DEVELOPMENT OF AN INNOVATIVE WEB-BASED TEACHING TOOL ILLUSTRATING LAND USE IMPACTS TO SOIL QUALITY AND FORMATION

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE STUDIES
(Soil Science)

THE UNIVERSITY OF BRITISH COLUMBIA
(Vancouver)

February 2010

ABSTRACT

Over the last few decades, post-secondary education has experienced an increase in the adoption of new technologies and approaches into the curriculum. Meanwhile, soil has not received the attention it warrants for its role in many of the current global environmental issues, such as food shortages and climate change. Innovative teaching approaches are needed to convey the message that soil is an essential natural resource for human survival and to raise the appeal of the discipline of soil science. The objective of this study was to develop and evaluate the web-based Land Use Impacts (LUI) teaching tool, which combined a problem-based learning (PBL) style case study with information technology (IT) to illustrate the impacts of three land uses on soil formation and quality for students enrolled in the fourth year/graduate university course on sustainable soil management. The LUI tool (http://soilweb.landfood.ubc.ca/luitool/) provides an authentic learning experience with the purpose of engaging students and providing greater access to information. The tool will be used extensively in the Sustainable Soil Management course offered at UBC which has a yearly enrollment of around 30 students. The tool includes instructional technologies, soils data from 1970 and 2005-2008, archival photos, maps, historical narratives, and web-links. Preliminary feedback showed that the tool successfully conveyed learning objectives and was appealing to the students. Eighty-five percent of student agreed that the tool's multimedia resources added to the appeal of the subject. By exposing students to complex questions without definite answers, promoting intellectual inquiry and analysis, stimulating critical thinking, and encouraging the application of knowledge to complex issues, the LUI tool stimulates higher cognitive processes and facilitates learning outcomes deemed essential by current employment demands. In long-term, this study will help promote development and use of innovative educational methods in soil science curriculum and, in turn, will enhance the appeal of this discipline among the next generation of natural resource scientists.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

First I am thankful to live on such an inspiring and nurturing place as Earth- what an amazing place we call home. Then I give thanks for family in which I was raised- without my many days in the garden and playing outside, I never would have realized my love of soil and all who depend upon it. I give thanks to my family and husband for their emotional (and occasional) financial support. Without their encouragement, I would have found this to be an extremely difficult process. I thank Mark Bomford, Art Bomke, Andy Jakoy, and Suzanne Simard for their involvement with the filming for the teaching tool; Andy Jakoy, Les Lavkulich, Chris Crowley, Saeed Dyanatkar, Peter Shanahan, Edmund Dugas, and Christian Evans for their technical and/or production assistance; at the University of British Columbia, help was also provided by the Office of Learning Technology (OLT), Telestudios, and the Faculty of Land and Food Systems Learning Centre; Art Bomke, Susan Watts, Jolie Mayer-Smith, Chris Crowley and Saeed Dyanatkar for their insight through the development of the project; and Maja Krzic, Les Lavkulich, and Edmund Dugas for their helpful suggestions on the thesis. The financial support for this study was provided by the UBC Teaching and Learning Enhancement Fund.

CO-AUTHORSHIP STATEMENT

I was responsible for the design and execution of the Land Use Impacts (LUI) tool with extensive consultation from the LUI-team. I also was responsible for the experimental design, data collection, and writing the manuscript. The members of the Land-Use Impacts team who provided guidance through consultations with the tool design and execution were Maja Krzic, Chris Crowley, and Saeed Dyanatkar. Maja Krzic provided guidance in the interpretation and presentation of the manuscript.

1 GENERAL INTRODUCTION

With the onset of global food shortages and climate change, the negative effects of anthropogenic activities on the earth's processes are becoming more apparent. It will take individual, national, and global action to ameliorate the impacts of these activities. Soil plays a crucial role in two of the most expansive and multifaceted environmental issues of our time, land conservation and global climate change. Hence, an effective response to these two issues will require citizens and governments with a good understanding of sustainable soil management.

During the past century, both the increase of human population and the signs of human-induced soil degradation have become particularly apparent. There are numerous estimates about the extent of soil degradation, and the International Soil Reference and Information Centre points out that 19.65 million km^2 of land have already been degraded from a total of 51.6 million km^2 total (Eswaran et al., 2001). It is clear that current soil degradation is occurring at rates faster than soil formation or soil conservation could protect (Wilkinson, 2005).

Soil formation is a slow process, better measured using geological time frames than human lifetimes, driven by five factors (i.e.,parent material, climate, biota, topography, and time) reacting in conjunction with various biological, chemical, and physical processes to create horizon differentiation. Early soil scientists did not fully recognize the major role that humans play in soil formation, considering humanity as simply a component of the biota factor. This was likely due to the lack of understanding about the rates of soil processes and the rates by which humans could drastically change the soil (Richter, 2007). As anthropogenic impacts on soil have become profoundly more noticeable in the last century, it has been proposed that humans be acknowledged as a factor in soil formation (Bidwell and Hole, 1964; Dudal, 2004). The term, *metapedogenesis,* was instated to denote human activity that alters soil formation as evidenced in the soil profile (Yaalon and Yaron, 1966). Because metapedogenesis is a fairly new concept, the knowledge of the rates and magnitudes of soil degradation from human activity has not been fully disseminated outside of the soil science community. Communicating this information to the scientific community, at large as well as to the general public, is necessary to insure that future land use decisions enhance sustainable land management (Mermut and Eswaran, 1997).

The need to effectively communicate the science of sustainable land management is complementary to the need to educate post-secondary students in soil science principles and applications, because they will be the future land practitioners and planners. The concept of soil quality was developed with a goal to identify a set of soil indicators that affect the soil's ability to properly function in a variety of roles (Doran, 2002). Primary measures of soil quality effectiveness are enhanced biological productivity, environmental quality, and human and animal health. Allowing students to learn how to assess soil quality and to apply their knowledge about soil to varied ecosystems and land uses should be one of the main focal points in soil science education.

1.1 Overview of Post-Secondary Soil Science Education

A rise in soil science research in North America and other parts of the world took place from the 1950s until the mid 1970s, as governments increased their support for soil and agronomic research in response to a growing population and the need for greater crop production (Letey, 1994; Pepper, 2000). Advances in agricultural production (i.e., new cultivars and hybrids, chemical fertilizers, and pesticides) allowed farmers to reach unprecedented crop yields in the 1970s. Over time, this led to marginalization of soil fertility management and the overall importance of the soil scientist (Lal, 2007).

As support for agricultural and crop production studies declined, environmental protection garnered more interest (Pepper, 2000), and this shift occurred along with changes in societal expectations of agriculture and agricultural university programs. The United States land-grant universities were created under the Morill Act of 1862 to ensure national prosperity and security (Zimdahl, 2003); however, United States security and prosperity are no longer viewed as being intricately linked with agriculture. Following all of these changes, the focus of soil science at many universities shifted from agricultural to environmental issues(Hopmans, 2007; Hartemink, 2008), altering both the faculty and the student populations (Pepper, 2000).

Since the 1980s, the discipline of soil science in North America has experienced a decline in student enrollment, academic appointments, number of department names with the word 'soil' in their title, and dwindling financial support for research by government programs (Mermut and Eswaran, 1997; Lal, 2008). A survey comparing student enrollment in soil science programs at North American universities in 1992 and 2004, showed that among 80% of universities that responded, 40% of them experienced a decline in the graduate student enrollment (Baveye et al., 2006). Similarly, other countries such as the Netherlands, New Zealand, Kenya, and Tanzania also experienced and continue to exhibit on-going decline in student numbers enrolled in soil-related programs (Hartemink et al., 2008). In a survey of Canadian and United States institutions that offer soil science courses, almost half of the 46 responders noted a decrease in soil science faculty appointments (Letey, 1994), indicating that universities are hesitant to fund increasingly smaller programs.

Decreased student enrollment can be ascribed to a number of social and cultural attitudes and trends. It is generally accepted that disciplines such as law or medicine have more money-making potential than soil science or agriculture, and a substantial portion of students drawn to those higher paying professions (McCallister et al., 2005; Baveye et al., 2006). The decrease of farmland and rural spaces, accompanied with an increase in urban population, has also contributed to decreasing student enrollment in soil science and agriculture, which traditionally drew a large component of their student enrollment from farming communities (McCallister et al., 2005). Additionally, more effort is required to increase the profile of soil science in high school and post-secondary education, so that soil science is seen as a viable career option. In a survey of over 2,000 students at the University of Florida conducted by Collins (2008), the respondents indicated that career opportunities were the most prominent factor in degree selection. Furthermore, students (and their parents) noted that they knew very little about career paths in soil science. Landa (2004) believes that there is a natural curiosity among younger students (elementary and middle school aged) for the 'substance underfoot,' but their opportunities to learn about soil in their pre-university years are limited. Once at university, they study soil science only if they enroll into agronomy or forestry programs, while those students in earth sciences or general science programs may only receive a limited exposure to basic soil science principles. Finally, the current offerings of soil science courses are often dated and overly traditional with very little curriculum innovation or emphasis on potential career pathways (Collins, 2008). Handelsman (1992) noted that one only has to see the University of Wisconsin agriculture hall displays showing rusty farm equipment and pre-color photographs to recognize that in comparison with how other university science departments represent themselves, the soil and agriculture department is part of a bygone era.

In response to the decline, some universities and faculty members have begun to address the trend through curriculum review and innovation. As the discipline's focus shifted from crop production to environmental protection and global issues (e.g., climate change), some felt the need to revamp and enhance soil education to maintain relevancy (Baveye et al., 2006; Collins, 2008). Some universities developed new courses that focus on environmental issues (McCallister et al., 2005), while others responded by creating interdisciplinary soil science programs. Student enrollment in interdisciplinary soils courses remained high at US land-grant institutions (Hansen et al., 2007). For example, California Polytechnic State University reorganized its soil science program to create three new degree concentrations (Land Resources, Environmental Management, and Environmental Science and Technology), which in its initial two years, almost tripled the student enrollment (Taskey, 1994).

The assessment and modernization of soil science pedagogy and curriculum at the university level is imperative. Soils are complex natural bodies composed of living and nonliving components, hence soil science builds upon principles of biology, physics, chemistry, ecology, and geology. Communicating applications of soil principles and soil management to students must address the complexity inherent in the topic. In the post-academic job world, soil problems are solved not solely by individuals, but by teams composed of scientists, land use planners, consultants, land managers, and/or governmental officials. Consequently, this will require future soil experts to be able to effectively communicate to non-experts. University instruction needs to address this dynamic pedagogical challenge by equipping students with the effective communication, team-work, and problem-solving skills needed to thoroughly master this complex subject (Smiles et al., 2000).

A natural resource and soil science education focusing on the rates and magnitudes of anthropogenic soil degradation would provide students with the scientific background to guide future land use decisions. Directing soil science education in this way would allow students to understand the system stressors, the adaptability or resilience of the soil or environment, and the degree of environmental change. As the world population grows, estimated to exceed 9 billion by 2050 (US Census Bureau, 2009), sustainable land use will become more of a pressing issue, and demand for individuals with knowledge of how to sustainably manage the land will rise (Mermut and Eswaran, 1997). To meet this need, soil science education should focus on soil functions, processes and sustainable management, conveyed by using many real-life examples. (Mermut and Eswaran, 1997).

Many soil scientists have reflected on the present state and future directions of the discipline and are calling for action. Some believe that soil scientists must facilitate and maintain outreach efforts to the general public and policy makers (White, 1997; Amundson, et al., 2003; Landa, 2004; Lin, 2005; Hopmans, 2007; Lal, 2008), while others are directing their efforts towards developing innovative curricula and upping recruitment from elementary to post-secondary schools (Handelsman, 1992; White, 1997; Landa, 2004; Lin, 2005; McCallister et al., 2005; Baveye et al. 2006; Wilding and Lin, 2006; Collins, 2008; Grabau, 2008; Peterson, 2008; Bouma, 2009). Considering that there is a large body of work to be completed, all of these aforementioned actions are valid efforts, providing that they lead to raised awareness about soil and soil science. The focus of soil science's curriculum redesign should be on soil's relevancy to current global issues, while providing students with strong foundations in soil science knowledge and higher order thinking skills to meet global and professional needs.

1.2 Innovative Approaches in Post-Secondary Education

Scientists from different disciplines have observed that the majority of post-secondary science is taught in contrast to the way science is practiced (Wieman, 2007; CSA, 2009). To meet industry and societal employment demands, present day scientists and professionals must possess not just content knowledge, but also be skilled communicators, critical thinkers, and collaborators (Koppi et al., 1997; Thompson et al., 2003; Amador and Gorres, 2004; Kirschner, 2004). Traditionally, the structure and design of science instruction was lecture-based and instructor-centred. This method, while practical for some learning outcomes, does not address all of the outcomes that are expected from a post-secondary education. Over the past two decades, university educators in Australia, the UK, Canada, and the US have moved the learner to the center of the educational process, thereby attempting to transition students from passive to active learners (Koppi et al., 1997; Parker, 1997; Oliver and Omari, 1999;

U.S. Dept. of Education, 2006). As Canadian post-secondary education has shifted to include more active, constructivist, and collaborative learning approaches, the results show largely positive gains in the critical thinking skills of students (Usher and Potter, 2006). Since 1992, numerous agronomic instructors have noted how incorporating case studies or laboratory inquiry learning in their courses, has improved the students' critical thinking, problem solving, and decision-making skills (Thien, et al., 2008).

Creating and implementing activities that build higher order thinking processes in students can be taxing on instructors' time and resources. New information technologies (IT) and innovative teaching approaches have a potential to help the instructors apply these activities (Oliver and Omari, 1999). Handelsman (1992) has shown that computer modelling, cooperative learning, and problem-solving approaches are effective in conveying complex and broad concepts to learners in an engaging way.

The popularity of IT in education has grown in the past decade, as shown by the number of students enrolling in online learning classes. A survey of over 200 US universities carried out by Allen and Seaman (2008) showed that from 2002 to 2007 enrollment in online courses increased by 20%, while the post-secondary student population increased only 2%. The Economist Intelligence Unit (2008) created a global online survey and conducted in-depth interviews with academia and private executives from the US (154 respondents), Europe (69), Asia-Pacific (43), and the rest of the world (23), to glean attitudes towards technology in higher education at present and over the next five to ten years. According to the survey 63% of respondents believed that online or electronic technological innovation would have a major impact on teaching over the next five years. Seventy-three percent of corporate respondents believed technology would be the primary deciding factor for students choosing a university. Many of the academic respondents (60%) indicated that the next five years would see post-secondary campuses shift from one-dimensional (physical) to multi-dimensional (physical and online). Post-secondary educators in natural resource sciences reflect this technology shift: a review of publications from the Journal of Natural Resource and Life Science Education had computers ranking as the most prevalent teaching aid in 1995 (Thien et al., 2008).

1.2.1 Information Technology

University educators have been exploring how IT can improve content delivery and have used technology to create new teaching tools. Some types of IT used in post-secondary education include websites, software, learning objects/tools, multimedia, virtual field trips, blogs, podcasts, and simulations. Incorporation of IT into the post-secondary classroom has ranged from distance education, to animated games and models, web-based collaborative tools, web-based multimedia learning experiences, and hybrid / blended courses (composed of both online and face-to-face instruction).

Despite the yet-undetermined results regarding IT's effectiveness in education, the use of IT for education has increased substantially over the last decade (Hede, 2002). With regard to the history of educational methodology, IT is still new and thus may not optimally address instructional pedagogy (Ewing, 2000; Abrami et al., 2006). However, research and application of IT does evidence some advantages and limitations of using IT in education, and continued research will further illuminate the benefits and drawbacks of IT-enhanced curriculum.

For many post-secondary instructors, the advantages of IT outweigh any perceived or measurable limitations. Course content enhanced by IT has temporal and spatial flexibility, reusability options, and wider accessibility than traditionally delivered course content. For example, the virtual field trip (VFT) which uses video, photo images, and text to allow students to 'travel' to a field site through the computer has become a popular educational tool because it offers instructor control of content and features, reusability, and greater accessibility for students to information (Hurst, 1998; Ramasundaram et al., 2005; Tuthill and Klemm, 2002). The VFTs provide compelling accessibility options for students who are unable to attend a physical field trip because of handicap, sickness, or scheduling conflict. Additionally, via VFTs, students can be exposed to material which would otherwise be time-consuming (e.g., a multi-week soils survey), expensive (e.g., an international tour of archaeological ruins), or dangerous/destructive to undertake in the field (e.g., lava flows or protected environmental sites) (Hurst, 1998; Tuthill and Klemm, 2002).

