to use a test on the Site Map, click on the testing button. The map will change but the test will work just as it did in the practice area.



Important Note: Each time you perform a test, a small **test marker** will placed on the map where the test took place.



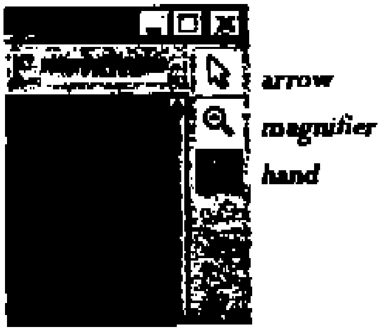


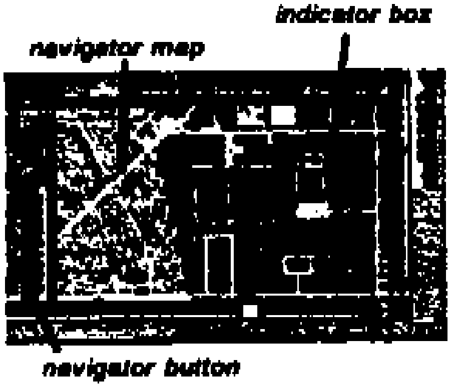
You can click on this marker to recall the test data screen from that point. To avoid cluttering up the map, only the markers for the test you currently have selected will be shown at the map at one time. To see the markers for a different test, select the test from the Testing Menu.

Zooming and Other Map Features

To help you perform each test there are a few more tools to use on the Site Map. By using the **magnifier** in the upper right you can zoom in on the map. To activate the **magnifier**, click on it, then click on the map where you want to zoom in. To zoom out, click on the **magnifier** again.

Navigate the zoomed in map by choosing the **hand** tool. After clicking the **hand** tool, you can click down anywhere on the Site Map and slide it in any direction by moving the mouse. The pink **indicator box** in the **navigator map** that pops up will indicate the portion of the large Site Map that is in view.



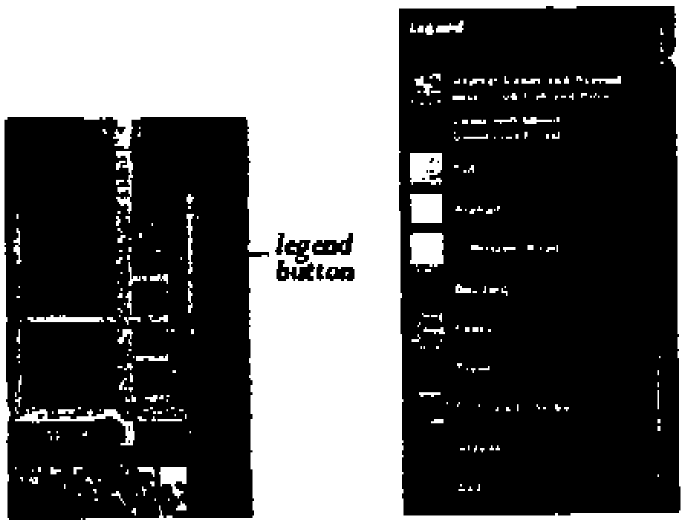


If necessary, you can hide the **navigator map** by clicking on the **navigator button**. To reopen the navigator, hit the button again under the **legend button**.

When you are done with the **hand**, click on the **arrow** or zoom out using the **magnifier** to resume with normal mouse functionality.

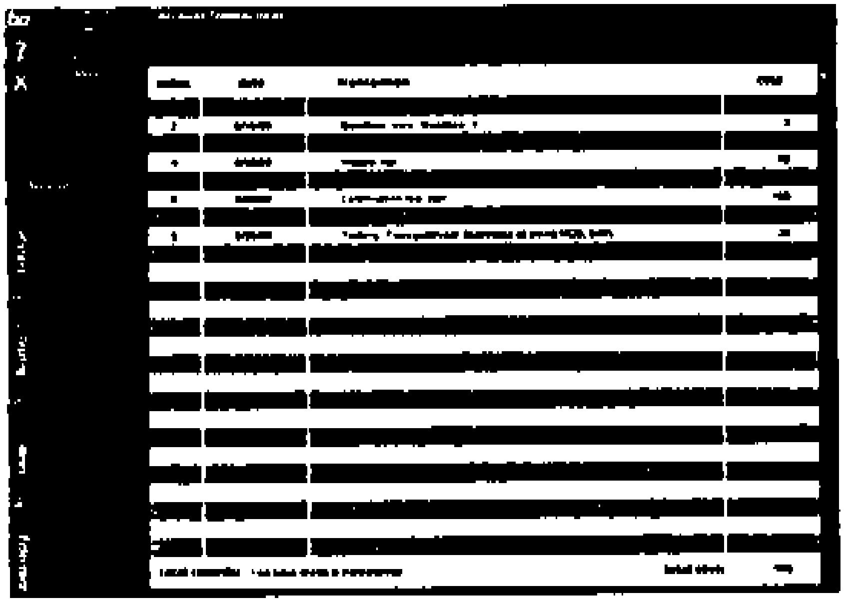
You can also use the **filter** menu to change the appearance of the map. Click the **filter** button near the top of the screen, then choose the filter you wish to apply to the map. In this image, the Street Name filter is being selected.

