DESIGN AND LEARNING OUTCOMES OF WEB-BASED INSTRUCTIONAL RESOURCES FOCUSED ON THE IMPACTS OF RESOURCE DEVELOPMENT ON NATIVE AMERICAN LANDS

by

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences

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APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the Division of Graduate Education.

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Erin E. Klauk

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# TABLE OF CONTENTS

1. INTRODUCTION ...................................................................................................1
   Problem ....................................................................................................................1
   Impacts of Resource Development on Native American Lands Website ..............4
   Research Questions ...............................................................................................5
   Literature Review .................................................................................................7

2. METHODS ............................................................................................................13
   Introduction ............................................................................................................13
   Impacts of Resource Development on Native American Lands Website ..........13
   Usability Study ......................................................................................................14
   Sample Population ...............................................................................................15
   Experimental Design ............................................................................................15
   Learning Style Test ..............................................................................................18
   Assessment ............................................................................................................21
      Pre-test Assessment ...........................................................................................21
      Learning Activities ............................................................................................22
      Post-test Assessment ........................................................................................26
      Exam Questions .................................................................................................26

3. USABILITY STUDY ............................................................................................28
   Introduction ............................................................................................................28
   Methods ..................................................................................................................28
      Participants ........................................................................................................28
      Instruments/Materials .......................................................................................29
      Design/Procedures ............................................................................................30
   Results and Discussion ..........................................................................................31
   Conclusions ............................................................................................................36

4. LEARNING OUTCOMES AND RESULTS ........................................................38
   Introduction ............................................................................................................38
   Research Question 1: Learning Outcomes of Content Knowledge .......................39
   Research Question 2: Teaching Advice ................................................................51
   Research Question 3: Learning Style Preferences and Student Outcome of
      Content Knowledge ..........................................................................................52
   Research Question 4: Working in the Web Environment I ...................................59
   Research Question 5: Working in the Web Environment II .................................64
   Research Question 6: Effectiveness of Thematic Web-Based Collections
      as a Motivator for Learning ..............................................................................68
TABLE OF CONTENTS – CONTINUED

5. DISCUSSION AND CONCLUSIONS .................................................................79

- Learning Outcomes...............................................................................................79
- ESCI 111 vs. ESCI 112......................................................................................80
- Jigsaw Activity vs. Role Play Activity..............................................................80
- Exam Question Results......................................................................................81
- Learning Style Preferences ...............................................................................82

Recommendations for the Future Development of Digital
Teaching/Learning Resources..............................................................................83

- Advice for the Effective Use of Digital Teaching Resources
  in the Classroom ...............................................................................................85
- Conclusions......................................................................................................87
- Future Work......................................................................................................88

REFERENCES CITED..............................................................................................90

APPENDICES .........................................................................................................94

- APPENDIX A: Institutional Review Board Permission.....................................95
- APPENDIX B: Assessment Tools and Learning Activities.................................97
- APPENDIX C: Learning Style Preferences.......................................................118
- APPENDIX D: Usability Study...........................................................................150
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Impacts of Resource Development on Native American Lands homepage</td>
<td>5</td>
</tr>
<tr>
<td>2.</td>
<td>Teaching about the effects of uranium mining on the Navajo Nation with an ESS approach</td>
<td>9</td>
</tr>
<tr>
<td>3.</td>
<td>Schematic diagram of one-group pre-test – post-test experimental design</td>
<td>17</td>
</tr>
<tr>
<td>4.</td>
<td>Learning style preferences used in this study, modified from Felder (1993)</td>
<td>19</td>
</tr>
<tr>
<td>5.</td>
<td>Average results of the quality of content Likert scale questions</td>
<td>32</td>
</tr>
<tr>
<td>6.</td>
<td>Average results of the ease of use Likert scale questions</td>
<td>35</td>
</tr>
<tr>
<td>7.</td>
<td>All student post-test results</td>
<td>42</td>
</tr>
<tr>
<td>8.</td>
<td>All student post-test results for pages that students specifically researched</td>
<td>43</td>
</tr>
<tr>
<td>9.</td>
<td>Comparison of student performance in the content knowledge section of post-test of ESCCI 111 and ESCI 112 for all students</td>
<td>45</td>
</tr>
<tr>
<td>10.</td>
<td>Comparison of student performance in the content knowledge section of post-test of the jigsaw and role play activities for all students</td>
<td>46</td>
</tr>
<tr>
<td>11.</td>
<td>Comparison of student performance in the content knowledge section of post-test of the jigsaw and role play activities for students who self-reported specifically researching a topic</td>
<td>48</td>
</tr>
<tr>
<td>12.</td>
<td>ESCI 111 exam question results</td>
<td>49</td>
</tr>
<tr>
<td>13.</td>
<td>ESCI 112 exam question results</td>
<td>50</td>
</tr>
<tr>
<td>14.</td>
<td>Normalization of learning style preferences</td>
<td>54</td>
</tr>
<tr>
<td>15.</td>
<td>Post-test results for students with strong and moderate learning style preferences for all subtopics</td>
<td>57</td>
</tr>
<tr>
<td>16.</td>
<td>Mean post-test results for students with strong and moderate learning style preferences</td>
<td>59</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>17.</td>
<td>Active/Reflective LSP distribution for all students</td>
<td>127</td>
</tr>
<tr>
<td>18.</td>
<td>Sensitive/Intuitive LSP distribution for all students</td>
<td>127</td>
</tr>
<tr>
<td>19.</td>
<td>Visual/Verbal LSP distribution for all students</td>
<td>127</td>
</tr>
<tr>
<td>20.</td>
<td>Sequential/Global LSP distribution for all students</td>
<td>128</td>
</tr>
<tr>
<td>21.</td>
<td>Active/Reflective LSP distribution for ESCI 111 students</td>
<td>128</td>
</tr>
<tr>
<td>22.</td>
<td>Sensitive/Intuitive LSP distribution for ESCI 111 students</td>
<td>128</td>
</tr>
<tr>
<td>23.</td>
<td>Visual/Verbal LSP distribution for ESCI 111 students</td>
<td>129</td>
</tr>
<tr>
<td>24.</td>
<td>Sequential/Global LSP distribution for ESCI 111 students</td>
<td>129</td>
</tr>
<tr>
<td>25.</td>
<td>Active/Reflective LSP distribution for ESCI 112 students</td>
<td>129</td>
</tr>
<tr>
<td>26.</td>
<td>Sensitive/Intuitive LSP distribution for ESCI 112 students</td>
<td>130</td>
</tr>
<tr>
<td>27.</td>
<td>Visual/Verbal LSP distribution for ESCI 112 students</td>
<td>130</td>
</tr>
<tr>
<td>28.</td>
<td>Sequential/Global LSP distribution for ESCI 112 students</td>
<td>130</td>
</tr>
<tr>
<td>29.</td>
<td>Active/Reflective LSP distribution for students who participated in jigsaw activity</td>
<td>131</td>
</tr>
<tr>
<td>30.</td>
<td>Sensitive/Intuitive LSP distribution for students who participated in jigsaw activity</td>
<td>131</td>
</tr>
<tr>
<td>31.</td>
<td>Visual/Verbal LSP distribution for students who participated in jigsaw activity</td>
<td>131</td>
</tr>
<tr>
<td>32.</td>
<td>Sequential/Global LSP distribution for students who participated in jigsaw activity</td>
<td>132</td>
</tr>
<tr>
<td>33.</td>
<td>Active/Reflective LSP distribution for students who participated in role play activity</td>
<td>132</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>34.</td>
<td>Sensitive/Intuitive LSP distribution for students who participated in role play activity</td>
<td>132</td>
</tr>
<tr>
<td>35.</td>
<td>Visual/Verbal LSP distribution for students who participated in role play activity</td>
<td>133</td>
</tr>
<tr>
<td>36.</td>
<td>Sequential/Global LSP distribution for students who participated in role play activity</td>
<td>133</td>
</tr>
<tr>
<td>37.</td>
<td>Active/Reflective LSP’s and physiography post-test performance for all students</td>
<td>133</td>
</tr>
<tr>
<td>38.</td>
<td>Sensitive/Intuitive LSP’s and physiography post-test performance for all students</td>
<td>134</td>
</tr>
<tr>
<td>39.</td>
<td>Visual/Verbal LSP’s and physiography post-test performance for all students</td>
<td>134</td>
</tr>
<tr>
<td>40.</td>
<td>Sequential/Global LSP’s and physiography post-test performance for all students</td>
<td>135</td>
</tr>
<tr>
<td>41.</td>
<td>Active/Reflective LSP’s and geology post-test performance for all students</td>
<td>135</td>
</tr>
<tr>
<td>42.</td>
<td>Sensitive/Intuitive LSP’s and geology post-test performance for all students</td>
<td>135</td>
</tr>
<tr>
<td>43.</td>
<td>Visual/Verbal LSP’s and geology post-test performance for all students</td>
<td>136</td>
</tr>
<tr>
<td>44.</td>
<td>Sequential/Global LSP’s and geology post-test performance for all students</td>
<td>136</td>
</tr>
<tr>
<td>45.</td>
<td>Active/Reflective LSP’s and hydrology post-test performance for all students</td>
<td>136</td>
</tr>
<tr>
<td>46.</td>
<td>Sensitive/Intuitive LSP’s and hydrology post-test performance for all students</td>
<td>137</td>
</tr>
</tbody>
</table>
LIST OF FIGURES - CONTINUED