According to a meta-analysis study, IT is not universally effective at helping people learn, but has been proven to be helpful in specific scenarios (Najjar, 1995). IT has been shown to enhance learning in situations when (1) the learners do not have extensive prior knowledge, (2) the varied components of IT content inherently relate together and the material is structured to support a learning objective as a connected whole, and (3) the IT media is used in development of a cognitive model (Najjar, 1995). Some studies showed that when visual and auditory information were presented together and were both integral to concept understanding, this dual mode simultaneous presentation of information served to increase the capacity of the working memory and facilitated learning (Low and Sweller, 2005; Najjar, 1995). The dual mode of presentation, or dual-coding theory, is based on the assumption that information stored in the brain coded with both the visual and verbal systems is better retrieved than information coded with just one system (de Jong, 2005).

Another advantage of IT incorporation is its potential to heighten students' motivation and interest in course content (Goldberg, 2005; Tal and Hochberg, 2003). Rich multimedia content enhances student interest by presenting multiple viewpoints for accessing the information and thereby supports the possibility that students will maintain attention until they have achieved understanding of concepts (Moore and Gerrard, 2002; Cox and Su, 2004). Students are able to visit IT-enhanced course content repeatedly and have multiple access points to the representational richness of the topic via video, photos, graphs, text, and audio media (Moore and Gerrard, 2002;

Polsani, 2003). Students may require multiple exposure to grasp the finer nuances of an issue, and for some users, repeated exposure to the varied media material is what assists them in comprehending the material (Hoffman and Ritchie, 1997). There are also indications that IT-enhanced courses increase student motivation by accenting student-instructor contact and enhancing learning outcomes (Riffell and Sibley, 2004).

Technology supports a learner-centric methodology, because students are able to apply their own preferences and learning styles to the material (Koppi et al., 1997; Arts et al., 2002; Tal and Hochberg, 2003; Muller et al., 2008). Student motivation can be significantly enhanced because students have the autonomy to access and use the learning material at their own discretion (Ewing, 2000). In two studies regarding learner autonomy and IT, third and fourth year university students benefited more from IT-enhanced courses than their first year peers. Third and fourth year students are generally more autonomous in their learning than first year students, hence more mature students are more likely to utilize and benefit from the greater flexibility offered through IT (Riffell and Sibley, 2004, 2005).

The human brain is a complex organ that gathers, stores, and creates information in unique ways. Although educators and researchers have been studying how we learn, no specific pedagogy has been proven to suit all learners. It is commonly accepted that students utilize different learning styles or approaches to build knowledge (McAndrews et al., 2005); however, while there are a number of learning style theories for instructors to choose from, none have been universally accepted. The two most well known theorists of learning styles, Howard Gardner (Theory of Multiple Intelligences) (1983) and David Kolb (Learning Style Inventory) (1981), independently developed theories to describe the varied cognitive avenues by which people learn information. With the theory of Multiple Intelligences (MI), there are 7 intelligences, which can be present in any combination in an individual, of which any 2-3 are generally dominant in any individual. The 7 intelligences, which convey the inherent intellectual ability or inclination of an individual, are bodily-kinesthetic, musical, logical-mathematical, linguistic, spatial, interpersonal and intrapersonal. In contrast, Kolb's learning style inventory (LSI) theory based on two cognitive dimensions of perceiving and processing, which when adjusted for (1) concrete or abstract and (2) action or reflection, produce 4 different learning styles. In Kolb's learning style inventory theory, the four learning styles which possess an inherent strength, notated in parenthesis, are: (1) divergers (imaginative ability), (2) convergers (application of ideas), (3) accommodators (experimenting or carrying out actions) , and (4) assimilators (creating theoretical models). Multiple Intelligences theory and LSI are actually not mutually exclusive in how they address the acquisition of knowledge. Generally, MI is concerned with the media which the knowledge travels through, while LSI is oriented around the architectural construction and manipulation of knowledge. An individual could be both a linguistic learner (MI) and converger (LSI); however an individual is unlikely to be an assimilitator with a highest ranking intelligence of bodily-kinesthetic, because of the inherent differences in those two learning styles.

From my years of teaching public school, I identified that by presenting information using (1) a variety of media, (2) in different contexts, or (3) by using different terms and figurative language, more students were inclined to learn the information. Different presentations of information appeal to different students, either because of physiological tendencies (e.g. preferring hearing words to reading them) or personal values (e.g. desire to learn about a topic when it is connected to a prior interest or value) and increase the likelihood that students will become engaged with the information. I use the term learning styles to refer to the broad range of inherent physiological and psychological (emotional) inclinations by which a student is most likely to access information for the purpose of knowledge acquisition. This definition of learning styles is general enough to incorporate both theories and to accommodate motivational theories too. By presenting curriculum with to appeal to a variety of physiological and psychological tendencies, the chances that a learner will become engaged with the information will increase. Continued exploration into the spectrum of human learning and consciousness may disclose a learning styles theory that is universally accepted and applied.

Along with the continued investigation to define a theory of learning styles, concurrent research with IT educational tools which are thought to effectively address different learning styles is being conducted (Garland and Martin, 2005; Mamo et al., 2005; Miller, 2005; Oh and Lim, 2005). At Iowa State University, an interactive, multimedia computer tutorial program for an introductory agronomy course was implemented in 2002 (McAndrews et al., 2005). The program was tested to determine if student learning styles impacted usage of the computer tutorial system. The results showed that the students' learning styles did not have any impact on the students' use of the program, therefore the authors concluded that the program was effectively designed to address different learning styles. In another study on learning styles and student use/interest of IT-enhanced instruction in a university biology course from 1996-1999, students exhibited a highly positive attitude towards the innovation (Sanders and Morrison-Shetlar, 2001). Researchers concluded that IT material used in this course was suitable for various types of learning styles because there was no relationship between learning style and attitude towards IT innovation. Admittedly, these studies are somewhat weak scientifically, because they attempt to prove that in a certain case IT is effective at addressing learning styles through this type of correlative reasoning. In the future, as we understand how humans learn to a greater degree, better balanced studies focused on the effectiveness of IT applications in education will be designed.

Though IT provides opportunities for instructors to innovate, there are diverse opinions as to whether these new technologies have enhanced student knowledge acquisition or whether they are simply presenting computerized versions of the same teaching pedagogy used previously. The prevalent attitude is that simply transferring textbook or lecture content to a web format does not necessarily result in automatic educational benefits (Jonassen et al., 1995; Parker, 1997), especially when no attention is given to the pedagogy or IT characteristics (Jonassen et al., 1995; Lefoe, 1998). Hede (2002) reviewed numerous meta-analysis studies and concluded that there is still no clear evidence whether IT in education provides a significant difference from traditional education. Hede strongly emphasized in his study that the application of IT educational material without regard to learner needs or course content can actually be detrimental to learning. This application that disregards learners or course content can be attributed as a major reason for the discrepancy of findings regarding IT's potential to foster effective learning.

Information technology had many inherent limitations. Though IT has been heralded for its ability to minimize the negative effects of time and space, but for anyone who has ever had to wait for more than ten minutes for a download to complete, the joys of technology use wear thin. Slow download of videos or website components has been noted as an annoyance or learning deterrent by students utilizing web-based learning experiences (Chumley-Jones et al., 2002). Similarly, poorly designed websites, video clips, or images defeat any advantages to flexibility or convenience for the student or instructors (Goldberg, 2005).

For some instructors, the cost and time to implement IT into coursework outweighs the benefits. While innovation, open source software, and new content sharing options are opening up possibilities to incorporate IT into the curriculum for more instructors, the cost of creating quality IT educational tools may still be too high for some.

Though students using IT may be more interested in the course content, interest does not always correlate with better learning (Goldberg, 2005). Information technologies may actually promote passive student interaction with content and, in turn, passive learning. The Geological Society of America and the Open University in the UK have identified that teaching aids that rely purely on slide-shows or videos with no data extraction or manipulation support passive learning (Hurst, 1998). Similarly, online learning with hypertext can create the same passivity, as students scroll through pages and links without interacting actively with the material (Koppi et al., 1997; Ward, 1998).

Educational IT can have negative effects on student learning and performance because of cognitive load. Cognitive load theory (CLT) refers to the relationship between new information and the cognitive organization and acquisition of the information in the learner's brain; it is centred with investigating the ability of an individual to build new knowledge and schema through storing information in working memory or long-term memory (Paas et al., 2003). In terms of instructional design, CLT researchers have studied how information presentation may contribute to individual knowledge acquisition (known as germane cognitive load) or how it may detract from individual knowledge acquisition (extraneous cognitive load). Extraneous cognitive load occurs when the information load is excessive and the brain's working memory is overloaded and prevented from comprehending new information. It is recognized that the brain can process and remember several new 'chunks' of information (generally three to seven ‘chunks’) in the working memory. With ill-structured IT learning environments, students may be exposed to more than their working memories can process effectively, and thereby experience extraneous cognitive load. For example, an instructor may include supplementary or 'exciting' IT content into the course material as a way of intriguing students, however, if the content is excessive, this can lead to extraneous cognitive load (Muller et al., 2008).

In Najjar's (1995) review of effective IT learning publications, multiple studies highlighted that with the dual presentation of material (multimedia as opposed to “monomedia”) learning was equal to or worse than when students were presented with “monomedia,” because the multimedia material was repetitive without presenting new information. The text and audio dual presentation resulted in poor student information retention, in contrast to the text and picture presentation, which had positive information retention in students. Multimedia does not conclusively aid learning. In some of the studies Najjar reviewed, IT incorporation resulted in neutral or negative learning effects, because the content presented was repetitive. In those cases, whether the multiple presentations of the material resulted in student extraneous cognitive load or boredom, the IT did not enhance learning.

Lastly, IT in the post-secondary classroom will never supplant the effectiveness of human interaction and actual field trips. Virtual field trips, for example, may include various information that students would not be able to see in the field, but the technology does not replace the actual sensory experience of being present on the site (Hurst, 1998). When instructors do choose to use IT in the classroom, the hope is that the addition of IT will add to (not detract from) student learning. Thus, poor performance from IT inclusion in a course may not be a result of IT itself, but rather of poor design.

Even though there are conflicting conclusions about application of IT in education, many studies point out that use of IT can improve teaching and learning (Abrami, 2006; Goldberg, 2005). In order to minimize any inherent negative effects, it is necessary to pay careful attention to the design, implementation, and review of IT essential to creating these effective educational technologies is reliance on best practices for IT design principles, awareness of student/course needs and specifications, and educational research.

It was relatively easy for instructors to incorporate previous educational technologies (e.g, television, radio, print) in their courses, however, the current extent of IT available to instructors is overwhelming, and given the frequency with which technology updates are occurring, incorporating IT into the curriculum would be an ambitious venture.. Certainly, some educational IT can be created solely by the instructors from their own acquired teaching knowledge and utilization of new software/applications designed to aid teaching. To create effective IT tools of high technical complexity and standards is costly and requires consultation and partnership with IT experts. One also needs to keep in mind that instructional design for IT educational material does not follow the same pedagogical methods as traditional classroom-based instruction (Abrami, 2006). Designers of educational IT material must make sure to address the most appropriate pedagogical practices for web-based learning. Many IT guidelines for best practices recommend that university educators partner with IT experts to create effective IT educational material (Naidu, 2003). The university instructor can best utilize his/her skills as a content expert in a team of other experts, which should include a combination of educational researchers and IT experts (Polsani, 2003). The role of the designer of educational material is to create an environment whereby students are engaged and enabled to construct meaningful knowledge (Jonassen et al., 1995).

To counteract the potential learner passivity, IT design should incorporate active, directive tasks. Successful web-based learning can facilitate knowledge construction and understanding by addressing the following three goals as outlined by Oliver and Herrington (2003): (1) inclusion of directive and engaging tasks, (2) scaffolding to support the learner, and (3) providing sufficient resources to support scaffolding and guidance to learners. By providing students with specified tasks and the material and scaffolding to achieve those tasks, active learning is promoted and passive learning is minimized.

There are several principles for the design of effective IT learning tools – a tool should be reusable, aligned with learning goals, accessible, and motivating (Polsani, 2003). Reusability in educational IT serves to make the cost of creating the IT much less than the cost at face value. When the creation costs are factored over years of student of use, often the IT turns out to be quite cost-effective. In order for learning to take place, new information must be meaningful to the learner (Jacobson et al., 2009). To ensure content relevance to students, instructors can either conduct student surveys and course evaluations or rely on their own observations gathered from their teaching career and note student challenges with concept acquisition (Jacobson et al., 2009). Those findings/observations are then addressed in the IT development (Chumley-Jones et al., 2002). Another issue that designers need to insure is that the IT developed is compliant with technical standards. Designers should plan for the lowest common denominator in terms of student technological equipment when designing new resources (Polsani, 2003; Goldberg, 2005). In this way, no students will be excluded due to their technological limitations.

Designers of educational material need to organize and plan the IT design and information delivery to minimize or prevent extraneous cognitive load. Generally, IT designers recommend organizing information so that there is (1) limited course information in the content menu section of the website and (2) grouping together of differing types of information and subsequent placement on separate menus. Other methods for minimizing extraneous cognitive load are still being developed and evaluated. Muller et al. (2008) hypothesized that inclusion of additional, irrelevant material would decrease student performance as a result of extraneous cognitive load; but the results were to the contrary. An online astronomy learning tool was developed to have two linear multimedia paths, one to serve as the control which was a concise version of the tool consisting of only the essential learning outcomes, while a second extended multimedia path served as the experiment which contained extra material, such as interviews with a professor discussing exciting topics in the field of astronomy. The tool was used by 50 high school students (from three high schools and one tutoring college) and 70 first year students at the University of Sydney, with approximately half being in each study group. Even though 50% extra, irrelevant (yet interesting) material was viewed by students in the experimental group, students did not show any decrease in understanding (Muller et al., 2008). Perhaps the students simply processed the information and were interested in the material, regardless of the fact that they had to spend extra time with information that had been deemed by the researchers and educators as 'irrelevant.' As researchers learn more about the brain and how it processes information, new guidelines for the design of IT educational tools will likely emerge.

We humans experience the world not as a set of problems to be solved, but rather stimuli and environments to assess, evaluate, and engage with, and the design of learning environments should reflect this (Prawat, 1993). Consequently, the design of authentic learning environments should resemble what individuals actually encounter in the real world. Many of the principles for IT educational design represent variations of principles used in authentic learning environment design. Herrington (2006) identified seven IT authentic learning principles, which were derived from studying the effective qualities of apprenticeships, and applied them to IT development. Authentic learning, also referred to as situated learning, is learning that most closely recreates the manner in which knowledge will be used in its actual context. These principles are:

1. learning is in context and reflects how it would be used in real life
2. tasks are authentic
3. there is access to expert perspectives and processing of information to serve as a model and a resource
4. students are enabled to access the information from multiple perspectives or roles
5. knowledge construction occurs collaboratively
6. there is time for presentation and articulation of knowledge, and
7. learning process includes reflection time

Therefore, how IT is incorporated into a mode of learning (i.e.,tool) is not as crucial, as to the degree which the mode of learning has been designed to most authentically present the information or the learning experience. By incorporating these principles into the IT design, more authentic learning experiences will take place.

1.2.2 Case-based Collaborative Learning

The ability to deal with problem-based situations is a highly desirable skill among graduates working in many professions (Koppi et al., 1997). Case-based collaborative learning is one of the problem-solving educational approaches that provides students with communication, problem analysis, and resolution skills. In case-based learning, students work on a scenario which has an ill-defined or unstructured solution and apply their content knowledge to create recommendations for issue resolution. Problem-based learning (PBL) is one of the case-based collaborative learning methods developed to facilitate self-directed learning, problem-solving skill acquisition, and inquiry learning (Hmelo-Silver, 2004). Before PBL emerged as a widely popular educational approach, agricultural educators were promoting similar case-based or inquiry-based approaches to teaching (Parr and Edwards, 2004). Problem-based learning arose out of dissatisfaction with medical science education in the 1950s and 1960s (Dochy et al., 2003), which was faced with the task of instructing students to learn content with a high complexity of subject matter, real-world examples and applications, while utilizing problem-solving and communication skills (Amador and Gorres, 2004). Problem-based learning centres around small student groups solving a problem or dilemma, which may or may not have a definite solution (Hmelo-Silver, 2004). Students working on a PBL case are provided with recommended reading that gives them background information for the case. Over the course of several weeks (or an entire term), student groups work through a case trying to address instructor-provided learning outcomes. The instructor also prepares a set of guiding questions to help both group and individual student learning (Norman and Schmidt, 1992; Finucane et al., 1998; Hmelo-Silver, 2004). During the course of a PBL case study, student learning is also guided by tutors who insure that students discussions stay focused. Students conclude the PBL case study with a demonstration of their group and individual learning and by providing recommendations for actions to solve the problem of the study case. Natural resources and agriculture sciences education in many instances have adopted the PBL approach because the curriculum contains similar instructional challenges as medical education (Arthur and Thompson, 1999; Amador and Gorres, 2004).