The map also has a **legend** that you can pop in/out by clicking on the legend button on the right edge of the screen.



Account

The Account simply shows a listing of all the transaction your company has performed during your investigation. It serves as you checkbook so you can monitor your spending.

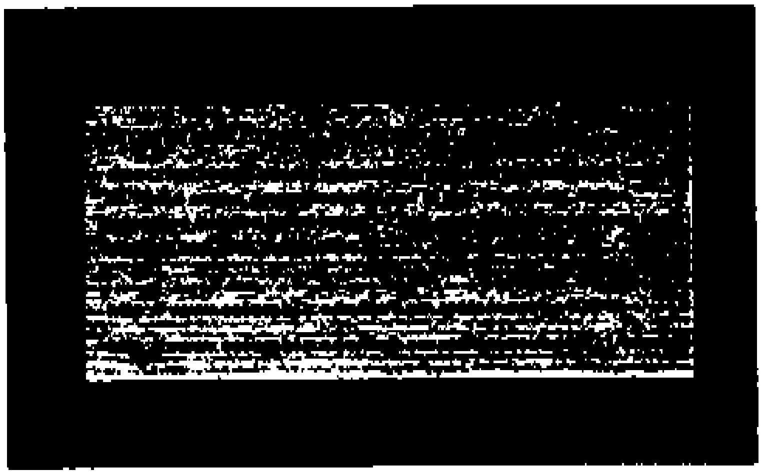


News

News displays news clippings from the Moraine newspaper that may be helpful to your investigation. Take some time to read those over as they may provide clues as to whom you should talk to in the town and what you should ask them about. The clippings will change from time to time, so check back often to see if new news is available.

Reference Tab

The Reference Tab contains weblinks to the course website and the *Brownfield Action Reference* website.



Troubleshooting Common Problems

I can't log in.

Make sure you are entering the correct name and password as when you filled out the contract. Passwords are case-sensitive. Then make sure your Internet connection is working. To test this, try accessing a website. If the problem persists, try restarting your computer or use a different machine.

I am getting SCRIPT ERROR. CONTINUE?

If SCRIPT ERROR occurs, click YES on the error message box and you should be able to continue normally. You may have to click YES more than once. If the problem persists, try logging out and logging back in and/or restarting your computer. Report the problem to your instructor and be sure to include where in *Brownfield* error took place.

Graphics appear choppy or are missing, objects are moving slowly or the machine is freezing.

Most likely the machine memory is low. To remedy this, close any other open applications (such as your Internet browser). If the problem persists, logout, restart the computer, then try again. If the problem still persists, use another machine with more memory and report the problem to your instructor.

The program won't show the movies and/or it is asking for Quicktime.

Quicktime is required for installation of Brownfield Action to take place, so most likely you either have an old version or it has been installed incorrectly. Quit *Brownfield and* visit http://www.apple.com/quicktime and download the most recent version of the free player or insert your *Brownfield Action 2.1* cd rom, open the Windows or Mac folder depending on your machine, and doubleclick on the Quicktime Installer.

I'm having trouble printing.

Check your printer settings to ensure your printer is working normally. As a test, try printing a simple text document from your computer. If the printer is working normally, then most likely your machine does not have enough memory to print. If this is the case, then most likely you will have trouble printing the longer documents. Try closing any other open applications and/or restarting your computer. If the problem persists, use another machine with more memory to print and report the problem to your instructor.

The program quits by itself or I'm getting error messages not listed above.

Logout and log back in and/or try restarting the computer. If the problem persists, write down the error message and pass it on to your instructor.

Brownfield takes over my entire screen and I don't know how to quit.

At any point, you can quit the program by pressing CRTL-Q or ESC (Windows) or Apple-Q or ESC (Mac). If possible increase your screen resolution to 1024 x 768.

For more help, consult the Brownfield Online Help website:
http://ccnmtl.columbia.edu/brownfield/help

APPENDIX F

Web Resources

Amtec (developers of Tecplot, three dimensional modeling software used to develop data model)
http://www.amtec.com

Barnard College's Introduction to Environmental Science I Course Website
http://www.columbia.edu/itc/barnard/envsci/bc1001/

Brownfield Action Reference Website
http://www.columbia.edu/itc/barnard/envsci/bc1001/bfaref/

Brownfield Action Download Site
http://ccnmtl.columbia.edu/projects/brownfield/download

Brownfield Action Help Website
http://ccnmtl.columbia.edu/projects/brownfield/help

Columbia Center for New Media Teaching & Learning
http://ccnmtl.columbia.edu/

Golden Software (developers of Surfer, the application used to develop the data model)
http://www.goldensoftware.com/

Macromedia (developers of Director, the programming application used in Brownfield Action)
http://www.macromedia.com