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>47. Visual/Verbal LSP’s and hydrology post-test performance for all students</td>
<td>137</td>
</tr>
<tr>
<td>48. Sequential/Global LSP’s and hydrology post-test performance for all students</td>
<td>137</td>
</tr>
<tr>
<td>49. Active/Reflective LSP’s and climate/biota post-test performance for all students</td>
<td>138</td>
</tr>
<tr>
<td>50. Sensitive/Intuitive LSP’s and climate/biota post-test performance for all students</td>
<td>138</td>
</tr>
<tr>
<td>51. Visual/Verbal LSP’s and climate/biota post-test performance for all students</td>
<td>138</td>
</tr>
<tr>
<td>52. Sequential/Global LSP’s and climate/biota post-test performance for all students</td>
<td>139</td>
</tr>
<tr>
<td>53. Active/Reflective LSP’s and cultural heritage post-test performance for all students</td>
<td>139</td>
</tr>
<tr>
<td>54. Sensitive/Intuitive LSP’s and cultural heritage post-test performance for all students</td>
<td>139</td>
</tr>
<tr>
<td>55. Visual/Verbal LSP’s and cultural heritage post-test performance for all students</td>
<td>140</td>
</tr>
<tr>
<td>56. Sequential/Global LSP’s and cultural heritage post-test performance for all students</td>
<td>140</td>
</tr>
<tr>
<td>57. Active/Reflective LSP’s and uranium deposits post-test performance for all students</td>
<td>140</td>
</tr>
<tr>
<td>58. Sensitive/Intuitive LSP’s and uranium deposits post-test performance for all students</td>
<td>141</td>
</tr>
<tr>
<td>59. Visual/Verbal LSP’s and uranium deposits post-test performance for all students</td>
<td>141</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>60.</td>
<td>Sequential/Global LSP’s and uranium deposits post-test performance for all students</td>
</tr>
<tr>
<td>61.</td>
<td>Active/Reflective LSP’s and exp/dev history post-test performance for all students</td>
</tr>
<tr>
<td>62.</td>
<td>Sensitive/Intuitive LSP’s and exp/dev history post-test performance for all students</td>
</tr>
<tr>
<td>63.</td>
<td>Visual/Verbal LSP’s and exp/dev history post-test performance for all students</td>
</tr>
<tr>
<td>64.</td>
<td>Sequential/Global LSP’s and exp/dev history post-test performance for all students</td>
</tr>
<tr>
<td>65.</td>
<td>Active/Reflective LSP’s and environmental impacts post-test performance for all students</td>
</tr>
<tr>
<td>66.</td>
<td>Sensitive/Intuitive LSP’s and environmental impacts post-test performance for all students</td>
</tr>
<tr>
<td>67.</td>
<td>Visual/Verbal LSP’s and environmental impacts post-test performance for all students</td>
</tr>
<tr>
<td>68.</td>
<td>Sequential/Global LSP’s and environmental impacts post-test performance for all students</td>
</tr>
<tr>
<td>69.</td>
<td>Active/Reflective LSP’s and human health impacts post-test performance for all students</td>
</tr>
<tr>
<td>70.</td>
<td>Sensitive/Intuitive LSP’s and human health impacts post-test performance for all students</td>
</tr>
<tr>
<td>71.</td>
<td>Visual/Verbal LSP’s and human health impacts post-test performance for all students</td>
</tr>
<tr>
<td>72.</td>
<td>Sequential/Global LSP’s and human health impacts post-test performance for all students</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>73</td>
<td>Active/Reflective LSP’s and policy post-test performance for all students</td>
</tr>
<tr>
<td>74</td>
<td>Sensitive/Intuitive LSP’s and policy post-test performance for all students</td>
</tr>
<tr>
<td>75</td>
<td>Visual/Verbal LSP’s and policy post-test performance for all students</td>
</tr>
<tr>
<td>76</td>
<td>Sequential/Global LSP’s and policy post-test performance for all students</td>
</tr>
</tbody>
</table>
## List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Data collection and analysis of research questions and corresponding assessment tools</td>
<td>27</td>
</tr>
<tr>
<td>2. Participants of usability study demographics</td>
<td>29</td>
</tr>
<tr>
<td>3. Quality of content Likert scale usability study questions</td>
<td>32</td>
</tr>
<tr>
<td>4. Quality of content Likert scale usability study questions</td>
<td>35</td>
</tr>
<tr>
<td>5. Hypotheses/questions examined in this study</td>
<td>39</td>
</tr>
<tr>
<td>6. Pre-test knowledge about uranium mining on the Navajo Nation</td>
<td>40</td>
</tr>
<tr>
<td>7. Final exam questions</td>
<td>49</td>
</tr>
<tr>
<td>8. Active/Reflective results for learning style preferences</td>
<td>125</td>
</tr>
<tr>
<td>9. Sensitive/Intuitive results for learning style preferences</td>
<td>125</td>
</tr>
<tr>
<td>10. Visual/Verbal results for learning style preferences</td>
<td>126</td>
</tr>
<tr>
<td>11. Sequential/Global results for learning style preferences</td>
<td>126</td>
</tr>
</tbody>
</table>
ABSTRACT