Even though PBL has become widely popular among post secondary institutions scientific evidence about effectiveness of the PBL is conflicting (Norman and Schmidt, 1992; Finucane, 1998; Dochy et al., 2003). Kirschner et al. (2006) notes that teaching approaches such as PBL have been ineffective because of the minimal guidance and structure offered to students. Norman and Schmidt (1992) investigated the psychological basis for PBL and found that though the theory of PBL is based on cognitive theory, studies of PBL show minimal or negative impacts to knowledge acquisition as a result of PBL instruction. Several studies that Norman and Schmidt reviewed demonstrated that PBL-instructed students performed more poorly on knowledge tests than non-PBL instructed students.

Studies that found PBL to have positive impacts on student learning have identified the following key advantages of this method (1) enhancement of self-directed learning, (2) creation of more stimulating and humane learning environments, (3) raised interest/motivation towards a subject (Norman and Schmidt, 1992; Finucane et al., 1998), and (4) better integration of basic and applied knowledge (Norman and Schmidt, 1992). Some studies have also shown that PBL can improve knowledge retention (Finucane et al., 1998), since the problem in a case study motivates students to learn and apply information about concepts that students otherwise might deem minimally enticing (Turgeon, 2007). The assumption that PBL supports acquisition of problem-solving skills in students is yet to be sufficiently supported by the literature (Norman and Schmidt, 1992).

1.2.3 Combining IT and Collaborative Learning

In the quest to find teaching methods that are closely related to real world practices, combining IT with case-based learning shows promise. Such an approach allows educators to bring their students one step closer to authentic learning by simulating real life situations similar to what professionals in that particular discipline deal with on a daily basis (Hoffman and Ritchie, 1997; Naidu, 2003).

During the past decade, numerous attempts have been made in various disciplines of post-secondary education to combine collaborative learning case studies with IT (Ward, 1998; Oliver and Omari, 1999; Barak and Dori, 2004; Taradi et al., 2005). Generally, there are two approaches to accomplish successful merger of these two methods. The first approach entails creating a collaborative online environment, whereby the students use the IT environment to complete the case study work by communicating online among their group and with the instructor(s). The courses with used online collaborative platforms that support case-based learning may or may not have face-to-face interaction with the instructor and other students (Collis, 1997; Guzdial et al., 1997). This is commonly enacted when an instructor wishes to have a distance education course that is modelled on the collaborative case-based approach. The second approach to combining IT and collaborative learning case studies involves creating an IT-based informational structure and database whereby students could view and gather the material to make their conclusions, and where the students interact in the classroom with peers and the instructor(s) (Arts et al., 2002; Oliver and Omari, 1999, 2001). This approach is more common in face-to-face courses where the instructor wishes to enhance his/her curriculum by blending technology into the present PBL course/inquiry learning environment.

The innovative blending of IT and collaborative learning case studies is inspiring, but its educational efficacy still needs to be evaluated. Although IT-enhanced curriculum has exhibited specific advantages for student learning (e.g., flexibility, accommodating various learning styles, etc.), it does not warrant a total shift to all online instruction, since, instructors and students derive numerous benefits from face-to-face learning. Similarly, PBL is beneficial, yet has noted drawbacks for student knowledge acquisition.

The best method for any level of education is to identify the student learning needs and to select the pedagogy(ies) and approach(es) which best suit that specific teaching and learning environment (Abrami et al., 2006). A selective, careful approach to developing curricular material, which incorporates aspects of both IT and PBL, will provide instructors with useful, accessible material for use in courses. Identifying student learning needs and then making IT and/or PBL accommodate the learning goals should ensure effective use of educational technologies.

1.4 Study Objective

Refocusing soil science education through innovative teaching methods can aid in increasing awareness about soil and the need for its conservation. Future natural resource managers and planners need access to engaging post-secondary education based on scientifically sound principles, and focused on the value of the ecosystem functions, to obtain sufficient knowledge to guide their future decisions in a sustainable direction.

Soil scientists are carrying out ongoing innovative research; meanwhile the student enrollment in soil science courses at post-secondary institutions across North America, and other parts of the world, has been declining during the past three decades. This signals a need for soil science curriculum reorganization and adoption of innovative teaching methods. We assume that creation of new educational resources, such as that which combines IT and collaborative case-based learning, is one possible approach to raise the appeal of discipline of soil science to students.

The objective of this study was to create the web-based teaching tool, which combined a PBL-style case study with a multimedia experience, to illustrate the impacts of three land uses on soil formation and quality. The hypothesis was that the tool would be an effective aid in teaching the impacts of land uses on soil formation and quality by generating student interest and appealing to multiple learning styles through rich media presentations. The tool was designed for the Sustainable Soil Management Course (AGRO 402/SOIL 502) at the University of British Columbia, Vancouver, Canada, which is an upper-level, elective course.

Based on a review of IT and collaborative teaching approaches, I rationalize that the teaching tool should be a combination of IT and PBL for it to be: (1) developed with learning objectives in mind, (2) flexible for alternative ways of teaching (e.g. online learning or face-to-face), (3) compatible with collaborative ways of learning, (4) appealing to multiple learning styles, and (5) adaptive to user feedback. The tool design was guided by the learning objectives and student learning needs. The tool must be flexible for alternative ways of teaching, because of the rapid rate with which technology and educational research are advancing. By thoroughly reviewing characteristics of IT and PBL for learning, and utilizing the best components of each, the tool has a greater probability of maintaining relevance as technology, educational and industry standards advance and change. By appealing to multiple learning styles, the tool can potentially engage more students in the content. An instructor can update the tool to extend its relevancy and life as new information is discovered. Such a tool would meet the discipline's educational needs because it relies on students utilizing prior content knowledge, and can teach various higher order and communication skills to meet societal and professional needs.

The long-term goal of this study is to promote development and use of innovative educational methods in soil science curriculum that will enhance the appeal of this discipline among university students. I believe that application of innovative approaches to soil science education will not only help to increase student enrollment but will also foster interest for the next generation of natural resource and soil scientists. In the long-term, this approach to education should lead to reduced soil degradation and establishment of sustainable soil management practices.

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2 DEVELOPMENT OF AN INNOVATIVE WEB-BASED TEACHING TOOL ILLUSTRATING LAND USE IMPACTS TO SOIL FORMATION AND QUALITY[*]

2.1 Introduction

Modernization of post-secondary soil science pedagogy and curriculum is essential in order to keep relevant with industry and global demands for graduates with solid content knowledge, higher order thinking skills, and collaborative working skills. Several universities (California Polytechnic State University, Cornell University, University of Marlyand, etc.) have addressed declining student enrollment by changing the soil science curriculum (Baveye et al., 2006; Collins, 2008; Jacobson et al., 2009), by creating new courses that focus on environmental issues (McCallister et al., 2005), or by creating interdisciplinary soil science programs (Hansen et al., 2007). Many soil scientists believe that the discipline should focus on creating more innovative curricula at all education levels to meet future demand for scientists with solid knowledge of soils (White, 1997; Landa, 2004; Baveye, et al. 2006; Wilding and Lin, 2006; Collins, 2008; Bouma, 2009). Because the discipline saw the decline of student enrollment (McCallister et al., 2005; Baveye et al., 2006), professional appointments (Letey, 1994), and funding grants (Mermut and Eswaran, 1997), some soil scientists have already been pressed to innovate to improve the relevancy of soil science to current environmental, resource, and socio-economic concerns.

Innovation in post-secondary soil science education and other sciences is challenged with the responsibility of covering core knowledge instruction and current global issues while meeting industry and societal employment demands for other skills. Due to industry demands, post-secondary science instruction has had to innovate to find ways to improve student skills in communication, critical thinking, and collaboration (Koppi et al., 1997; Smiles et al., 2000; Thompson et al., 2003; Amador and Gorres, 2004;

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[*] A version of this chapter will be submitted for publication. Strivelli, R.A., Krzic, M., Crowley, C, and Dyanatkar, S. Development of an Innovative Web-based Teaching Tool Illustrating Land Use Impacts to Soil Formation and Quality.

Kirschner, 2004). Case-based collaborative learning (and problem-based learning, PBL, as one of its methods) has been widely adopted by agricultural and natural resource educators since the early 1990s to build the skills of communication and group work while reinforcing relevant content knowledge (Arthur and Thompson, 1999; Amador and Gorres, 2004; Hmelo-Silver, 2004; Thien, et al., 2008). Information technology (IT) is another recent addition to post-secondary learning, which has been shown to help students build skills and to create motivating, authentic learning environments. In some instances IT can be used to reinforce learning by allowing for multiple viewing of content (Hoffman and Ritchie, 1997; Moore and Gerrard, 2002; Polsani, 2003), aid in the mental development of a cognitive model (Najjar, 1995), and to achieve effective instruction that addresses multiple learning styles (Jain and Getis, 2003).

By combining IT and case-based collaborative learning, the post-secondary instructor has the opportunity to utilize the advantages of both innovations in improving the educational experience for the student. This combination is particularly promising for development of examples/tools that provide students with authentic learning experiences through simulating real life and professional problem scenarios (Hoffman and Ritchie, 1997; Ward, 1998; Oliver and Omari, 1999; Naidu, 2003; Barak and Dori, 2004; Taradi et al., 2005). Both approaches are also shown to enhance student learning by creating a positive learning environment, through providing a more stimulating learning environment, and/or offering greater learner control over the process of learning (Koppi et al., 1997; Arts et al., 2002; Tal and Hochberg, 2003; Muller et al., 2008). Student motivation can also be enhanced, either through the opportunity for students to investigate solutions and guide their own learning using prior knowledge with PBL (Norman and Schmidt, 1992; Finucane et al., 1998) or by including varied multimedia into course content which presents multiple viewpoints for students to access information (Hoffman and Ritchie, 1997; Moore and Gerrard, 2002; Polsani, 2003; Cox and Su, 2004).

The benefits of combining IT and PBL into one teaching tool are that this tool could create greater appeal for the subject of soil science and could work with existing collaborative learning natural resources courses, which have been frequently utilized in soil science over the last two decades (Arthur and Thompson, 1999; Amador and Gorres, 2004; Hmelo-Silver, 2004; Thien, et al., 2008). A tool created with IT offers flexibility for the university instructor, by allowing the instructor to easily carry out updates and maintain weblinks to resources.

The objective of this study was to create and evaluate a web-based teaching tool, which combined a PBL-style case study with IT that illustrates the impacts of three land uses on soil formation and quality for students enrolled in the fourth year/graduate university course focused on application of the principles of sustainable soil management. The tool would be designed for those with some background in soils, preferably those having completed at least an introductory soil science course. The teaching tool should be a combination of IT and PBL for it to be: (1) developed with learning objectives in mind, (2) flexible for alternative ways of teaching (e.g. online learning or face-to-face), (3) compatible with collaborative ways of learning, (4) appealing to multiple learning styles, and (5) adaptive to user feedback. Such a tool would meet the discipline's educational needs because it relies on students utilizing prior content knowledge, and can teach various higher order and communication skills to meet societal and professional needs.

2.2 Methodology

The land use impacts (LUI) tool developed for this study consists of the following two components (1) a PBL-style case study that addresses evaluation of the impacts of three land-use practices on soil formation and quality in Pacific Spirit Park and University of British Columbia (UBC) Farm, Vancouver, British Columbia, and (2) a multimedia website, which includes streaming video, text, data, photographs, maps and weblinks. The tool was developed for the AGRO 402/SOIL 502 – Sustainable Soil Management course offered by the Faculty of Land and Food Systems (LFS) at the University of British Columbia (UBC) in Vancouver, Canada. The course typically enrolls approximately 30-40 undergraduate (third or fourth year) and graduate students from the Faculties of LFS, Forestry, Science, and Applied Sciences. The course emphasizes an interactive, collaborative case studies exploration, based on the PBL approach. The overall objective of this course is to teach students how to apply fundamental soil science principles in sustainable management of forested, agricultural, and urban (or constructed) ecosystems. During the course, each student works on three, four-week-long case studies in which each case is focused on either soil chemistry, soil physics, or soil biology.

Development of the LUI tool included a planning and conceptualization phase (September 2007 to April 2008), an implementation phase (May 2008 to April 2009), and an evaluation and refinement phase (April 2009 to Dec 2009). The project time line was in agreement with recommendations for educational IT design as outlined by Polsani (2003). The LUI tool was developed as a collaborative effort of a multidisciplinary team that included educators, scientists, and IT experts (Appendix I). The diversity of the LUI team is representative of the recommended collaborative approach needed for development of effective IT curriculum (Naidu, 2003; Polsani, 2003).

2.2.1 Problem Based Learning-Style Case Study

The LUI case study is one of several cases used in the AGRO 402 / SOIL 502 course and was designed to be a part of the soil chemistry section. By comparing soil data obtained in 1970 and 2005-2008, the case study emphasizes the message that soil quality can deteriorate rapidly and is rebuilt extremely slowly. For four weeks, students work in groups of 4-6 to address the learning outcomes of the study case (Table 2.1). Students are introduced to the LUI case study, and soil science principles relevant to the case, through a lecture given at the beginning of the week 1 and in the case specific weekly handouts. The handouts direct students how to utilize the LUI tool through weekly tasks, learning outcomes, and guiding questions (Appendix II). Students are also provided with the soils data (Appendix III). At the end of week 4, each group gives a 20-minute presentation to the whole class outlining their case's key points. During the week following the group presentation, each student then prepares a term paper in which he/she outlines his/her individual learning.

The overall design of the LUI tool case study was guided by seven learning principles for development of authentic web-based teaching material as outlined by Oliver and Herrington (2003) and Herrington (2006). Specific examples of how the LUI tool addresses these web-based learning goals are outlined in Table 2.2.

Study sites were selected based on their applicability to the case study learning outcomes. The following four criteria were identified for site selection: (1) sites needed to be located on the same soil type and in the same climatic region, (2) sites needed to be under different land-uses, which had been established long enough for soil to show the land-use effects (two decades more), (3) land-uses needed to be representative of different levels of site disturbance, and (4) data sets of a broad range of soil properties obtained over several decades are available for each site. Based on these criteria, three study sites were chosen in the Point Grey area (i.e., within the Pacific Spirit Park and UBC Farm) of Vancouver, British Columbia (49°15' N, 123°14' W).

Study sites were located within 5 km of each other in a humid, maritime region and all sites were located on Humo-Ferric Podzols. Sites were representative of the most typical land-uses in this area, namely, (1) one-time logging, (2) multiple logging events, and (3) forest clearing with ongoing agricultural cultivation. Sites were originally under Douglas-fir (*Pseudotsuga menziesii* Mirb.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), and western redcedar (*Thuja plicata* Donn ex D.Don) forest.

All three study sites were logged selectively in the late 1800s and experienced isolated and spotty forest fires. The second-growth forest study site which included a mix of Douglas-fir, western hemlock, and western red cedar was logged in the late nineteenth century and then allowed to regenerate naturally to its current state of second growth forest. This site experienced minimal development aside from the creation of trails and paths, and is currently part of the Pacific Spirit Regional Park (Metro Vancouver, 2009). By contrast, the alder study site has experienced several logging events, starting with the late 1800s and followed by logging and stump removal in the 1920s and late 1940s for housing development that never occurred. After each logging, alder (*Alnus rubra* Bong.) established on the site, and today is the dominant tree species at this site. The cultivated study site was selectively logged in the 1880s, allowed to regenerate, and in 1966 cleared for the establishment of agricultural experimental fields. Since then, the site has been seeded/planted with a range of annual and perennial crops, limed, manured, and fertilized.

The study sites were first sampled in 1970 by Lavkulich and Rowles (1971), who conducted the initial study on the impacts of land-use practices on soil development in this area, and sampled again in 2005 with additional sampling in 2008 for several soil properties that were not determined in 2005. At each site, a soil pit was excavated, and each soil profile was described in detail by identifying the soil horizons and recording horizon thickness, soil color, texture, and structure. Samples were collected from each soil horizon and analyzed for 25 properties using the standard analytical soil methods (Appendix III). Soil properties included into the case study data set included color, texture, structure, pH (in $CaCl_2$ and H_2O), total C, total N, C/N ratio, total P, available P, total concentration of Ca, Mg, K, Na, Cu, Mn, Ni, Zn, Fe, Al, cation exchange capacity (CEC), and exchangeable Ca, Mg, K, and Na.