This study explored the use of web-based learning by introductory Earth science students (n = 269) to develop an understanding of how students learn in this environment. This was done in two stages. First, the design, development and testing of an online teaching resource about the impacts of uranium mining on the Navajo Nation (http://serc.carleton.edu/research_education/nativelands/navajo/index.html) was done using best practices in web design and a series of usability studies. Second, the effectiveness of this website as a learning tool was evaluated by engaging students in two instructional activities (jigsaw, Tewksbury, 1995; role playing, Teed, 2005) to measure learning outcomes in this digital environment. Data about the students, including assessment of learning style preferences, were collected, and student learning was measured by pre- and post-tests, observation logs and final exam questions. Research questions this study addressed include: (1) Do students effectively use this site to learn about the impacts of uranium mining on the Navajo Nation using an Earth system science approach? (2) What advice can be given to faculty who design similar resources and/or use this site to teach? (3) Does this site facilitate the learning style preferences described by Felder (1993)? (4) What do students actually do when working in this environment? (5) Does this thematic collection enable or hinder student learning? And (6) does this web-based thematic collection serve as a possible motivator for learning as suggested by Edelson (2001)? Results show that learning (at acceptable to excellent levels) was achieved by the majority of students; learning was mostly independent of larger course context including the instructor and material already covered; and learning adequately served students of all learning style preferences. Regardless of learning activity, this study demonstrated that learning goals must be clearly defined first to achieve desired learning outcomes. If the learning goal is content mastery, a jigsaw activity resulted in higher levels of performance; and for the affective domain, engaging students, and showing relevance and connections to their lives, a role playing activity may be better. In both cases, clear instructions and expectations are essential to achieve learning goals.
CHAPTER ONE

INTRODUCTION

Problem

The purpose of this research project was to evaluate the effective use of digital resources, which were designed and developed specifically for this study, for instructional use in introductory geoscience courses, and to provide guidance for the design and development of new instructional resources via digital libraries. This research project was funded by the National Science Foundation through the DLESE Community Services Center (DCSC; Grant EAR 03-06708) to explore the use of digital libraries in support of integration of research and education. This study is also part of an initiative to investigate research on learning in the geosciences with the Science Education Resource Center (SERC) (e.g. Manduca et al., 2002).

The question of how students learn in an environment rich in digital resources was addressed in two stages. The first stage of this project involved the design, development and testing of an online teaching environment. A case study approach was used to develop a thematic collection of on-line resources focused on the topical issue of the impacts of resource development on Native American lands, specifically the impacts of uranium mining on the Navajo Nation. The thematic collections, developed entirely for this study, include digital resources on the natural environment of the Navajo Nation (physiography, geology, hydrology, climate, biota), the cultural heritage of the Navajo people, and the history and impacts of uranium mining on human health, environmental
degradation, and public policy. By selecting and reviewing resources from the open web (e.g. Manduca and Mogk, 2000; Kastens et al., 2005), and placing these resources in appropriate contexts (Lagoze et al., 2006; Manduca et al., 2006), our goal was to create a learning environment that would promote student learning through inquiry and discovery (NSF 96-139).

Thematic collections of on-line resources were developed by discovery of resources from the open WWW, with an emphasis on using resources from credentialed sources such as federal agencies (e.g. USGS, EPA) and other institutions of higher education. Review and selection criteria include a) scientific credibility, b) potential use in instructional activities, and c) robustness (i.e. the websites are stable and reliable). All resources were cataloged by creating metadata records in the SERC content management system (Fox et al., 2005) to facilitate search and discovery functions (e.g. by topic, audience, type of resource). These metadata records are Open Archive Initiative compliant using Dublin Core standards, and are available for harvesting by other digital library systems (e.g. the National Science Digital Library, Digital Library for Earth System Education).

Additional on-line resources that were developed for this project include a study guide for teachers, suggested instructional activities (jigsaw, Tewksbury, 1995; role playing, Teed, 2005), a glossary for students without prior knowledge in geology, and a place to contribute additional resources. The finished product of these webpages can be viewed at http://serc.carleton.edu/research_education/nativelands/index.html. This instructional module was evaluated based on “best practices” in web design (SERC,
2006a), navigation structure, quality of content, coverage of the subject material, aesthetics, ease of use, and user satisfaction (e.g. the site is interesting, useful) in a series of usability studies.

The second stage of this thesis project focused on the effectiveness of this website as a learning tool. Using this website, a lab was conducted for students (n=269) in ESCI 111 (Physical Geology) and ESCI 112 (Physical Geography) at Montana State University in the fall of 2005. This study engaged students in two instructional activities (jigsaw, Tewksbury, 1995; role playing, Teed, 2005) to measure the extent of learning in this digital environment. Demographic data about the students, including assessment of learning style preferences, was collected and student learning was measured by pre- and post-tests, observation logs and final exam questions.

The use of digital resources is gaining importance as traditional library research is becoming less favored and on-line research is becoming more the status quo. However, access to information cannot be equated with learning. In this study, student learning was assessed in a digital learning environment, including content mastery and awareness and attitudes about science and society. Student performance in these areas was correlated with self-determined learning style preferences. This study provides guidelines for the future development of digital teaching resources, and advice for their effective use in the classroom.
Impact of Resource Development Website

The *Impacts of Resource Development on Native American Lands* collection (Figure 1) has created investigative, case-based studies (e.g. Starting Point: Using Investigative Cases in Geoscience [http://serc.carleton.edu/introgeo/icbl/index.html](http://serc.carleton.edu/introgeo/icbl/index.html); Stanley and Waterman, 2006) that explore new methods for integrating geologic research into undergraduate education. The thematic collections within this study are centered on the impacts of uranium mining on the Navajo Nation. This collection is designed primarily for undergraduate and graduate level instructors and students to be used either for in-class instructional activities or for independent study. These collections are also designed to demonstrate the relevance of the geosciences to Native American peoples and to interest and recruit more Native American students to the geosciences. To assist geoscience educators, this collection includes tips for teaching indigenous people, and a detailed study guide is provided with suggested teaching activities to use this online resource in geoscience classrooms. All resources are cataloged and searchable using information technologies developed at the Science Education Resource Center at Carleton College.
Research Questions

As web-based learning becomes more common, it is necessary to develop an understanding of how students learn in this environment. The research questions that were addressed through the execution of this study are: (1) To what degree does a
website such as
(http://serc.carleton.edu/research_education/nativelands/navajo/index.html) create an
effective learning environment? In the recent past, a large amount of work has been
dedicated to the creation of “thematic collections” in digital libraries and in the
development of on-line case studies (e.g. Starting Point at
http://serc.carleton.edu/introgeo/index.html, SERC, 2006b; BioQUEST at
http://bioquest.org/case99.html, Waterman and Stanley, 2006). However what is the
evidence that these thematic collections actually improve learning by students? And, (2)
Given that such thematic collections exist, what are the most effective instructional
practices that can be used to promote student learning in this environment? Ancillary
questions include:

- Do students effectively use this site to learn about the impacts of uranium mining
  on the Navajo Nation using an Earth system science approach?

- What advice can be given to faculty who design similar resources and/or use this
  site to teach?

- Does this site facilitate the learning style preferences described by Felder (1993)?

- What do students actually do when working in this environment (e.g. search with
  a purpose, wander aimlessly, jump from site to site, spend time looking at a topic
  in depth)?

- Does this thematic collection enable or hinder student learning (e.g. Does it
  facilitate inquiry, discovery and in-depth analysis, or does it provide too-easy
access and superficial understanding? How does it impact critical thinking and information literacy)?

- Does this web-based thematic collection serve as a possible motivator for learning as suggested by Edelson (2001)?

**Literature Review**

Earth system science (ESS) is a new organizing basis from which to teach about the Earth in a holistic manner (Ireton et al., 1996). This study illustrates how the digital learning environment, *Impacts of Uranium Mining on the Navajo Nation*, can support this approach when using the activities included for learning/teaching. ESS includes studies of the interrelationships between natural and social systems, the ways energy and materials cycle through the different "-spheres", as well as the workings of climate and the biosphere. ESS fosters the synthesis of disciplinary knowledge into a holistic model of Earth with broader interdisciplinary significance (SERC, 2006c). SERC (2006c) describes ESS as an integrated system of chemistry, physics, biology, mathematics and applied sciences that seeks a deeper understanding of the physical, chemical, biological and human interactions that determine the past, current and future states of the Earth. This provides a physical basis for understanding the world in which we live and upon which humankind seeks to achieve sustainability. A web-based learning environment is hypothesized to be an appropriate medium to demonstrate the interconnectedness of different parts of the Earth system in the creation of thematic collections and by providing the linkages between topics of interest.
Understanding the Earth as a system offers many possibilities for teaching Earth science from a new perspective. The ESS approach to teaching and learning provides opportunities to engage students in hands-on, inquiry-based experiences that capture the excitement of the new discoveries in the Earth and space sciences. The ESS approach also demonstrates the importance of the Earth system to our personal and communal lives (Ireton et al., 1996). One of the goals reported in Ireton et al. (1996) is to unite Earth and space scientists behind this new paradigm for Earth science education as a way of providing an understanding of the Earth system to the broadest possible audience.

The educational investigative case studies developed in this project explore resource development on Native American lands. An ESS approach is used to allow students to discover the impacts to the environment and on the Navajo people as a result of uranium mining on the Navajo Nation. Figure 2 illustrates the topical areas encompassed by the ESS approach developed on the website. In this case study, thematic collections are developed around ten subtopics to develop a holistic picture of what is occurring (or has occurred) here. In this example (Figure 2), these subtopics include geology, physiography, hydrology, climate, biota, culture, uranium deposits, exploration and development history, human health impacts, environmental impacts and policies.
Figure 2 – Teaching about the effects of uranium mining on the Navajo Nation with an ESS approach
(http://serc.carleton.edu/research_education/nativelands/navajo/index.html).

New educational media such as digital libraries are now available for widespread instructional use in both formal and informal settings, however, little is known about the
effective use of these digital resources either in terms of teaching methods used by
teachers or learning outcomes by students. Value is added with the use of digital libraries
in a “Google™” world by giving a) immediate access to a credentialed and reviewed
collection (i.e. individuals do not have to wade through thousands of returns); and b)
resources are placed in an appropriate educational context (Lagoze et al., 2006; Manduca
et al., 2006). The web environment can lead to a dynamic learning environment that
encourages both inquiry and discovery. As Edelson (2001) demonstrates, this dynamic
learning environment is a potential motivator to learn because learning is inspired by
either curiosity or an imperative to know how to solve a significant problem. In a web-
based learning environment, there is an opportunity to closely link content in the form of
text, images, maps, animations, and to link primary science with derivative commentary
(e.g. editorials, popular press articles about science) and pedagogy. There is also an
opportunity to purposefully link to resources that address multiple learning styles so that
“abstract, textual, visual, musical, social, and kinesthetic media represented enable
students to become engaged in their ideal way of learning (Brown, 2002, p.3).”