2.2.2 Multimedia Material

In addition to the PBL-style case study, the LUI tool also includes a website that incorporates a variety of multimedia material such as streaming video, text, soil data, current and archival photographs of study sites, and geological and geographical maps of the study area.

During the planning phase of this project, we conducted extensive Internet surveys of existing open-access teaching resources focused on natural resources which were developed for either post-secondary education or the popularization of science (e.g., National Geographic, Discovery Education, Smithsonian's Dig It! exhibit). We also consulted with numerous IT professionals with expertise in web design, interactive media, and distance education. Initially, the team considered making the tool interactive with Web 2.0 features that allow for user-generated content. Upon further review, these features were not included since it was important to maintain the integrity of the website's content. We also decided not to include online facilities for collaborative group work since students enrolled into the course for which the tool was developed already have access to WebCT (Blackboard Inc., Washington, DC), which allows for asynchronous online collaboration and discussion.

Video production was completed during June-July 2008. The videos were filmed using a Canon HDV camera (Canon XH-A1), using high grade mini DV tapes, a boom mike, and when necessary, a screen to reflect light. The filming crew consisted of the host/narrator, a site-specific content expert, the course instructor, a director, and a videographer. After filming, a rough edit was created by compressing and editing the material for visual and audio flow using Final Cut Pro editing software application (Final Cut Studio, Apple Inc., Cupertino, CA). The rough edit was further refined to insure that it was aligned with the case study learning objectives.

Video design was modelled after the virtual field trip, which allows students to 'travel' to a specific site by viewing video, photo images, and text included into the LUI tool on their own time. Virtual field trips provide temporal and spatial flexibility, information accessibility for students, instructor control over content and features, and reusability (Hurst, 1998;Tuthill and Klemm, 2002; Ramasundaram et al., 2005).

During video production, we took numerous photographs of the sites, and additional photo images were obtained from online collections of the UBC Archives (http://digitalcollections.library.ubc.ca/ubchistory.html) and UBC Farm (http://www.landfood.ubc.ca/ubcfarm/). Several maps, which show topography, soil types, and surficial parent material of the area, were obtained from the UBC Geography Library. The maps (measuring about 1 m by 0.5 m) were scanned in sections and transferred into pdf format. The separate pdf files were pieced together in Adobe Photoshop (Adobe Systems Inc., San Jose, CA) and pdf files of the complete maps were included in the LUI tool website.

The website was developed using Joomla!® (Open Source Matters, Inc., New York, NY), an open source content management system. This user-friendly system allows the course instructors to update or alter content with ease. The team identified seven principles (Table 2.2) for designing the LUI tool using prior knowledge and reviewing best practices for creating web-based learning environments that foster authentic knowledge construction (Oliver and Herrington, 2003; Herrington, 2006).

2.2.3 Feedback Compilation

Land Use Impacts tool evaluation was undertaken to assess if the tool was effective in allowing students to meet the learning objectives of the case study on illustrating the impacts of land-uses on soil formation and quality The evaluation was completed by a review team composed of current students enrolled in the AGRO 402/SOIL 502 course who used the tool and students who took the course in previous years. Review team members expressed agreement to participate in the evaluation by signing a consent form which explained the purpose of the evaluation and future uses of the data gathered (Appendix IV) and satisfied the UBC behavioural ethics requirements for studies involving human subjects (Appendix V). Former students on the review team, who did not use the tool as part of a formal course, were asked to review the website and case study learning objectives on their own time. All feedback participants completed the online form that was posted on the LUI tool website.

The feedback form (Appendix VI) was modelled after design-based research principles (Barab and Squire, 2004; Sandoval and Bell, 2004; Wang and Hannafin, 2005). To comply with design-based research procedures, a description of the tool, its learning outcomes, and the overall objective for this study were included in the feedback form. Design-based research involves complete disclosure of study intentions to study participants, which allows for participants to be fully informed for their evaluation of the tool and allows researchers the ability to study the effects of the innovative learning experiment in the actual classroom where learning is occurring (Sandoval and Bell, 2004). The form included 10 quantitative questions and 4 open-ended questions, with each quantitative question designed to assess the degree to which various case study learning outcomes were met. Students evaluated the quantitative questions on a Likert 5-point scale, where 1= strongly agree, 2= mildly agree, 3= neutral, 4=mildly disagree, and 5=strongly disagree.

In addition to the online feedback form, one-on-one, 15 minute interviews were conducted with student members of the review team who took the course at the time of the LUI tool implementation. This allowed us to obtain additional information about student impressions (Appendix VII). Student feedback was compiled, analyzed, and shared with all LUI tool team members for refinement discussions. Statements which had lower agreements were reviewed for potential improvement, as were areas of concern raised by the open-ended questions on the form and the one-on-one interviews.

2.3 Land Use Impacts Tool Application

Because the tool combines a PBL-style case study and IT multimedia content, its design and evaluation reflect this dynamic. The two components were assessed as a whole for fulfillment of study objectives by examining the feedback forms, student interviews, and application of the design principles for authentic web-based learning (Table 2.2).

2.3.1 Organizational Structure of the LUI Tool

The LUI tool can be found at http://soilweb.landfood.ubc.ca/luitool/. A diagram of the website layout is shown in Fig 2.1, while quantity of accompanying multimedia per website pages is shown in Table 2.3. The LUI tool was developed to educate university students on the topics of land use impacts on soil formation and quality in an engaging manner. Consequently, multimedia was combined with a learning management system (website) and designed with awareness of prior student knowledge and learning needs to provide them with multiple avenues to achieve learning outcomes of the case study.

The LUI tool homepage opens with a rotating photo slide-show of the study sites and introductory paragraph to orient students to the website. The homepage slide-show contains a selection of photographs that illustrate study sites and accompanying captions or questions that refer to interesting facts about soils in general and the study sites. The aim of the slide-show is to capture students' interest at the very beginning of website exploration. An additional benefit of the slide-show was that it was embedded into the text so that images can be viewed in place, and students did not have to leave the web page (Jacobson et al., 2009).

The website has two menu bars to maintain a simple layout design: a navigational menu on the top of the page with logistical links and the content menu on the left-hand side. Both menus are visible at all times when exploring the site, to allow non-linear, viewer-directed site navigation. The navigational menu includes links to pages that (1) introduce the tool, (2) introduce the LUI tool team members, (3) outline the project's credits, (4) provide contact information, and (5) direct students to information about further learning opportunities and examples of some initiatives that support sustainable soil management. The content menu provides links to the pages that (1) outline the concept of soil formation, which is one of the two key concepts for the case study, (2) describe the most dominant soil type (i.e., Podzol) on the study sites, (3) outline the second key concept of the case - soil quality, (4) present detailed description of each study site, and (5) provide other land use examples for further exploration. An additional feature shown on the homepage is a separate password-protected link where students who are registered in the AGRO 402/SOIL 502 course can find case study handouts, data sets, and required references.

Each study site has an individual page assigned to it with two to three streaming videos, text, and photos that highlight the unique features of that particular site. The videos were sectioned into 5-7 minute clips covering the representative vegetation, soil types, and topographical features of the site. All videos were organized in a similar way, in which the content expert provided information on the soil and site description, management history, and current land-use practices. Each video closes with a question directed to students, regarding future soil management choices for that particular site. This was representative of a typical, real world site assessment that accompanies soil description and identification, simulating for students the experience of an actual field trip. As Cox and Su (2004) have pointed out, for virtual field trips to be effective, they need to mimic closely the experiences that students would have if they were taken on a real field trip. To further enrich student learning, different content experts were featured for each study site. At the same time, the host/narrator remained the same for all videos to warrant continuity of material covered among different videos. The experts were selected to represent varied age range, gender, and professions (i.e., forest ecologist, soil scientist, farm manager, and geologist), thereby illustrating the diversity of professionals that rely on soil science principles for their work.

The text on each of the study site pages provides additional reinforcement of the information covered by the content expert in each video. Whenever possible, an attempt was made to provide links to other web-based information to enhance student learning. The concepts of complexity and interconnectivity among past and present land-use practices and soil formation and soil quality are developed by introducing some of the same issues at each study site.

Separate web pages were designated for two key concepts of the LUI tool case study - soil formation and soil quality. Students need to gain an understanding of these two concepts to be able to properly address learning outcomes no. 1 and 4 in the study case (Table 2.1). To ensure that students have enough of background information on soil formation and quality, descriptions of both concepts, numerous links to other web-based information, and pdf files of several key references were provided on the LUI tool website. The concept of soil quality was developed to identify soil indicators that describe the soil's ability to properly function in a variety of roles (Doran, 2002). Key components of soil quality are enhanced biological productivity, environmental quality, and human and animal health. Students in the AGRO 402 / SOIL 502 course were asked to identify soil quality indicators and include them in a comprehensive framework that was then used to assess if the specific land-use was diminishing or enhancing soil quality. This task mimics a real world task, which a land manager would conduct during a site evaluation for a specific land use. This is in agreement with one of the principles for authentic web-based learning as outlined by Herrington (2006) that learning should reflect actual knowledge application in the context of real world experience.

The final structure of the LUI tool's website was quite involved because of the inclusion of multiple web pages, streaming videos, study site maps, slide-shows, and photographs. As several studies have pointed out, this complex (i.e., non-linear) organization of websites invited exploration, encouraged novel idea association, and enhanced student learning (Klemm and Tuthill, 2003; Jacobson et al., 2009). Furthermore, each web page contains a variety of photographs, maps, and other visual content, as this has been shown to aid in maintaining student interest in using web-based teaching tools (Cox and Su, 2004). As Table 2.3 shows, visual resources tend to be fairly evenly distributed among the web pages, as has been indicated by Jacobson et al. (2009) to better sustains users' interest.

2.3.2 Tool Evaluation

The review team completed a survey to evaluate the LUI tool for overall effectiveness in conveying concepts, appealing content, effectiveness for group work, structure, and accessibility. Out of the 12 students who used the LUI tool in term 2 of the 2008/09 academic year, eight responded to the online student feedback, giving a 67% completion rate. Five former students reviewed the LUI tool and completed surveys. Six students (50%) participated in one-on-one interviews about the tool (Appendix VII) to address issues which the survey might not have addressed. Although the number of the review team was small, it does represent 30% of the students enrolled in the class use the tool The number of review team members was further restricted by the PBL requirements to keep student groups small (i.e., between 3-7 per group).

Four feedback questions from the survey(Table 2.4) were designed to determine the LUI tool's ability to convey case study concepts. All reviewers included in the survey agreed (either mildly or strongly) that the tool was effective at presenting the case concepts, indicating that the students considered the LUI tool to be pedagogically sound. Students' confidence in the web-based learning pedagogy is crucial, as evidenced by a medical education review of 76 web-based learning studies, from a total 206 surveyed found in Medline or ERIC databases published between 1992 and 2001 . Their review showed that found that sound pedagogy is more important to student satisfaction than use of a particular type of technology or method of instruction (Chumley-Jones et al., 2002). A study carried out by Barak and Dori (2004) on project-based learning in an IT environment for undergraduate chemistry courses (Israel Institute of Technology) showed that students (95 out of 215 total), who used the IT-integrated PBL, scored higher and performed better than those students (120/215) who completed coursework by solving problems in the traditional way. The LUI tool's ability to convey concepts relates to findings of a meta-analysis of several studies of the effectiveness of multimedia in aiding knowledge acquisition, which showed that when multimedia is connected and designed to develop a cognitive framework, it was effective at promoting student learning (Najjar, 1995). The multimedia included in the LUI tool was selected on the basis of being connected to other media in the LUI and reflexive of the LUI learning goals. For this reason, we believe that the tool is supportive of student development of a cognitive framework.

One of the primary goals for the development of the LUI tool was to facilitate student excitement for learning about soil quality and formation by presenting a wealth of information through a variety of media. It was hypothesized that students would find the LUI tool appealing, because the current generation of students has a strong interest in IT and have expressed preference towards IT-enhanced curriculum (Oliver and Omari, 1999; Sanders and Shetlar, 2001; Chumley-Jones et al., 2002; Amador and Gorres, 2004; Taradi et al., 2005). Three statements in the feedback form were designed to assess if the multimedia inclusion enhanced the appeal of the LUI tool by catering to differing learning styles (Table 2.4). Feedback shows that the varied media did facilitate student motivation and excitement for learning about land use impacts on soil formation and quality. Eleven reviewers (85%) agreed (strongly or mildly) that the visual resources (opening slide-show, photos, maps, streaming videos) added to the appeal of the subject. Twelve (92%) agreed with a statement that the web links, supplementary material, and other included information added to the tool's appeal. Oh and Lim (2005) suggested that IT-enhanced coursework with multiple options for information retrieval (e.g.,face-to-face, paper, or computer screen) would appeal to students because they prefer to have access to information in a form that suits their learning preference. The LUI tool, with its streaming videos, text, maps, slide-shows, and pdf reference files provides multiple options for students to interact with the information to suit their preferred learning styles. A similar teaching tool, the Chinampa virtual field tour was piloted in an undergraduate “Introduction to Soil Science” course (15 students) and a sophomore sustainable land use seminar (4 students) at Cornell University in 2005 by Jacobson et al. (2009). Their tool showed similar satisfactory results, that the had positive attitudes towards the virtual field tour and found the virtual field tour media more engaging than reading an article or textbook (Jacobson et al., 2009).

One aspect of IT-enhanced coursework which does not receive positive feedback from students is reading text from a computer screen. As shown in a study by Oh and Lim (2005) in which 73% of 104 students surveyed at the University of Tennessee noted preferring reading text on paper to a computer screen. Their survey also showed that 45% prefer learning in which they take notes while listening to a lecture and 36% prefer learning in which they listen to a lecture, read material, and take notes simultaneously.

Based on the responses to the open-ended feedback questions, we discovered that 5 (42%) reviewers found the videos to be the most useful component of the LUI tool (Appendix VIII). “The videos were great; we need more of them [in courses],” said one student in the interviews. In contrast, 3 reviewers (25%) categorized the videos as the least useful part of the tool. About half of reviewers surveyed commented to some degree about the need to adjust the videos for ease of information retrieval/reviewing, content redundancy, or length. Based on the responses obtained during the one-to-one interviews, 4 out of 6 respondents felt that the videos were beneficial, and 3 of those reviewers expressed that the videos require some type of accompanying outline to provide the maximum help in the learning process.

The LUI case study was anticipated to be well received by the reviewers because it had many of the same characteristics as noted by Arthur and Thompson (1999) for being successful for a case study work. The LUI case study has an (1) undetermined outcome, (2) specific focus, (3) complex content, and (4) representation of multiple stakeholders' interests. For example, the successful representation of multiple stakeholders was confirmed by student responses, where 11 reviewers (85%) agreed that variety of experts made the LUI tool interesting.

One question in the feedback form evaluated the effectiveness of the LUI tool to better stimulate group work relative to other cases in the course. Three reviewers strongly agreed that the tool enhanced group work, 4 mildly agreed and while the other 6 were neutral. In a study by Arthur and Thompson (1999) similar moderate approval ratings were obtained from students regarding guidance provided in the PBL case (with a average rating of 3.6 on a 5-point scale, where 5=strongly agree and 1=strongly disagree). It is common that students may not have a choice over their group members, and certainly student opinions about the specific group that they worked with could impact their approval ratings for this question. In the future, we intend to ask students to assess the LUI tool's ability to stimulate group work without reference to other cases' ability and to survey the students via open-ended questions or interviews regarding their assessment of the LUI tool to meet this goal. This type of assessment for group work effectiveness can aid in guiding future improvements of the LUI tool. A limitation of this question for reviewers who took the course in previous years, was that the reviewers only had their own memories of past cases to refer to, while the 8 current students had immediate experiences to relate the LUI case study to.

One question in the feedback form addressed the tool's information organization by having students rate their agreement with the statement: “The structure of the tool facilitates my understanding of soil science concepts.” Six reviewers (46%) strongly agreed with the statement and 6 (46%) mildly agreed, indicating that all reviewers were generally satisfied with the LUI tool website structure. Based on our results, the reviewers did not the tool to be acting as an impediment to their learning process which would have been counterproductive.