Digital libraries differ from traditional libraries. They not only provide searchable
cataloged resources, but also contain framing context around the resource collection.
Digital libraries should provide more than the simple search and access of traditional
libraries (Lagoze et al., 2006), as it is important for students to interact with the
information. Manduca and Mogk (2000, p.8) state that digital libraries

build on traditional libraries and add dynamic dimensions because they are
a(n) instantaneous, global distribution of information according to specific
user needs; organization of information to allow effective access from
numerous points of entry; access to real-time and archived data sets and
have the ability to render this information in ways useful and meaningful to the widest range of users; and creation of new, virtual communities of scholars.

Winn (1995) and Driscoll (2002) have examined how people learn. Winn (1995) states that there are two general factors that influence how well people learn information. These include how information is presented, and how students interact with it while learning. Information becomes knowledge because students interact with it (Winn, 1995). There are four principles that offer a framework to teachers for thinking about how technology can support their instruction (Driscoll, 2002); learning occurs in context; learning is active; learning is social; and learning is reflective. Because learners try to understand by relating to prior knowledge, learning in context can help learners steer clear of misunderstanding. Technology can facilitate learning by providing real world contexts that engage learners in solving complex problems (Duffy and Cunningham, 1996; Honebein, 1996; Cognition and Technology Group at Vanderbilt, 1997; Driscoll, 2002). In the learning environment in this study, “real world” context is provided, as the students are learning about the actual issues surrounding uranium mining on the Navajo Nation.

As a Chinese proverb illustrates, learning is also active, “Tell me, I forget. Show me, I remember. Involve me, I understand.” By using technology to guide them, students are able to work with ideas and learn without bringing misconceptions to the classroom. “When students become active in learning, the focus of learning shifts from covering the curriculum to working with ideas” (Driscoll, 2002; Scardamalia, 2006). The web environment tested in this study illustrates active learning, as the learning the
students take part in is guided, but completed on their own. Technology provides “the means through which individuals engage and manipulate both resources and their own ideas” (Hannafin et al., 1999, p.128). This media makes it possible for learning to be the centered on the experience of the student. The National Science Foundation (1996, p.v) states that “inquiry should be non-linear, guided by the interests of the user, and offer flexibility in the path of inquiry and the depth of investigation.”

Driscoll’s (2002) last two principles state, learning is social and learning is reflective, are also illustrated in this study. The design of the teaching activities used in this study facilitates social learning, as the students learn in groups. Research on cooperative learning by Johnson et al. (1991) indicates that “positive peer relationships are essential to success in school and that isolation and alienation are predictors of failure” (Srogi and Baloche, 1997, p.1). Learning in this environment is also reflective, as each learning experience is concluded by a group discussion of what was learned, as well as a post-test that allowed the students to reflect on what and how they learned.

Although this review supports learning in a digital environment, and that learning reaches multiple learning styles, it is important to note that working in this media does not guarantee learning. Learning falls into the hands of educators to use these available technologies along with proper guidance to support learning. To facilitate this, some digital libraries, such as the one being tested in this study, provide teaching activities to serve as guides for educators and students.
CHAPTER TWO

METHODS

Introduction

The intent of this thesis project is twofold; to develop and test the usability of an online teaching module to facilitate student learning on the subject of the impacts of resource development on Native American lands, and to test the effectiveness of this online resource in facilitating student learning. The website was tested in the fall 2005 with ESCI111 and ESCI112 students (n = 269).

Impacts of Resource Development on Native American Lands Website

This website was designed for this study in collaboration with SERC, using “best practices” in web design, which are routinely used at SERC (2006a). Many components went into the design of this site. First, extensive research was done on uranium mining on the Navajo Nation and all subtopics. Working with experts on the topic (Dr. Steve Semken and Perry Charley) and broadly searching web-based resources, the best (digital and paper) resources were selected for the module based on source credibility, relevance to topic, and expected pedagogic value. Next, these resources were cataloged using the Content Management System at SERC (Fox et al., 2005) to provide resource-level metadata to enable searching and browsing. Both individual metadata records and each web page were reviewed following established quality assurance protocols (SERC, 2006a). After all resources to be used in the digital library for this module were
cataloged, the physical layout of the website was designed. This led to actual webpage building, including writing the framing text for each subtopic (e.g. geology, hydrology), embedding images, embedding links to the glossary, embedding resources lists organized by topic, and constructing the website navigation structure. A study guide was added with teaching activities specific to this module. In addition, a page was built for teachers to find tips and resources to better facilitate teaching indigenous peoples. These pages were developed to facilitate multiple levels of understanding. Basic understanding can be gained about uranium mining on the Navajo Nation by using only the framing text on the webpages, more knowledge can be gained by following the top resource links, and still more knowledge can be gained by spending time on more resource links. These webpages can be viewed at


Usability Study

The usability of this website, described in detail in chapter 3, was tested by a focus group of 13 geology professors, graduate students and undergraduate students prior to implementation of the website in the lab sections. This instructional module was evaluated for web design, navigation structure, quality of content, coverage of the subject material, aesthetics, ease of use, and user satisfaction (e.g. the site is interesting, useful).
Sample Population

Two classes of introductory students at Montana State University, physical geology and physical geography, participated in the experiment. Physical Geology (ESCI 111) had an enrollment of 155 students, of which 122 took part in this study. The professor for this class was Dr. William Locke, who has been teaching for 27 years, having taught ESCI 111/112 twenty to thirty times (Locke, pers. comm.). Topics of study that were covered prior to the lab for this study include minerals, rock classes, magma and igneous rocks, volcanoes, sediment and sedimentary rocks, metamorphic rocks, geologic time, making Earth, motion in the Earth, deformation of rocks, global tectonics and tectonics and landscapes.