Accessibility is paramount to success in creating an effective web-based teaching tool. Accessing videos in a timely manner is a key factor for maintaining student interest and satisfaction, as slow download of videos or website components has been noted as an annoyance and learning deterrent in several other studies (Chumley-Jones et al., 2002; Choi, 2003). The LUI tool videos are viewed by streaming off the Internet, which only takes around 5-10 seconds to be buffered for viewing. For all reviewers, with one exception, this format seemed to be satisfactory, because they did not report any problems regarding video accessibility. For the one exception, it was revealed during the one-on-one interview, that this reviewers was using an Internet browser version that was two versions prior to the current released version (i.e., using Internet Explorer 6.0, as opposed to Internet Explorer 8.0). The team concluded that the outdated browser version was responsible for the video delay.

All text provided on the LUI toll website could be printed as a pdf document. This alternative provides options for those students who do not enjoy reading text on a computer screen. It has been reported by Oh and Lim (2005) that 76% of students (72) surveyed preferred reading text on paper rather than from a screen.

There was no negative feedback about web accessibility or dead weblinks, which was reassuring, since this factor has been shown to be a problem in other studies. In one web-based learning study with Oliver and Omari (2001), students at Edith Cowan University, Australia were directed to a series of weblinks to find the majority of information that they needed to complete their learning objectives. Oliver and Omari found that only 46% of their first-year students (110) found the technology to be reasonably supportive of the learning process (based on a five point scale with 5 being the highest support, 3 being what was reasonably expected, 1 being the lowest support). While the LUI tool does contain weblinks on the site, the weblinks are predominantly supplemental in nature, with the core information provided on the LUI tool website and not hosted elsewhere. In this way, the LUI team ensured that the students have all necessary information to support their learning.

2.3.4 Land-Use Impact Tool Refinements

The final phase in LUI tool development was the incorporation of the feedback to improve the tool components that were deemed lacking or ineffective. These actions are planned to be completed during the winter of 2009/10. The tool design is that it is adaptive and allows for ease of updating and improvements.

Three reviewers noted the difficulty with having “long” videos and seeking out specific information from the videos to use later in their group presentation and/or term paper preparation. Based on feedback received, the LUI tool, though appealing in terms of visual and video content, needed refinement in content presentation. The students who provided negative feedback regarding the video length or navigation did suggest that supplying accompanying notes/outline to use as a note-taking device while watching the videos would be an asset. This was in agreement with a study of 74 undergraduate psychology students carried out at Northwest Missouri State University by Barnett (2003) who noted that inclusion of outlines or skeletal notes (as opposed to the instructor providing complete notes) increased student test performance. This was also supported by findings of a study by Sanders and Shetlar (2001) at Georgia Southern University of undergraduate biology students. Seventy two percent of students in that study downloaded course outlines for note-taking in class and 28% noted that the outlines helped them to focus on the material. The LUI team will create pdf files containing these outlines to accompany each video. In order to facilitate active student learning, we are going to create outlines, as opposed to full video scripts (as requested by one reviewer that we have interviewed).

Some of the reviewers noted in the interviews that the LUI text was similar in style to textbooks and therefore was not appropriate as web reading. In order to effectively communicate the relevant scientific information, yet retain the short reading attention span that often accompanies reading on the web, the LUI team is reviewing and editing the LUI tool text and trying to format the information to be more accessible for the web-reader. We are refining the text to delete superfluous adjectives and lengthy descriptions. Wherever possible, the text will be organized into bulleted lists and simplified. In this way, the same information will be presented, but in a more concise fashion.

Additionally, a few students in the interview noted that the homepage was not overly engaging or interesting. As Hodges (2004) pointed out the beginning of a lesson is the best time to grab a student's attention and in turn to motivate them to learn. To improve the homepage and to assure students' attention at the beginning of the case study, we revised the slide-show captions. Questions used in the slide-show were designed to encourage students to access prior knowledge to either (1) derive an answer or (2) predict the answer for the question. In addition, we also incorporated “Did You Know?” facts in an additional rotating textbox below the content menu, on all web pages, except for the homepage. By adding these intriguing facts about soil and plants in the “Did You Know?” textbox, we hope to generate student interest in soil.

The hope is that the LUI tool will spark student long-term interest in soil conservation. To inform students about some on-going initiatives carried out around the world regarding soil conservation and sustainable management practices we created tjhe web page “ Learn More!” that outlines several links to various scientific and professional societies, soil science programs at post-secondary institutions, and ideas for promoting soil conservation through the changing of personal behaviors. By providing links to these societies and ideas for actions, the tool allows for an engaged student to continue exploring levels of participation with the subject, and to find opportunities for extra-curricular learning. As students learn more about soil quality, they may be motivated to take action to participate in soil conservation. This is supported in the literature, which shows that public engagement in resource management decision making is crucial (Sims and Sinclair, 2008). Sustainable soil management education should then inform students, to some degree, about becoming active and engaged with resource management decision making.

Only two students mentioned in the interviews that they had visited the links provided at the “Learn More” page, which signalled that appeal of this page needs to be improved. The changes are planned to occur include: (1) change of the title to “Get Soil Savvy”, (2) addition of more links and (3) more recommended actions to personally contribute to promote soil conservation, and several photographs that will illustrate these actions. A link is also provided to a short podcast created by a former AGRO 402/SOIL 502 soil science student, describing her appreciation for soil.

The LUI case study was developed specifically for the AGRO 402/SOIL 502 course, and we hope that the tool will serve as a model for incorporating IT into other post-secondary courses that deal with management impacts on natural resources. When completing the feedback form, several students noted that the tool could be also utilized in several other natural resource courses offered by the Faculties of Forestry, Science, Land and Food Systems, or Applied Science.

2.4 Conclusions

Over the past few decades, post-secondary education has experienced increased incorporation of many new technologies and approaches into the curriculum. Two of these approaches, IT and PBL-style learning, were combined in this study to create an innovative, engaging teaching tool for an upper-level post-secondary soil management course. In developing the LUI tool we tried to maximize the advantages of each of the two components- IT's flexibility and adaptability and PBL's capability to foster an authentic learning environment, application of core concepts, and collaborative work. At the same time, we tried to avoid the inherent limitations of these two components, namely IT's tendency to promote passive learning or feelings of isolation and PBL's potential lack of structure, or sufficient resources, and tendency to overwhelm participants.

While the tool development process was time-consuming and intensive, the student feedback showed that the tool was effective at engaging students. The tool design and structure have been found appropriate for an upper level university course. The LUI tool successfully addressed, to some degree, all of the design principles for effective IT teaching tools. The tool successfully conveyed the learning objectives and feedback shows that the use of multimedia (videos, images, and text) was appealing to the students. The review process for the tool identified several refinements that will be completed by March 2010 to maximize the usefulness of the technology and to better meet student learning needs. By combining IT and PBL-style case study, the LUI tool was able to engage students with the subject matter. Students appreciated the opportunity to explore material included in the LUI tool and the multitude of topics that ranged from soil formation, description and identification, and quality, to arrive at deeper understanding of sustainable soil management practices. By exposing students to complex questions without definite answers, promoting intellectual inquiry and analysis, stimulating critical thinking, and encouraging the application of knowledge to complex issues, the LUI tool provides a teaching resource for upper level, post-secondary natural resource courses.

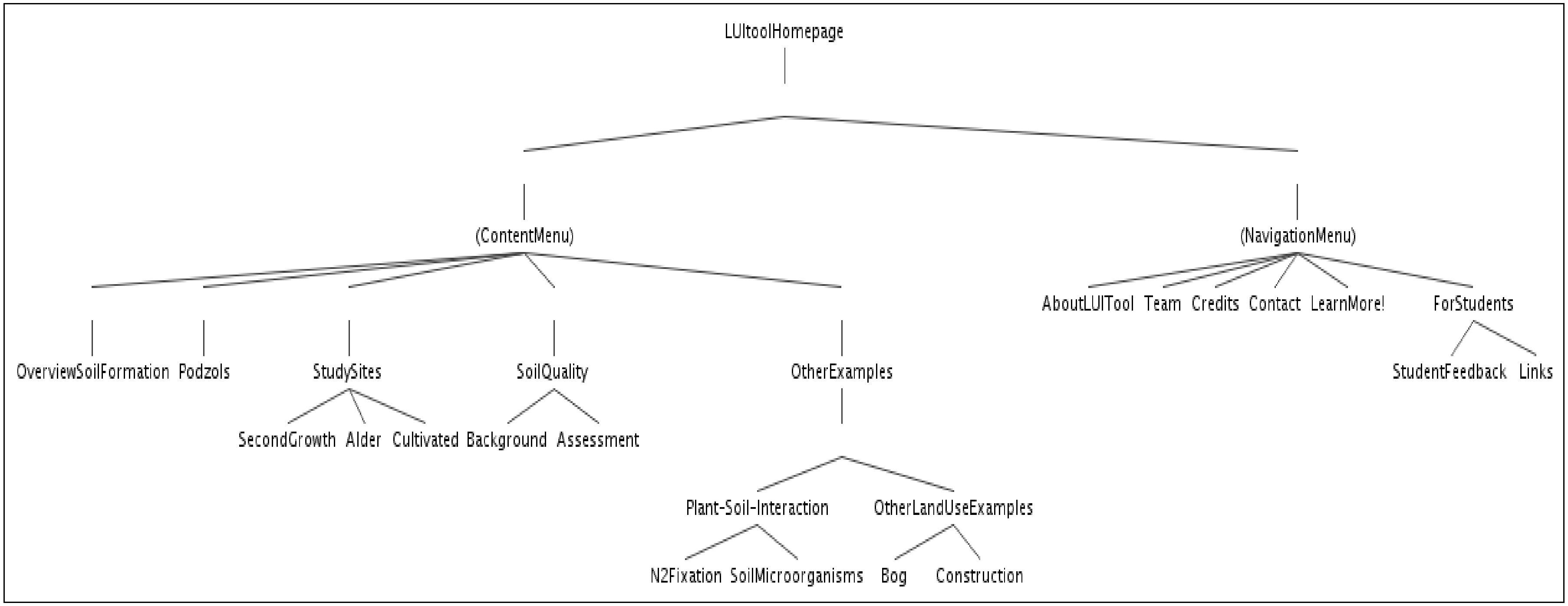

Fig. 2.1. Schematic organization of Land Use Impacts (LUI) tool website

Table 2.1. The four-week time line of the Land Use Impacts (LUI) case study

Week	Learning outcome	Student task
1	No.1 - Gain basic understanding about soil formation factors and processes, focusing on the most common soil type (Podzol) on Pacific Spirit Park and UBC Farm	a) Become familiar with the LUI tool. b) Review background information on soil formation, processes, and classification, focusing on the Podzolic soil order. c) Share individual learning with group members (ongoing for weeks 1-4)
2	No.2 - Evaluate the extent of management impacts on soil properties under three land-uses and over 35 years.	a) Review the soil properties given in the data set regarding the three study sites and ensure comprehension of processes and inter-relation of processes. b) Review background information on management practices carried out on the study sites. c) Gain basic understanding of soil quality concept.
3	No.3 - Evaluate to what degree human impacts are changing natural soil processes and argue for/against the designation of a sixth factor of soil formation. No.4 – Identify soil quality indicators that could be used to monitor the sustainability of the management practices at the Pacific Spirit Park and UBC Farm.	a) Review background information on metapedogenesis concept. b) Develop a soil quality framework for three land-uses on Pacific Spirit Park and UBC Farm.
4	-	a) Student group presentations about key findings.

Table 2.2. Examples of how the Land Use Impacts (LUI) tool addressed authentic web-based learning environment principles as developed by Herrington (2006)

Principle	LUI tool application
Learning reflects actual knowledge application in the context of the real world experience.	Students are provided with several guiding questions to use in assessing the impacts of land uses on soil quality without being instructed that there is one correct answer.
Student tasks are authentic (engaging, complex, and involve multiple steps for completion)	Students are given data and background information, and are to derive their conclusions and present these to the class as if the class is group of stakeholders in this land review process.
Students can access expert perspectives which serve as a resource and as models for problem-solving in the field	Expert perspectives are provided via course instructors and in LUI tool videos.
Knowledge construction occurs collaboratively	Case study is completed as a group project during which each student is responsible for finding answers to a specific topic. Students share their learning within the group, and then with the rest of the class.
Sufficient resources are included to allow students to access the information from multiple perspectives and which provide scaffolding of the material	Students are able to obtain the information from the viewpoints of multiple experts. They are asked to use varied types of media included in the LUI tool. Students are also directed to external sources of information such as book chapters, scientific manuscripts, and other web-based material.
Students are given sufficient time to present and articulate knowledge	Students have 3 weeks to analyze information before their 20-minute group presentation. This is followed by one additional week of preparation of individual report in which each student presents his/her own learning.
Learning process includes reflection time.	Students are given feedback for group presentations and individual term papers.

Table 2.3: Media type and quantity for Land Use Impacts tool website.

Page Placement	Page Name	Media Type and Quantity					
		Pages of Text/handouts	Images	Maps	Weblinks	Videos	Graphs/Tables
Homepage	-	1	13	-	18	-	-
Content Menu	Overview of Soil Formation	1	1	-	5	-	-
	Podzols	2	2	1	11	-	1
	Study Sites	2	3	6	2	-	-
	Soil Quality	1	1	-	-	-	-
	-Background	1	1	-	-	-	-
	-Assessment	1	1	-	-	-	1
	-Second Growth	1	5	-	-	2	-
	-Alder	1	8	-	-	2	-
	-Cultivated	1	8	-	-	2	-
	Other Examples	1	2	-	2	-	-
	-Bog	1	-	-	-	1	-
	-Construction	1	-	-	-	1	-
Navigation Menu	About	1	1	-	-	-	-
	Team	1	8	-	-	-	-
	Credits	0	1	-	2	-	-
	Contact	0	1	-	-	-	-
	Learn More!	1	1	-	4	-	-
	For Students	4	1	-	6	-	1

Table 2.4. Feedback responses, grouped by assessment topic

Statement Focus	Number of respondents that chose* [n=13]:		
Case study learning objectives	**Strongly agree**	**Mildly agree**	**Neutral**
The tool was effective at presenting the impacts of land uses on soil quality	9	4	0
It was effective at presenting the impacts of land uses on soil formation.	8	5	0
The tool was helpful in facilitating my understanding of soil science concepts	10	3	0
The structure of the tool facilitates my understanding of soil science concepts	6	6	1
Enhancing topic appeal by catering to different learning styles			
The use of extensive visuals elements enhanced the appeal of the subject.	11	2	0
The use of multiple narrators enhanced the appeal of the topic.	11	1	1
The incorporation of weblinks, review material, and supplementary information enhanced the appeal of this subject.	12	1	0
Overall appeal of tool			
The tool stimulated my interest in this subject.	9	4	0
The presentation of soil science concepts had a lasting/emotional impact on me.	5	4	4
Effectiveness for group work compared to other cases			
The structure or organization of the tool aided in making the group work and participation in this case study more efficient than other case studies used in the AGRO 402/SOIL 502 course.	3	4	6
Structure/Organization of the tool was beneficial			
The structure of the tool facilitates my understanding of soil science concepts	6	6	1
The structure or organization of the tool aided in making the group work and participation in this case study more efficient than other case studies used in the AGRO 402/SOIL 502 course.	3	4	6

*Note: The feedback forms also included the options “strongly disagree” and “mildly disagree,” however, no respondent chose either option for any of the questions. Consequently, those two response options are not presented in this table.

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3 GENERAL CONCLUSIONS

3.1 Synthesis of Study Findings

A renaissance of soil science is approaching, as the discipline receives growing attention from the media and research communities. The growing interest in the discipline comes from an acknowledgement that soil science is needed to guide future solutions to current problems of food shortages and climate change. To insure that we have the educated land scientists to meet this need, new information and new ways of communicating information are needed (Hartemink and McBratney, 2008). Educational research and IT offer numerous potential approaches to innovating soil science education at the university level.

The LUI tool was designed as a web-based, PBL-style teaching tool which would engage upper level undergraduate as well as graduate students in learning about land use impacts to soil formation and quality. The tool combined PBL and IT to (1) accommodate different learning styles, (2) be compatible with collaborative learning, and (3) be adaptive to user feedback. Although IT-enhanced curriculum is being heavily adopted at the post-secondary level, students still desire face-to-face learning. The LUI tool was developed to provide a flexible teaching resource that could be used with face-to-face and online learning that would also allow for user-friendly instructor updates.

An interdisciplinary team took two years to develop and refine the tool. The LUI tool design combined multimedia with a learning management system (website) and can be found at http://soilweb.landfood.ubc.ca/luitool/. The design was guided by the awareness of prior student knowledge and learning needs and we attempted to provide in the tool multiple avenues to access the information needed to fulfill of the case study learning objectives.

The final structure of the LUI tool's website included multiple web pages, streaming videos, study site maps, slide-shows, and photographs. The LUI tool homepage opens with a rotating photo slide-show with interesting facts or questions and introductory paragraph to interest student and orient them to the website. The website has pages on the study case concepts, detailed descriptions of each study site, logistical information, and links to information about further learning opportunities, with a separate password-protected link where students who are registered in the AGRO 402/SOIL 502 course can find case study handouts, data sets, and required references. Each study site has an individual page assigned to it with two to three streaming videos, text, and photos that highlight the unique features of that particular site. All videos were organized in a similar way, in which the content expert provided information on the soil and site description, management history, and current land-use practices. The text on each of the study site pages provides additional reinforcement of the information covered by the content expert in each video. Furthermore, each web page contains a variety of photographs, maps, and other visual content, as this has been shown to aid in maintaining student interest in using web-based teaching tools (Cox and Su, 2004). As several studies have pointed out, this complex (i.e., non-linear) website organization invites exploration, encouraged novel idea association, and enhanced student learning (Tuthill and Klemm, 2002; Jacobson et al., 2009).

Thirteen reviewers evaluated the LUI-tool for its effectiveness at addressing case study concepts and learning outcomes, accessibility, appeal, and ability to stimulate (encourage) group work. The tool was evaluated by analyzing reviewer responses to an online feedback form with 10 multiple choice and 4 open-ended questions, and one-on-one student interviews. From feedback, 13 (100%) of the respondents agreed (either mildly or strongly) that the tool was effective at presenting the case concepts, indicating that it was pedagogically useful. Eleven reviewers (85%) agreed (strongly or mildly) that the multimedia resources (images, maps, streaming videos) added to the appeal of the subject. The web links, supplementary material, and other included information added to the tool's appeal, as well, according to 12 (92%) of the reviewers. Analysis of the open-ended feedback indicated that 5 of reviewers noted that the videos were the most useful component of the LUI tool. Seven of students felt that the tool was more effective than other course case studies for group work. In terms of the tool's structure, reviewers responded with 6 strongly agreeing and 6 mildly agreeing that the structure facilitates understanding of soil science concepts. Tool accessibility was also reviewed and for all surveyed students, with one exception, the tool format was satisfactory and students did not report any problems regarding video or web accessibility. The feedback obtained to date has been positive, and these data will be continue to be collected in future years to further refine the tool if necessary and to develop a cohesive evaluation of the tool's efficacy.

From the feedback, I conclude that the LUI tool was effective at conveying content knowledge. Inclusion of varied media were successful for adding to the appeal of the tool and were presented in a user friendly manner. The tool is likely to appeal to multiple learning styles, as there is a variety of media presented and different means of accessing the case study information. To learn about the study sites, students can (1) watch videos that provide a 'tour' of the sites, (2) read the information online or print articles and web text to read the information on paper, (3) analyze maps and images, (4) analyze soil properties, and (5) discuss findings with their group members. By including several different means to access information, we increased the chances that a student will be using at least one learning style that he prefers to achieve knowledge.

3.2 Advantages and Limitations of the LUI Tool

3.2.1 Advantages of the LUI Tool

The variety of media presented in the LUI tool allows students to individualize their learning experience. For example, students who prefer reading text on paper to reading from a computer screen can download and print pdf documents of the online text. Students who prefer using visual media to absorb knowledge may watch the videos repeatedly, analyze the maps, and only briefly skim the text. Students who like to review lots of related, yet nonessential topics in order to understand an issue holistically have optional weblinks and extra videos to view .

The LUI tool is designed to foster a sense of exploring and discovery, which would in turn create a sense of excitement in learning for students and would foster foster active learning. The study site videos were designed as if they were stops on a field trip, so that students may listen and follow along with the 'field trip host.' After watching the videos, to satisfy their curiosity, students can review maps, background geology, weblinks, and related videos (e.g., Camosun bog, construction site) to further explore the sites.

The LUI tool is innovative in that it integrates soil science research into undergraduate teaching. It also and could serve the university by being a source of information for the UBC Vancouver Campus Plan Steering Committee and UBC Sustainability Committee about short- and long-term effects of several land management practices carried out in this area.

The LUI tool addresses and prevents some of the inherent limitations of PBL. The LUI tool provides structure and presents the information in an organized fashion to help students to orient themselves with the information. This can aid to prevent the sense of chaos and confusion that some student feel when working through a PBL case. Another aspect of the LUI tool that counteracts PBL limitations is that the students are told and the website states, that all necessary information needed to come up with a solution is included in the tool. This may be comforting to those who have difficulty working with the ill-defined context of PBL. Lastly, the resource rich nature of the LUI tool allows for students with lesser soils knowledge to have easy access to supplementary material. The material is also a benefit for those learners who exhaustively review provided information to achieve a holistic framework cognitive framework of the knowledge.

The LUI tool was designed to accommodate expansion if desired. Course instructors can include additional study sites, develop other PBL-style case focusing on the existing study sites, or develop new cases that would focus on the same land-uses but in different parts of British Columbia, or Canada, or the world. An instructor who wants to recreate a similar teaching tool has a format that has been developed that she can copy. An instructor could use a case already in use and create a website with similar formatting and organization, thereby minimizing the time inherent in designing the information architecture of a website.

The LUI tool maximizes UBC and Vancouver resources by making them easily accessible to a larger population than were available in their previous forms. The LUI tool illustrates two soil profiles from selected sites in Pacific Spirit Park which is part of the Metro Vancouver Parks and Recreation system. Metro Vancouver requires permits for digging and disturbing this section of the park. By filming the soil profiles, we save students not only the time and effort required to receive a permit, but also protects the forest from this type of human disturbance. Several of the maps in the LUI tool were not available online before the tool's creation and were only accessible by physically searching through the map cabinets in the UBC Geography Library.

3.2.2 Limitations of the LUI Tool

The LUI tool provides limited online interactivity for students, though the team had originally intended to include such technology. The LUI project budget was limited and we determined that interactive features would add to the tool's appeal but not necessarily enhance the learning experience, therefore we chose not to create interactive features.

The tool currently does not include any direct experiential activities for fieldwork. For many scientists and professionals, fieldwork is an essential component of their work, and in this way, the tool does not reflect of authentic knowledge application, which in the case of soil science would call for experiential fieldwork. Additionally, experiential learning is strongly supported as being an effective teaching approach. Exclusion of experiential activities from the tool was based on two choices: (1) the LUI team did not want the tool to lose focus or effectiveness by trying to address too many different learning styles and (2) in the current course for which the LUI tool was developed, there are many other case studies with opportunities for experiential learning. Experiential activities could be added to the tool at a later date. On example of at experiential activity would be to have students dig a soil pit in their region and the soil profile from their region with the profiles in the LUI tool and determine which land use from the tool most reflects the look of or processes occurring in their profile.

One of the major deterrents for IT-incorporation into curriculum is cost. The LUI tool cost a combined amount of $50,089 to create, $35,889 in grant money and $14,200 from in-kind contributions (Appendix IX). Without funding from the university's Teaching and Learning Enhancement fund, the creation of the tool would have no been possible. For other instructors facing similar funding concerns, the LUI tool does offer a template, which can be copied and modified to fit another course. An instructor who used the LUI tool as a template would be saving most of the creation costs and would only need to create a case study and fund the web and media development. Partnering with other institution offices that are centred around enhancement of student learning might also offer means for instructors to minimize development costs.

While the small number of students who reviewed seemed to be representative of the student body in the entire course, this is not a definite certainty. We did not review the demographics of the student reviewers to insure that the tool reviewers reflected a cross-section of students, therefore, there could possibly be a predominance of Forestry students, for example, which would imply that the reviewers were not representational. Additionally, former students who reviewed the tool were students who were willing to review the tool, which may have implied a lasting favorable attitude towards soil science, and therefore a tendency to view associated teaching tools in a positive manner.

Unfortunately, when writing the feedback form for the statement, “The presentation of soil science concepts had a lasting/emotional impact on me,” I did not specify that by “lasting emotional impact,” I meant “positive, lasting emotional impact.” In my interpretations, I originally made this assumption, but it is not accurate to assume that unequivocally that students intended the same “positive” impact that I did. Therefore, although I can assess their impressions of impacts, the tool may have had a negative impact on students.

Students reviewed the tool before their final grades were received, but after students received their grades for this specific course. The decision for the reviewers to complete the feedback forms at that point in time was decided to insure a larger student population which was present for reviewing the tool. Historically speaking, many of the students graduate after the grades are entered for this term. Getting reviewers to complete the feedback form when they are not currently students at UBC any longer would be a challenge.

3.3 Future Directions

Future applications of the LUI tool are likely to centre around the enhancement of soil science education at UBC and other universities. One potential outcome could be that the tool could foster either directed studies or new case study exploration. For example, under guidance from the course instructor, a student could sample and analyze soil from Camosun bog or a developed site in the area. Sampling the bog would enhance the richness of the case study, because the bog is representative of the lowest topography in this area. A separate case study could be developed analyzing the impact of aspect and slope on soil formation, by adding soils data from the bog to the case study to represent a transition from the highest to lowest elevation in the region. Having access to a soil under urban development would enhance the study and connect with other studies being conducted regarding soil quality of urban soils. Additionally, the LUI tool could be a section in a course that is centred around human land use impacts to soil.

The LUI tool may serve as a model for development of other interactive, multimedia soil science courses at UBC or at other universities in British Columbia, Canada, and around the world. The LUI tool also contributes to the growing body of web-based soil teaching tools which is an ongoing initiative championed by Dr. Krzic within the Canadian Society of Soil Science which is designed to integrate the soil science programs among several universities in British Columbia..

In a broader sense, the LUI tool will add to the growing body of research on hybridized or blended learning, in which a course has integrated IT and a face-to-face component. Limited research has been conducted in Canada on hybrid learning and the intention is to increase attention to this type of instructional approach (Abrami et al, 2006). The tool can bring attention to the need in post secondary education to diversify the manner in which curricula are presented to students and the need to maximize the way in which technologies are used in education.

3.3.1 Recommendations

Through the process of creating the LUI tool we can offer several suggestions for others interested in completing similar curriculum developments.

- Plan for sufficient (and extra) time for project completion. As also noted by Polsani (2003) planning and executing a project over the course of 1-2 years allows for the project to be thoroughly conceptualized and executed.
- Identify student learning needs for a particular course and use these as a guide for designing the teaching tool. Student learning needs are at the heart of the design process. A study by Chumley-Jones et al. (2002) showed that distinguishing between which type of technology or instructional approach is crucial for student success; the type did not matter as long as the pedagogy was sound.
- Involve students as much as possible in the design and evaluation. A large pool of student advisers will allow for integration of multiple perspectives that can enhance tool development.
- Create a multidisciplinary team to oversee tool development. Learning tool experts suggest this approach and although it will add more time and meetings to the process, the expertise of a wide range of individuals is more than any one person can offer to the tool development (Naidu, 2003).
- Engage new reviewers partway through the design process. In order to assess if one is developing exciting and motivating ways of presenting information, it is important to have both novices and experts in other disciplines review content presentation. Content that may be motivating and exciting to an expert is not necessarily exciting to a first-year student or other professionals. Therefore, engaging new reviewers who have not been a part of the design process to give input to insure that your content presentation has broader appeal.

- Stringently review new ideas and technologies that arise during project development for alignment with the project goals before incorporating new components. As you are working on executing your project, new innovative ideas or applicable technologies are likely to emerge. When this occurs, review the project goals and student learning needs to assess if the incorporation of the idea or technology truly suits the project. If it does not, explore if this innovation could be better used as the starting point for a new project as opposed to incorporating into the existing project.

We hope that this tool would inspire students and excite them to pursue further soil science studies. Students who were surveyed expressed that they appreciated the opportunity to explore material included in the LUI tool and the multitude of topics that ranged from soil formation, description and identification, and quality, to arrive at novel associations and deeper understanding of sustainable soil management practices. By exposing students to complex questions without definite answers, promoting intellectual inquiry and analysis, stimulating critical thinking, and encouraging the application of knowledge to complex issues, the LUI tool can stimulate higher cognitive processes, and can facilitate learning outcomes deemed essential by current employment demands. Yearly, approximately 30 students will take the course. The tool could be easily used in other similar post-secondary courses that deal with management impacts on natural resources thus reaching many more students each year. Lastly, but not least, this tool may inspire other soil science instructors to address the manner by which they deliver their classes and inspire further pedagogical innovations and explorations.

3.4 References

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APPENDIX I: LAND USE IMPACTS TOOL TEAM MEMBERS

Member	Role
Dr Maja Krzic	Team Leader, AGRO 402/SOIL 502 instructor and Associate Professor, Faculty of LFS, UBC
Dr Art Bomke	AGRO 402/SOIL 502 instructor and Associate Professor, Faculty of LFS, UBC
Rachel Strivelli	Principal Researcher, Video host, educational adviser and former AGRO 402/SOIL 502 student
Dr Les Lavkulich	Site selection and adviser to project, Professor Emeritus, Faculty of LFS, UBC
Dr Suzanne Simard	Second growth forest and forest ecology host and Associate Professor, Faculty of Forestry, UBC
Andy Jakoy	Alder site host and geology expert, Professor Emeritus, BC Institute of Technology
Mark Bomford	UBC Farm Program Coordinator
Chris Crowley	Video producer, educational consultant for online teaching tools and distance education, Office of Learning and Technology, UBC
Saeed Dyanatkar	Videographer and website developer, UBC-Telestudios

APPENDIX II: CASE STUDY HANDOUTS, WEEK 1-4

Case Study: Land-use impacts on soil quality on University Endowment Lands

(week 1)

Case specific learning outcome: Characterize the soil quality under three land-use practices (i.e., one-time logging, multiple logging events, and forest clearing + ongoing cultivation) on the University Endowment Lands, with emphasis on soil chemical attributes/properties.

With the help of a series of guiding questions and the interaction with course instructors, you will accomplish the following tasks:

1. Interpret the results of a couple of past studies carried out on the University Endowment Lands.
2. Describe your learning in a written format (as individual students) and orally (as a working team).

Background:
All the necessary information about this case study you will find within the LUI Tool website (http://soilweb.landfood.ubc.ca/luitool/), which was specifically designed for this case study.

Assignment for week 1:
You should familiarize yourself with the biophysical characteristics of the University Endowment Lands, by reviewing the LUI Tool web site. During the week 1, you will need to focus on the following sections of the LUI Tool:

- Overview of soil formation
- Podzols
- Study sites

Upon watching video clips for the three study sites, please reflect on the following:

- **Alder Forest Site** - Since the climax species at this site is nearing its maximum life span, what management choices do you propose for this site?

- **Second Growth Forest Site** – How would you characterize the soil quality at this site? Is this site productive?

- **Cultivated Site** - What management concerns regarding soil do you expect to encounter at the UBC Farm?

NOTE: It might also be useful to familiarize yourself with general characteristics of Podzols (which is the most common soil type on the University Endowment Lands) by viewing a video clip entitled “Podzol” posted at the following site http://projects.oltubc.com/SOIL/homepage.htm

References re. Podzol formation

Lundström, U.S., N. van Breemen, and D. Bain. 2000. The podzolization process. A review. Geoderma 94: 91-107

Sauer, D., H. Sponagel, M. Sommer, L. Giani, R. Jahn, and K. Stahr. 2007. Podzol: Soil of the Year 2007. A review on its genesis, occurrence, and functions. J. Plant Nutr. Soil Sci.170: 581-597.

Before next week’s tutorial, your team should research any gaps in knowledge regarding the guiding questions for week 1.

Guiding questions for week 1:

1. **How did Podzols form on the University Endowment Lands?**
   Describe the formation of Podzols on the University Endowment Lands by focusing on the five factors of soil formation (i.e., parent material, topography, biota, climate, and time).

2. **What are components of the soil quality framework?**
   Prepare a soil quality framework for the cultivated site at the UBC Farm focusing on the following soil function: “*Soil provides a medium for plant growth*.”

- During framework development, consider would you add/remove some of the soil processes and soil attributes/properties in the soil quality frameworks for the alder forest and second growth forest sites as compared to the cultivated site? Explain.

- Emphasis for the framework should be on soil chemical properties.

Case Study: Land-use impacts on soil quality on University Endowment Lands

(Week 2)

For the week 2, you should familiarize yourself with the soil data for the three study sites. Data were collected in 1970 (see Lavkulich, L.M. and C.A. Rowles. 1971. Effect of different land use practices on a British Columbia Spodosol. *Soil Science.* 111: 323-329.) and 2005 (go to the "Study Case data" link).