Physical Geography (ESCI 112) had an enrollment of 173 students, 147 of which took part in this exercise. The professor for this class was Dr. Mark Skidmore, who has been teaching two years, and this was his first time teaching ESCI 112 (Skidmore, pers. comm.). Topics of study that were covered prior to the lab for this study include the atmosphere, insolation and temperature, temperature and pressure, pressure and wind, atmospheric moisture, air masses and storms, climate types, climate zones and change, hydrosphere, plate tectonics, earthquakes, volcanoes, and weathering and slopes.

Experimental Design

The experimental design in this study is a modified version of Campbell and Stanley (1963) and the one-group pre-test/post-test design (Figure 3). This design was used to compare results from two similar classes of non-majors, with no pre-requisites
(Cook and Campbell, 1979). The experiment is set up as O1 X O2, where O = observation and X = treatment.

Using data from all students enrolled in ESCI 111 and ESCI 112, observations were made to see if a) background material from the two courses made a difference in learning outcomes; and b) the personality and teaching styles of two different professors made a difference (established vs. new faculty). This data was tested to see if a) learning style preferences made a difference; and b) the instructional style of the exercises (jigsaw vs. role play) made a difference. The extent of learning outcomes in this environment (via pre- and post-tests) is also demonstrated in this experiment.

Illustrated in Figure 3, this experiment consisted of all the students taking a learning style test developed by Felder and Soloman (2002). The students were then required to participate in the lab designed for this study during one of their two hour lab periods. During this lab, the students were observed through a pre-test that was used to determine the baseline knowledge of students by asking what their prior knowledge of the subtopics covered about uranium mining on the Navajo Nation. Next, the groups took part in one of two laboratory exercises, the jigsaw or the role-play (described in detail in the learning activities section of this chapter), in which they 1) used the digital resources, where they were commonly paired on computers, and 2) continued the activity in collaborative groups. The groups were then observed a second time through a post-test very similar to, but more extensive than the pre-test previously given. Approximately one month later the students were asked two questions pertaining to the lab in their final examination.
Figure 3 – Schematic diagram of one-group pre-test – post-test experimental design.

Student learning in this web-based activity was assessed through pre- and post-tests (Appendix B) via a scoring rubric for activity outcomes (Appendix B) and content mastery on standard course exams. Permission from the Institutional Review Board was received for this study to use human subjects (Appendix A), and student performances were correlated anonymously with an ID number among the learning style preference tests and pre-/post-tests.
Prior to performing the lab, the students were given the *Index of Learning Styles* Questionnaire (Felder and Soloman, 2002) (Appendix C) to determine their learning style preferences. This information was used to determine how on-line learning environments support one or more self-reported learning style preferences. This was achieved by correlating each student learning style preference with the effectiveness of web-based learning from the content knowledge section of the post-test.

To assess the effectiveness of this website as a learning tool, student attitudes and content knowledge mastery were measured before and after completion of the assigned lab activity. Pre- and post-tests consisted of similar questions to document changes in content mastery and attitudes/awareness about the issue of impacts of uranium mining on the Navajo Nation. In each class (ESCI 111 and ESCI 112), approximately half of the lab sections did the jigsaw activity, and the other half did the role play activity. The two activities were normalized by making sure each activity was represented in both the morning and afternoon, and by class size (i.e. eight students vs. 20 students). The product of both exercises included guided discovery worksheets showing what each student did individually, and “report outs” to the class on their assigned topics or roles. To gauge retained knowledge, exam questions regarding the impacts of uranium mining on the environment were asked on the final exam.

**Learning Styles**

The *Index of Learning Styles* questionnaire (Felder and Soloman, 2002) (Appendix C) was used to assess preferences on four dimensions (Figure 4) to determine
the students’ self-defined preferences for learning. This information is used to determine which learning styles the online teaching tool facilitates (Felder, 2005). A student's learning style profile provides an indication of possible strengths and tendencies that might lead to success or difficulty in different academic settings (Felder, 2005).

![Learning Style Preferences](image)

Figure 4 – Learning style preferences used in this study, modified from Felder (1993).

As described by Felder (1993), Felder and Silverman (1988), and Felder and Spurlin (2005), brief descriptions of each learning preferences are as follows. Active learners prefer to learn by doing things while reflective learners prefer thinking things
through; sensitive learners prefer information that comes through their senses while intuitive learners favor information that arises internally through memory, reflection, and imagination; visual learners prefer learning from pictures, diagrams, graphs and demonstrations while verbal learners prefer learning from written and spoken words or formulas; and sequential learners prefer to learn in a logical progression of small steps while global learners understand by learning holistically. On each continua (Figure 4), strong preferences include scores of 1, 2, 11 and 12, moderate preferences include scores of 3, 4, 9 and 10, and mild preferences include learning style preference scores 5-8 (Felder, pers. comm.). For this study, strong and moderate preferences are used for analysis, while mild preferences are discarded (Figure 4).

Research shows students are set apart by different learning styles, focusing on different types of information, tending to operate on perceived information in different ways and achieving understanding at different rates (Felder, 1993). When a student’s learning style is attuned with the teaching style of a course instructor, he/she tends to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject than do his/her counterparts who experience learning/teaching style mismatches (Felder, 1993).

As a science teacher or a web designer of resources meant to teach science students, it is imperative to make sure that all learning styles are accommodated. Some problems encountered by students whose learning styles have not been reached include students feeling as if they are being addressed in an unfamiliar foreign language, getting lower grades than students whose learning styles are better matched to the instructor’s
teaching style, not developing an interest in the course material, or losing interest in science altogether (becoming one of the more than 200,000 who switch to other fields after first science courses each year) costing society potentially scientists (Seymour and Hewitt, 1997; Felder, 1993).

Assessment

Assessment is defined as data collection with the purpose of answering questions about student’s understanding, attitudes, skills and instructional design and implementation (Ebert-May, 2004). Palomba and Banta (1999) describe assessment as a process that focuses on student learning; a process that involves reviewing and reflecting on practice as academics have always done, but in a more planned and careful way. Marchese (1987) describes assessment as the systematic collection, review, and use of information about educational programs undertaken for the purpose of improving student learning and development.

Below is a summary of each of the assessment strategies and activities that were conducted. These were used to address the research questions asked and to measure the student knowledge gained and student attitudes based on their experience.