To be able to interpret the soils data you need to make sure that you understand all soil properties that were evaluated in 1970 and 2005. For this, you might need to consult one of the general soil science books such as ***The nature and properties of soils*** by Brady N.C., and R.R. Weil (2008) 14th ed. [book is on reserve in Woodward Library] or SoilWeb on-line teaching tool (http://www.landfood.ubc.ca/soil200/).

Assignment for week 2:

During the week 2, you will need to focus on the following sections of the LUI Tool:

1. Soil Quality
2. Student Links: Study Case Data
3. Maps
4. Student Links: References, specifically the following:
   a) Lavkulich, L.M. and C.A. Rowles. 1971. Effect of different land use practices on a British Columbia Spodosol. *Soil Science*. 111: 323-329.
   b) Cultivated Site documents
   c) Bose Soils as described in the *Soils of the Langley-Vancouver Map Area* (link can be found on the Podzols page)

Before next week's tutorial, your team should research any gaps in knowledge regarding the guiding questions for today's session.

Guiding questions for week 2:

- The soil chemical properties are derived from the complex interaction of the soil mineral and organic colloids, weathering processes, vegetation, and past management. Given the information about the Bose soil at the LUI Tool website, what are the key soil indicators of its chemical condition for plant growth?

- What are potential effects of the soil organic matter on the soil chemical properties/attributes on the University Endowment Lands?

Case Study: Land-use impacts on soil quality on University Endowment Lands

(week 3)

Background:

Human-induced processes and changes that create an impact or alteration to the soil profile are termed **metapedogenesis** (Yaalon and Yaron, 1966). Early soil scientists did not recognize humans as a major part of soil formation, but simply a part of the biota factor. This oversight may have been caused by lack of understanding regarding the rates of soil processes and the rates with which we could drastically change the soil (Richter, 2007). Increasingly, the impacts of human actions on soils have become evident. One action following the knowledge and awareness that humans impact soil formation and soil quality would be to persuade scientists, farmers, foresters, and other users of the land to identify and monitor human-induced changes to the soil. Consolidating and communicating the impacts of human-induced changes on soil bodies facilitates viable management recommendations.

For the week 3, you will need to compare 1970 and 2005 data to determine if there is any evidence of human-induced changes in soil formation. Is there any evidence on the study sites of metapedogenesis?

During the week 3, you will need to focus on the following sections of the LUI Tool:

1. Overview of soil formation
2. Podzols
3. References, metapedogenesis articles

Assignment:

- Before next week's session, your team should research any gaps in knowledge regarding the guiding questions for today's session.

- Continue to refine and adjust your soil quality framework to reflect your understanding of the data.

- Prepare presentation, incorporating main objectives into the talk (please consult guidelines given in the course syllabus).

Guiding questions:

1. By comparing 1970 and 2005 data, evaluate the extent of land-use impacts on soil properties over 35 years.
2. Can it be argued that metapedogenesis is occurring on the soils of the University Endowment Lands?

Case Study: Land-use impacts on soil quality on University Endowment Lands

(week 4)

Tutorial: Group presentations and synthesis

Each group will present results of their work (***please remember that your presentation should be max 20 minutes long***) and along with the instructors will compare and contrast the methods of diagnosis and interpretations of soil chemical quality in all case studies done during this month.

The presentations will be evaluated on the basis of content, structure, and delivery. One of the signs of successful presentation is how well the presentation engages other groups into discussion.

Review of Main Learning Outcomes:

1. Students will list and justify soil quality indicators that could be used to monitor the sustainability of the management practices at the UBC Farm
2. Students will evaluate to what degree human impacts are changing natural soil processes (such as podzolization) and to argue for/against the designation of a sixth factor of soil formation (metapedogenesis).
3. Students will evaluate the alterations to soil properties that have occurred over 35 years.

OR

4. Students will evaluate the alterations to the soil properties that have occurred because of human management choices.

APPENDIX III: STUDENT SOILS DATA IN THE LAND USE IMPACTS TOOL CASE STUDY

Table III.1. Selected morphological properties of the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	Color (moist)	Type of soil structure	Soil bulk density (g/cm^3)
2nd growth forest				
LF	13-7	-	-	n/a
H	7-0	-	-	n/a
Ae	0-2	5YR 4/2	Medium granular	1.04
Bf1	2-12	7.5YR 4/6	Weak angular blocky	1.10
Bf2	12-69	7.5YR 4/6	Weak sub-angular blocky	1.31
Cg	69-75	7.5YR 5/6	Weak angular blocky	1.30
IIC	75+	2.5YR 5/4	Single grained	n/a
Alder forest				
LF	19-15	-	-	n/a
H	15-0	-	-	n/a
Ae	0-10	7.5YR 5/4	Weak sub-angular blocky	0.77
Bf1	10-20	7.5YR 6/8	Strong sub-angular blocky	0.70
Bf2	20-56	10YR 6/6	Strong sub-angular blocky	1.14
Cg	56-63	10YR 5/4	Single grained	1.09
IIC	63+	5YR 6/4	Single grained	1.25
Cultivated (upper slope)				
Ap	0-30	10YR 3/4	Strong angular blocky	n/a
Bf1	30-40	10YR 4/6	Weak sub-angular blocky	n/a
Bf2	40-80	10YR 4/6	Weak sub-angular blocky	n/a
C	80+	7.5YR 4/2	Strong angular blocky	n/a
Cultivated (mid slope)				
Ap	0-35	10YR 3/4	Moderate platy	0.76
Bf1	35-50	10YR 5/8	Moderate angular blocky	n/a
Bf2	50-110	10YR 5/8	Moderate angular blocky	n/a
C	110+	10YR 7/2	Massive	n/a

Table III.1 continued. Selected morphological properties of the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	Color (moist)	Type of soil structure	Soil bulk density (g/cm^3)
Cultivated (lower slope)				
Ap	0-35	7.5YR 3/2	Strong sub-angular blocky	0.80
Bf1	35-45	7.5YR 4/4	Weak angular blocky	n/a
Bf2	45-70	7.5YR 6/8	Weak angular blocky	n/a
C	70+	7.5YR 5/4	Weak sub-angular blocky	n/a

Table III.2. Selected properties of the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	pH in H_2O	pH in $CaCl_2$	Organic matter (%)[†]	Organic matter (kg/ha)	Total C (%)	Total N (%)	C/N	Total P (ppm)	Available P (ppm)
2nd growth forest										
LF	13-7	4.6	4.0			32.8	1.67		840	3.1
H	7-0	4.4	3.6			19.5	1.06		611	3.6
Ae	0-2	4.5	3.9			3.9	0.18		225	2.5
Bf1	2-12	5.5	4.6			4.2	0.21		296	3.3
Bf2	12-69	4.9	4.6			4.3	0.21		453	1.6
Cg	69-75	5.1	4.8			1.2	0.06		380	2.7
IIC	75+	5.2	4.8			0.9	0.04		534	2.6
Alder forest										
LF	19-15	5.0	4.5			14.2	0.80		705	2.2
H	15-0	5.1	4.4			5.4	0.31		553	0.9
Ae	0-10	5.3	4.7			1.5	0.06		291	0.5
Bf1	10-20	5.5	4.9			1.7	0.07		441	0.6
Bf2	20-56	5.5	4.7			1.3	0.06		357	0.2
Cg	56-63	5.2	4.5			1.7	0.09		274	1.1
IIC	63+	4.8	4.3			1.9	0.10		296	3.2
Cultivated (upper slope)										
Ap	0-30	5.8	5.0			8.7	0.51		1999	33.6
Bf1	30-40	6.0	5.3			5.9	0.31		431	1.3
Bf2	40-80	6.1	5.3			3.1	0.15		388	1.4
C	80+	5.7	5.1			1.2	0.06		338	3.6
Cultivated (mid slope)										
Ap	0-35	5.2	4.8			8.1	0.38		666	3.7
Bf1	35-50	5.6	5.1			4.5	0.23		445	2.2
Bf2	50-110	5.7	5.1			2.5	0.12		367	4.7
C	110+	5.5	5.0			1.2	0.07		326	9.4

Table III.2. continued. Selected properties of the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	pH in H_2O	pH in $CaCl_2$	Organic matter (%)[†]	Organic matter (kg/ha)	Total C (%)	Total N (%)	C/N	Total P (ppm)	Available P (ppm)
Cultivated (lower slope)										
Ap	0-35	6.4	5.8			10.8	0.56		1431	26.9
Bf1	35-45	6.2	5.5			5.0	0.25		296	0.8
Bf2	45-70	5.9	5.3			5.1	0.30		324	1.4
C	70+	5.7	5.2			3.0	0.18		258	2.6

[†] Percentage of the organic matter (OM) can be calculated as: %OM = (% total C) x (1.724 kg org. matter / kg total C)

Table III.3. Total concentration (ppm) of elements in the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	Total (ppm)							
		Ca	Mg	K	Na	Cu	Mn	Ni	Zn
2nd growth forest									
LF	13-7	8167	581	1273	943	20	665	3.8	72
H	7-0	5578	496	1797	1901	16	546	2.8	27
Ae	0-2	5460	520	2516	2650	1	297	0.9	12
Bf1	2-12	4664	604	2003	2613	1	310	1.9	16
Bf2	12-69	4273	886	2314	2370	4	207	1.5	13
Cg	69-75	4933	979	2106	2289	9	191	2.4	18
IIC	75+	4654	1888	2152	2374	17	632	5.2	24
Alder forest									
LF	19-15	5812	795	1626	2090	18	399	3.1	50
H	15-0	5423	365	1717	2116	10	384	2.2	25
Ae	0-10	5611	200	1792	2685	-	95	0.6	4
Bf1	10-20	5642	198	1655	2586	-	99	0.5	4
Bf2	20-56	4637	262	1597	2536	1	129	0.5	4
Cg	56-63	4477	563	1727	2624	7	178	1.9	15
IIC	63+	5545	1287	1921	2916	4	253	4.2	21
Cultivated (upper slope)									
Ap	0-30	6538	881	1941	2295	25	422	2.5	49
Bf1	30-40	3626	1220	1701	1893	10	187	3.7	21
Bf2	40-80	2944	1194	1579	2168	10	168	3.5	19
C	80+	4912	1017	1767	2492	10	197	2.5	16
Cultivated (mid slope)									
Ap	0-35	4879	633	2154	2216	9	377	3.0	33
Bf1	35-50	3658	1564	1749	1881	8	197	6.6	23
Bf2	50-110	3186	1525	1637	1616	8	159	4.1	18
C	110+	2747	1649	1916	1698	9	174	4.6	19

Table III.3 continued. Total concentration (ppm) of elements in the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	Total (ppm)							
		Ca	Mg	K	Na	Cu	Mn	Ni	Zn
Cultivated (lower slope)									
Ap	0-35	7152	1170	2108	1956	13	328	4.2	46
Bf1	35-45	4126	1556	1962	1910	9	224	3.9	24
Bf2	45-70	3319	1448	1766	1999	10	208	4.1	22
C	70+	3027	2126	1637	1980	8	172	7.1	21

Table III.4. Total aluminium and iron in the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	Total (ppm)	
		Fe	Al
2nd growth forest			
LF	13-7	1172	777
H	7-0	4716	2348
Ae	0-2	6756	2726
Bf1	2-12	5921	3581
Bf2	12-69	6826	4503
Cg	69-75	3902	2534
IIC	75+	15467	6462
Alder forest			
LF	19-15	4936	3319
H	15-0	2032	894
Ae	0-10	1754	971
Bf1	10-20	1754	959
Bf2	20-56	1325	878
Cg	56-63	2188	1105
IIC	63+	4312	2053
Cultivated (upper slope)			
Ap	0-30	3795	2272
Bf1	30-40	3982	2723
Bf2	40-80	4494	2849
C	80+	3325	2057
Cultivated (mid slope)			
Ap	0-35	3056	2028
Bf1	35-50	3404	2630
Bf2	50-110	3336	1942
C	110+	2811	1674
Cultivated (lower slope)			
Ap	0-35	3435	2089
Bf1	35-45	3993	2923
Bf2	45-70	3913	2466
C	70+	3730	2257

Table III.5. Exchangeable aluminium and iron in the soils at the study sites as determined in 2008

Site and horizons	Depth (cm)	Oxalate‡ %				
		Fe	Al	Mn	P	Si
2nd growth forest						
Bf1	18-65	0.58	1.22	0.03	0.03	0.41
Bf2	65-78	0.48	1.61	0.01	0.03	0.58
BC	82-90	0.40	1.30	0.00	0.04	0.42
II C	100	0.23	0.41	0.00	0.02	0.09
Alder forest						
Bfh	30-40	0.44	1.43	0.00	0.03	0.48
Bf	40-75	0.33	1.27	0.00	0.02	0.53
Bcg	75-90	0.36	1.19	0.00	0.03	0.51
II C	90	0.40	0.58	0.00	0.02	0.25
Cultivated (mid slope)						
Bf	25-90	0.42	1.00	0.00	0.04	0.35

‡ Ammonium oxalate extractable

Table III.6. Exchangeable properties of the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	CEC ($cmol_c$/kg)	Exchangeable cations ($cmol_c$/kg)				Base saturation[§]
			Ca	Mg	K	Na	(%)
2nd growth forest							
LF	13-7	78.6	28.8	3.7	1.5	0.1	
H	7-0	50.8	9.9	1.3	0.4	0.1	
Ae	0-2	13.0	1.0	0.1	0.1	0	
Bf1	2-12	8.7	1.4	0.1	0.1	0	
Bf2	12-69	8.2	0.4	0.1	0	0	
Cg	69-75	4.3	0.1	0	0	0	
IIC	75+	4.0	0.4	0.1	0.1	0	
Alder forest							
LF	19-15	23.2	9.9	1.1	1.1	0	
H	15-0	13.0	3.6	0.2	0.1	0	
Ae	0-10	4.4	1.1	0	0.1	0	
Bf1	10-20	4.1	1.4	0.1	0.3	0	
Bf2	20-56	3.0	0.6	0	1.2	0	
Cg	56-63	4.1	0.5	0	0.2	0	
IIC	63+	7.8	1.0	0.3	0.1	0.1	
Cultivated (upper slope)							
Ap	0-30	14.1	9.1	0.5	0.1	0.1	
Bf1	30-40	6.5	2.9	0.2	0.1	0	
Bf2	40-80	12.6	1.7	0.1	0.1	0	
C	80+	3.0	1.5	0.1	0.1	0	
Cultivated (mid slope)							
Ap	0-35	7.7	2.3	0.1	0.3	0.1	
Bf1	35-50	3.6	0.8	0.1	0.1	0.1	
Bf2	50-110	2.2	0.5	0.1	0.1	0.1	
C	110+	2.0	0.9	0.1	0.1	0.1	

Table III.6. continued. Exchangeable properties of the soils at the study sites as determined in 2005

Site and horizons	Depth (cm)	CEC ($\mathrm{cmol_c/kg}$)	Exchangeable cations ($\mathrm{cmol_c/kg}$)				Base saturation[§]
			Ca	Mg	K	Na	(%)
Cultivated (lower slope)							
Ap	0-35	17.2	15.5	0.9	0.3	0.1	
Bf1	35-45	6.5	3.8	0.4	0.1	0	
Bf2	45-70	3.1	1.8	0.2	0.1	0.1	
C	70+	2.9	1.4	0.3	0.1	0.1	

[§] Percentage base saturation (BS) is calculated as: BS % = [(Ca + Mg +K + Na) / CEC] x100

Table III.7. Particle size analysis of the >2 mm soil at the study sites as determined in 2005

Site and horizons	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural class[¶]
2nd growth forest					
LF	13-7	-	-	-	
H	7-0	-	-	-	
Ae	0-2	57.7	31.9	10.4	
Bf1	2-12	65.8	24.5	9.7	
Bf2	12-69	68.0	24.3	7.8	
Cg	69-75	72.2	23.5	4.2	
IIC	75+	73.8	23.1	3.1	
Alder forest					
LF	19-15	-	-	-	
H	15-0	-	-	-	
Ae	0-10	70.8	28.1	1.1	
Bf1	10-20	76.7	20.8	2.5	
Bf2	20-56	79.7	16.8	3.5	
Cg	56-63	76.7	18.9	4.6	
IIC	63+	77.0	20.0	3.0	
Cultivated (upper slope)					
Ap	0-30	76.9	14.7	8.4	
Bf1	30-40	92.4	6.6	1.0	
Bf2	40-80	95.0	4.0	1.0	
C	80+	73.3	23.6	3.1	
Cultivated (mid slope)					
Ap	0-35	83.8	3.5	12.7	
Bf1	35-50	93.5	4.6	1.9	
Bf2	50-110	96.7	2.5	0.8	
C	110+	91.6	6.1	2.4	
Cultivated (lower slope)					
Ap	0-35	77.0	14.4	8.6	
Bf1	35-45	86.5	10.3	3.2	
Bf2	45-70	91.9	5.6	2.3	
C	70+	96.2	2.2	1.6	

[¶] To be determined on a textural triangle

APPENDIX IV: CONSENT FORM

THE UNIVERSITY OF BRITISH COLUMBIA

Faculty of Land and Food Systems
Grounded in Science | Global in Scope

Suite 248 - 2357 Main Mall
Vancouver, B.C. Canada V6T 1Z4

Tel: 604.822.1219
Fax: 604.822.6394
www.landfood.ubc.ca

Feedback on Teaching Tool Participant Consent Form

Project: "Land Use Impacts on Soil Quality and Formation"

Principal Investigator: Dr. Maja Krzic, Assistant Professor, Faculty of Land and Food Systems, University of British Columbia; Tel: 604-822-0252

Co-Investigator (*CONTACT FOR STUDY): Rachel Strivelli, M.Sc. candidate, Faculty of Land and Food Systems, University of British Columbia; Tel: 604-872-0331; Email: rachelstrive@hotmail.com

Purpose: The research goal of this project is to create the Land Use Impacts (LUI) teaching tool that provides students with a multimedia web-based experience and allows them to learn about the impacts of various land uses on soil formation and soil quality in the AGRO 402 / SOIL 502 course.