Pre-test assessment (Appendix B)

To determine students’ previous content knowledge, as well as to illustrate the knowledge gained after doing the lab exercise, a pre-test was given to all participating students. The pre-test was meant to determine the students’ level of awareness of the issues surrounding uranium mining on the Navajo Nation, and assess the preconceived
knowledge the students may have had about the physiography, geology, climate, biota, hydrology, cultural heritage, and uranium deposits on the Navajo Nation, as well as the exploration and development history of uranium mining, environmental impacts, human health impacts and policies from this mining on the Navajo Nation. The pre-test was divided into three sections; (1) demographics, (2) content knowledge questions that addressed the above subtopics, and (3) questions on the student’s attitudes about learning in a web-based environment.

Learning activities (Appendix B)

This study was predicated on active-learning by the students, requiring them to investigate specific subtopics within the website while finding answers for a guided discovery worksheet, and then to organize and communicate their findings orally in groups to the class. The two activities that were used as the laboratory exercises to measure the effectiveness of this online teaching tool were the jigsaw activity (http://serc.carleton.edu/research_education/nativelands/jigsaw.html) and the role play activity (http://serc.carleton.edu/research_education/nativelands/roleplaying.html).

The nature of the two activities used in this lab was similar in many ways. Both activities are centered on learning in a web-based collaborative environment using the same online resource. Also, by using knowledge gained from this online resource, both labs were focused around answering the questions:

- What are the benefits from mining uranium on these lands?
- Who benefits from uranium mining on these lands?
• What are the impacts (e.g. health, economic) on the Navajo peoples and the local environment?

The product of both exercises included completed guided discovery worksheets showing what each student did individually, and closing discussions that address the three questions above about the overall issue of uranium mining on the Navajo Nation. However, in detail the implementation of the two activities and the questions on the guided discovery worksheets differed, resulting in different learning outcomes (i.e. different learning paths were pursued as students worked towards the ultimate learning goals).

In the jigsaw activity, four groups of students in each lab were required to explore specific dimensions of uranium mining on the Navajo Nation and become “experts” on their assigned subtopics (i.e. a directed discovery exercise). Each of the ten subtopic webpages was assigned to one group. In the next stage of the activity, students reconvened into new groups, with one member from each of the former groups. Each of the “experts” taught their subtopics to the other students, resulting in all students having gained knowledge in each subtopic with completed guided activity worksheets.

In the role play activity, the students were each assigned a role to play while carrying out this activity, including consulting geologists, the mining industry, tribal elders, or public health officials/EPA. In the role play activity, specific webpages were not required to be researched as they were in the jigsaw, but were recommended (i.e. an open discovery exercise). Because there was not as much emphasis on learning specific content knowledge on each subtopic, the students were able to concentrate more on the
overall issue, not the specific facts of each subtopic. Next, all the students playing the
same roles got into groups and decided on essential evidence that informed their point of
view for the “town meeting” or “report outs” to the class. During the “town meeting,”
the students debated their points of view and completed their guided activity worksheets.

The questions on the guided discovery worksheets that the students answered
were similar; however some questions appeared on the role play activity worksheet that
were not included on the jigsaw worksheet, and vice versa (See Appendix B). Subtopics
that both the jigsaw and role play guided activity worksheets covered evenly included
physiography, geology, environmental impacts, human health impacts and policy.
Because the jigsaw activity was by nature designed to teach each of the students about all
ten subtopics, its supplementary guided activity worksheet includes slightly more
questions specific to these subtopics so that the students gain content knowledge.
Subtopics that were covered in greater depth on the jigsaw worksheets are hydrology,
cultural heritage, uranium deposits, and exploration and development history. One
subtopic, climate and biota, was covered on the jigsaw worksheets, but not at all on the
role play worksheets.

The role play worksheet did ask many of the same questions as the jigsaw
worksheet, but also included additional questions not asked in the jigsaw. The answers to
these questions could not be found directly on the website. The answers reflect the
opinions of the students based on what they learned during the activity in the role they
were assigned. Motivation for this approach was partly to see if students could extend or
transfer the information to a new situation beyond the historical events already studied.
Questions the students who role-played the mining industry included, “How will you interact with the Navajo Nation if you go in and mine again?” and “How would the Navajo benefit from mining uranium again (jobs, profits, tax base, etc.)?” Tribal elder questions included, “Looking to the future, what impacts or benefits might you expect?” and “How will you balance potential jobs and revenues against environmental and health impacts?” Public health officials/EPA questions included, “What are your concerns about public health if the mines were to be reopened?” and “What would you require to protect these lands and waters if the mines were to be reopened?”

To assess the effectiveness of this website as a learning module, student attitudes and knowledge were measured as the students worked through the lab assignment by the researcher and the class TA. They filled out observation logs corresponding to each stage of the lab activity to record information about student reactions (amazement, outrage, confusion). These logs recorded attitudes about using the website while the students were on the computers. Also, “report-out” observation logs were used while the students were in groups discussing their topics and reporting these findings out to the class. Finally, both lab activities concluded with group discussions that were tape-recorded. These discussions were open to student feedback about the website, the activities, and the students’ personal attitudes on uranium mining on the Navajo Nation, or their increased awareness of the role of geology and environmental science in nation wide public policy in other examples similar to uranium mining on the Navajo Nation.
Post-test assessment (Appendix B)

The post-test was divided into three sections; (1) content knowledge, (2) questions about the student’s attitudes, and (3) usability of the website. The content knowledge section of the post-test was very similar to the pre-test in order to compare the knowledge the students gained after completion of their learning activity. The ranges of answers were scored on a continuum from no answer, needs improvement, adequate, quality, and exemplary. These answers were ranked according to the Cognitive Domain of Educational Objectives (Bloom, 1956). These include, ranking from lowest to highest skills, knowledge, comprehension, application, analysis, synthesis and evaluation.

The questions about student attitudes measured attitudes about learning in a web-based environment, learning in a collaborative environment, and about their personal attitudes on uranium mining on the Navajo Nation. These measurements included their increased awareness of the role of geology and environmental science in nation wide public policy such as the uranium mining on the Navajo Nation. The usability section of the post-test included a series of Likert scale questions addressing the quality of content on the website, as well as additional questions regarding the ease of use of the site.

Exam questions (Appendix B)

The final measure of content mastery was determined by questions on the formal class final examination. To gauge knowledge retained and student comprehension of the topic, two exam questions regarding the type of uranium deposit on the Navajo Nation, and impacts of uranium mining on the environment and human health were asked on the final exam.
The goal of these assessment tools is to assess individual student learning as demonstrated by performance on the instrument designed by the researcher (Table 1).