This research will be used in a Masters thesis report, as part of a graduate degree at the University of British Columbia. The final thesis report will be a public document. An abridged version of the thesis will be developed into a manuscript that will be submitted to an international education journal for publication.

Study Procedures: The LUI Tool Feedback will consist of one online feedback form, which will take 10-15 minutes to complete and evaluation of student comprehension and articulation of concepts in the mandatory written report on the land use impacts case study. The online feedback and questions will address the following topics:

5. The perceived appeal of soil science,
6. Student acquisition of knowledge,
7. Understanding about soil quality concept, and
8. Understanding about the effectiveness of the online tool.

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During this feedback process students may be asked questions about experiences with soil science, teaching/learning methods, or online educational tools. Statements and discussions that arise from these topics, or that occur over the course of the feedback process, may be included in association with this course in the co-investigator's final thesis report or related materials (e.g., conference presentation, manuscript).

Potential Risks: Participation in this feedback process poses minimal risk. Student statements may be used for publications, reports or presentations in association with the AGRO 402/ SOIL 502 course.

Potential Benefits: Participation in the feedback process may facilitate new knowledge about: the soils of the Vancouver region, how to gauge soil quality, how land use practices impact soil quality, and student learning in relation to online teaching tools.

Confidentiality: For students who wish to participate in this feedback process, student identity will be kept confidential. Data that links student name to student statements will be password protected on the co-investigator's computer.

The final thesis report may contain statements or images taken during the course. Your name will not be disclosed in relation to any statements or images in association with the course for the final thesis report, presentations, or related materials.

Sponsors: We acknowledge the following for financial support of this thesis research project: UBC's Teaching and Learning Enhancement Fund.

Contact for information about the study: If you have any questions or desire further information with respect to this study, you may contact Rachel Strivelli (co-investigator) at: 604-872-0331, or Dr. Maja Krzic (principal investigator) at: 604-822-0252.

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Fax: 604.822.6394
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Contact for concerns about the rights of research subjects: If you have any concerns about your treatment or rights as a research subject, you may contact the Research Subject Information Line in the UBC Office of Research Services at 604-822-8598 or if long distance e-mail to RSIL@ors.ubc.ca.

Consent:

I, ________________________, understand that my participation in this study is entirely voluntary and I may refuse to participate or withdraw from the providing feedback on the teaching tool at any time without any penalty [for example, class standing, etc.].

I give my consent to participate in the feedback process for this research project as described in this consent form by signing below.

Your signature below indicates that you have received a copy of this consent form for your own records. Your signature indicates that you consent to participate in this teaching tool feedback process.

____

Participant's Signature   Date

____

Printed Name of the Participant signing above

The signature of a Witness is <u>not required</u> for behavioural research.

APPENDIX V: UBC RESEARCH ETHICS BOARD CERTIFICATE OF APPROVAL

The University of British Columbia
Office of Research Services
Behavioural Research Ethics Board
Suite 102, 6190 Agronomy Road, Vancouver, B.C. V6T 1Z3

CERTIFICATE OF APPROVAL - MINIMAL RISK

PRINCIPAL INVESTIGATOR:	**INSTITUTION / DEPARTMENT:**	**UBC BREB NUMBER:**
Maja Krzic	UBC/Land and Food Systems/Agroecology	H09-00485

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:

Institution	Site
UBC	Vancouver (excludes UBC Hospital)

Other locations where the research will be conducted:
N/A

CO-INVESTIGATOR(S):
Rachel Astra Strivelli

SPONSORING AGENCIES:
Teaching and Learning Enhancement Fund - "Land-Use Impacts on Soil Quality: A Virtual and Experiential Education Project"

PROJECT TITLE:
Land Use Impacts Teaching Tool

CERTIFICATE EXPIRY DATE: March 11, 2010

DOCUMENTS INCLUDED IN THIS APPROVAL:

DATE APPROVED:
March 11, 2009

Document Name	Version	Date
Protocol:		
Research Proposal and Summary	N/A	February 15, 2009
Consent Forms:		

Participation Consent Forms	N/A	February 17, 2008
<u>Questionnaire, Questionnaire Cover Letter, Tests:</u>		
Feedback Form	N/A	February 17, 2008
<u>Letter of Initial Contact:</u>		
Invitation to Participate in Research Study	N/A	February 17, 2008
<u>Other:</u>		
http://soilweb.landfood.ubc.ca/luitool/		

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.

Approval is issued on behalf of the Behavioural Research Ethics Board
and signed electronically by one of the following:

Dr. M. Judith Lynam, Chair
Dr. Ken Craig, Chair
Dr. Jim Rupert, Associate Chair
Dr. Laurie Ford, Associate Chair
Dr. Anita Ho, Associate Chair

APPENDIX VI: FEEDBACK FORM

The Land Use Impacts teaching tool was created to provide students with a multimedia web-based experience to assist in teaching about the impacts of land uses on soil formation and soil quality. The tool was designed with the intention of appealing to multiple learning styles and providing greater information access.

Having viewed all pages of the teaching tool, please evaluate how well the tool met above stated objectives. Your honest and thoughtful feedback will aid in revisions and improvements of this tool.

Student Number:

1. The tool was effective at presenting the impacts of land uses on soil quality
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

2. The tool was effective at presenting the impacts of land uses on soil formation
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

One goal of the tool was improving appeal to learning styles. The following three statements address this goal.

3. The use of extensive visuals (photos, videos, maps) enhanced the appeal of the subject.
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

4. The use of multiple narrators discussing related topics enhanced the appeal of the topic.
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

5. The incorporation of weblinks, review material, and supplementary information enhanced the appeal of this subject.
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

6. The tool stimulated my interest in this subject.

Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

7. The tool was helpful in facilitating your understanding of soil science concepts.
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

8. The structure of the teaching tool facilitating your understanding of soil science concepts.
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

9. The presentation of soil science concepts had a lasting or emotional impact on you.
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

10. The structure or organization of the tool aided in making the group work and participation in this case study more efficient than other case studies used in the AGRO 402/SOIL 502 course.
Scale of 1-5, where 1 = strongly agree, 2 = mildly agree, 3=neutral; 4=mildly disagree, and 5=strongly disagree

[Following section is fill-in the blank]
Elaborate any of the questions further in the space below.

[There will be 5-8 lines of space provided for answer]

For further adjustments to the tool, please answer the following:

1. Which components of the tool need to be improved/changed? Please provide some examples, ideas, clarifications…….
2. Which components of the tool did you find to be most useful?
3. Which components of the tool did you find to be least useful?
4. Would you use this tool for any other course besides the AGRO 402/SOIL 502 course? If yes, please specify the course.

APPENDIX VII: TABLE OF STUDENT ONE-ON-ONE INTERVIEWS

Questions posed to students				
Is there a need for more supplementary material?	**Your Impression of the videos**	**Should the Land-Use Impacts Tool include a N2-fixing video?**	**Should it include a PDF document with "Tips for Success" in the Course**	**Other comments**
Articles on Organic Matter	-Were Helpful -Wanted synopsis of the videos in point/outline form -Had to rewatch many of the videos to write down stuff	Yes	Yes	-
Extra videos on chemical properties	-Were Great -Need more of them	Yes		
Sufficient on podzols; perhaps more data on other parts of UEL	-Needed bulleted list of video content	Maybe helpful	Yes	Seemed like a reasonable amount of work for the case study
perhaps more background	-Make them load faster; show more things that you want to see, rather than read about them. -Make movies more concise	Not interested; show the root nodules	?	Distribution of work between 4 weeks was fine
Plant indicators videos for all site	-Videos were too long, make them into smaller sections	Definitely; more direction would definitely be helpful	Yes.	Finding the information for the case study was hard- no clear goal

Appendix VII continued: Table of Student One-On-One Interviews

Questions posed to students				
Is there a need for more supplementary material?	**Your Impression of the videos**	**Should the Land-Use Impacts Tool include a N2-fixing video?**	**Should it include a PDF document with "Tips for Success" in the Course**	**Other comments**
Expected to see more research papers	Videos were good, but lengthy. It was hard to view and write down specifics. Need a written script/narrative of videos. The videos help you to understand the information quickly, but having the written information helps for when you are transcribing and writing the report paper.	It's an important thing to have	It would be helpful, but not for me personally	Overall layout of the case seemed chronological. Wishes course described more information at the beginning.

APPENDIX VIII: OPEN-ENDED FEEDBACK FORM RESPONSES, QUESTIONS A-D

Form Questions			
a) Which components of the tool need to be improved/changed?: **Please provide some examples, ideas, clarifications ...**	**b) Which components of the tool did you find to be most useful?**	**c) Which components of the tool did you find to be least useful?**	**d) Would you use this tool for any other course besides the AGRO 402/SOIL 502?**
1. Further editing of the video interviews to remove redundancies in explanation of background information. ie, all sites were at one point glaciated, this could be emphasized by the first speaker alone. 2. For students with some background in soils, it would be good to provide more information going beyond the basics of formation. Details of chemical processes involved in metapedogenesis, or links to places to learn about them, would be appreciated. 3. At some point in time it would be good to see all of the soil analysis data for the UBC Farm compiled into an online database, perhaps the LUItool is a good place for this.	The solid backgrounder on podzol formation. The abundant colourful visual aids.	-	AGSC 450
make all references available online (through a link)	all the descriptions of soil formation and background information and the pictures!	-	this type of tool would be useful if modified for different agro pbl courses but I probably wouldn't use the material from this site specifically for much else but personal reference.

Appendix VIII continued: Open-ended Feedback Form Responses, Questions A-D

Form Questions			
a) Which components of the tool need to be improved/changed?: **Please provide some examples, ideas, clarifications ...**	**b) Which components of the tool did you find to be most useful?**	**c) Which components of the tool did you find to be least useful?**	**d) Would you use this tool for any other course besides the AGRO 402/SOIL 502?**
I found the movies a bit long winded and it was hard to pick out the important points	the information on podzol formation/characteristics, as well as some of the relevant links	The movies	Maybe, I can\'t think of a specific course, but potentially a project within some of my geography or AGSC courses that is focused on the endowment lands
I would have appreciated a summary of the videos as well.	I think that the wide variety of videos and supporting text was very useful. I also think that the section providing extra links was helpful.	The videos were quite long, although they were very helpful.	I am not sure.
I did enjoy the videos, but they were very long, and it was frustrating trying to go back and look for information. I think it could be improved if there was also some written notes about the videos online.	The history of the sites, and the extra resources like papers and weblinks	the videos - for me, just because I learn and retain more from reading.	-
Written information of the videos!! If I did not remember something, I had to watch all the video again.	Web links and the soil surveys information	-	Well, in México, for "Use and management of soil"
There were a lot of movies to go through in the first week of the case. The amount of time is probably what people should be spending working on the class anyways but I think that some people would skip watching them.	background information	if I remember correctly.. some of the links to papers didn't work	If I had a class where I needed to talk about specific soils that were covered here I would probably use it as a source. If information was provided in this style for another course I would use it.

Appendix VIII continued: Open-ended Feedback Form Responses, Questions A-D

Form Questions			
a) Which components of the tool need to be improved/changed?: **Please provide some examples, ideas, clarifications ...**	**b) Which components of the tool did you find to be most useful?**	**c) Which components of the tool did you find to be least useful?**	**d) Would you use this tool for any other course besides the AGRO 402/SOIL 502?**
Looks great!	feeling like I was on a field trip	-	SOIL 200, AGRO 401
i couldn't find the login tab at first. maybe i'm an idiot but it didn't pop out at me and it took me a minute to find it. maybe make it bigger? or put it elsewhere? the eye does not go to the top of the page but rather along the left side where the rest of the tabs are. great images, user friendly, videos are very well done.	links to other sites (podzols etc) was good	-	agsc 250 might reference it when they do the UBC Farm field trip.
For each video, I would add a table of contents/chapters with links to different parts of the video	Videos for study site examples; these helped me link pedology/descriptions with management implications	Overview of Soil Formation - but it's still useful.	Soil 200, perhaps.[#]
Navigation was slightly confusing when I first signed in. I understand now that you just click through and find what you want to find. A glossary might be helpful especially for the public who may not have a strong soil science background	videos were easy to watch, informative and attention grabbing.	? I didn't browse through the whole thing very thoroughly, so it is hard to tell. I appreciate more information in the video clips, and less written on a webpage	yes. A good introduction to the importance of soil, and some soil science concepts. Also the UBC Farm videos would be helpful for new farmers to get an idea of what soil management looks like functioning small scale farm.

Appendix VIII continued: Open-ended Feedback Form Responses, Questions A-D

Form Questions			
a) Which components of the tool need to be improved/changed?: **Please provide some examples, ideas, clarifications ...**	**b) Which components of the tool did you find to be most useful?**	**c) Which components of the tool did you find to be least useful?**	**d) Would you use this tool for any other course besides the AGRO 402/SOIL 502?**
The link between land use and soil formation is not explicit in many of the examples	Study site videos	None - all are needed	Sections could be useful for Soil 200 & Agro 401

#Other comments, not addressing the immediate questions: The reasons I haven't answered "strongly agree" to everything are related to my being a stranger to this course & case study and the fact that the LUI tool is targeted primarily towards 402/502 students doing a specific case study. If you want people outside of 402/502 to use this tool, I think you have to make this clearer in your Home or About page. Other related suggestions: -the horizontal navigation bar at the top is really secondary to the vertical navigation bar on the left; make the font smaller in the horizontal navigation bar or move it to the bottom-more self-contained sections within the text; it reads a bit like a textbook and unless I have to read it all, I won't and will try to skip paragraphs -in the Podzols component, move distribution of Podzols to the beginning. I didn't understand why Podzols was the only soil order in the navigation bar (and hence, didn't realize the importance of the Podzols section) until I realized this site is targeted towards land impacts on the Pacific Spirit Park and UBC Farm.

APPENDIX IX: COST BREAKDOWN FOR DEVELOPMENT OF LUI TOOL

Service type funded	Services specifics	Cost
Student Stipend	One-year stipend for graduate student, Rachel Strivelli	18,000
Professional services	Video production and editing (OLT team): a) Production phase = (4 days of video shooting at UBC campus) b) Post-production phase: Editing (15 days) Compression for DVD/video streaming (2 days) Graphics Web programming (6 days)	3,580 6,000 1,100 1,000 4,000
Materials and supplies	Video tapes, DVDs, photocopy charges, etc.	500
Administrative fee	5.00%	1,709
In-kind contribution	Dr. Krzic (140 h x $80/h), the instructor for AGRO 402/SOIL 502 and AGRO 430/SOIL 503, will contribute 1 month of her time towards development of teaching tool -Office of Learning Technologies (OLT) 2 days of technical support, server space 10 mg development and production space	11,200 3,000

Total budget = $50,089 ($35,889 from Teaching and Learning Enhancement Fund + $14,200 in-kind)