Table 1 - Research questions and data collection and analysis with corresponding assessment tools

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data collection and analysis</th>
</tr>
</thead>
</table>
| Do students effectively use this site to learn about the impacts of uranium mining on the Navajo Nation using an Earth system science approach? | 1. Pre-test/Post-test (Content knowledge)  
2. Exam Questions                                                                  |
| What advice can be given to faculty who design similar resources and/or use this site to teach? | 1. Usability Study  
2. Pre-test/Post-test (Content knowledge)  
3. Exam Questions                                                                  |
| Does this site facilitate the learning style preferences described by Felder (1993)? | 1. Learning Style Test  
2. Post-test (Content knowledge)                                                    |
| What do students actually do when working in this environment? (E.g. search with a purpose, wander aimlessly, jump from site to site, spend time looking at a topic in depth?) | 1. Observation Log 1 (Website discovery)                            |
| Does this thematic collection enable or hinder student research? Does it facilitate inquiry, discovery and in-depth analysis, or does it provide too-easy access and superficial understanding? How does it impact critical thinking and information literacy? | 1. Post-test (Student attitudes)                                      |
| Does this web-based thematic collection serve as a possible motivator for learning as suggested by Edelson (2001)? | 1. Post-test (Student attitudes)                                      |
CHAPTER THREE

USABILITY STUDY

Introduction

A usability study was conducted to test the quality of content and design of the Impacts of Resource Development on Native American Lands website. The goal of this study was to identify any revisions and new information needed to enhance the effectiveness of this online teaching and learning module prior to implementing the second part of the study focused on learning outcomes.

Methods

Participants

The participants for this study consisted of thirteen volunteers. The participants ranged from age 19 to 59 and consisted of three upper level Earth science undergraduate students (two MSU, one non MSU), six MSU Earth science graduate students, one MSU physics graduate student, one MSU professor of geology, and two non MSU community members (Table 2). All participants were familiar with the research objectives and goals of this project. This population was composed of eleven Caucasians (C), one Native American (NA) and one Hispanic American (HA). There were seven males and six females.
Table 2 – Participants of usability study demographics

<table>
<thead>
<tr>
<th>ID #</th>
<th>Age</th>
<th>Sex</th>
<th>Nationality</th>
<th>Major/Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56</td>
<td>M</td>
<td>Caucasian</td>
<td>Geology Professor (MSU)</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>M</td>
<td>Native Am.</td>
<td>Earth Science Graduate Student (MSU)</td>
</tr>
<tr>
<td>3</td>
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<td>F</td>
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<td>Earth Science Undergraduate Student (MSU)</td>
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<td>Earth Science Graduate Student (MSU)</td>
</tr>
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<td>Caucasian</td>
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<tr>
<td>6</td>
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<td>F</td>
<td>Hispanic Am.</td>
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</tr>
<tr>
<td>7</td>
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<td>F</td>
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<td>23</td>
<td>N</td>
<td>Caucasian</td>
<td>Physics Graduate Student (MSU)</td>
</tr>
</tbody>
</table>

Instruments/Materials

The instrument used to perform this pilot study (Appendix D) was designed by the researcher with guidance from previous usability studies performed on similar websites. The questions and tasks asked of each participant were identical. Prior to the study, each of these tools and the format of the usability study were reviewed by Karin Kirk (MSU) and Ellen Iverson (SERC), both having performed similar studies on web development at SERC.
Design/Procedures

The usability study was conducted in a two and a half hour time block. As compensation for time spent taking part in the study, a pizza lunch was provided. The study consisted of participants working independently on computers, thoroughly reading through each webpage while documenting their questions, comments, and concerns on observation logs (Appendix D) provided by the researcher for 90 minutes. The next 15 minutes consisted of the participants filling out a questionnaire that rated the quality of content and ease of use of the website on a 1-5 Likert scale, and answering questions about the quality, usability, and other additional aspects of the site (Appendix D). The final 45 minutes of the usability study consisted of a discussion between the participants, the researcher, and the researcher’s advisor, Dr. David W. Mogk, about the website usability.

In this study, three scenarios were used to start participants off with their web reviewing tasks. Scenario one included five participants, while scenarios two and three included four participants each. Scenario one is finding information on this site for an introductory course for environmental geology. In scenario two, this site is found on a Google™ search by an introductory level Earth science instructor. They are asked if they can find information to adopt or adapt to their classes. In scenario three, an environmental geology student is asked if they can use this site for their research project on the impacts of resource development on a Native American land.

During the first part of the study, the researcher monitored the participants and made observations (body language, enjoyment/frustration navigating, etc.). The
researcher did not interact with the participants during this part of the study, as the participants were asked to keep track of what they were doing on observation logs. During the final section of the study, the participants were invited to voice any questions, concerns, comments and ideas related to the website. This focus discussion consisted of a conversation about the clarity of the website as well as the participants’ general attitudes about the site.

Following the usability study, data analysis was conducted so that the researcher could take into consideration the comments and advice of the participants to make the teaching/learning module as effective as possible. Based on these recommendations, the website was revised to heighten the website’s effectiveness, ease of use, quality of content, clarity, and overall usability.

Results and Discussion

Each of the above scenarios was assessed on a 5-point Likert scale from 1 (strongly negative) to 5 (strongly positive) (Figure 5). The questions correspond to the usability study questions in Table 3. Respectively, the average participant answers for the scenarios for all 10 questions are 4.20, 4.18, and 4.13 out of a possible 5. The average for all of the questions, including all three scenarios is 4.17 out of 5. Because these results are all over 4 on average, the participants agreed that quality of the content on the website is well suited for each of the three scenarios presented.
Participants were asked if they were at all familiar with this topic before this study. Results showed that seven participants were not familiar with this topic, while four were vaguely or slightly familiar with it; however none of them were educated specifically on the topic of uranium mining on the Navajo Nation. Eleven of the
participants wanted to explore the topic further, and two stated they would if they had time.

The question that asked how the content was engaging to the participant, yielded many responses. One participant stated, “The site allows you to get into a proposed topic. If you read something and then had a thought for more knowledge on a topic related, there would be a link available to explore more deeply into the new topic,” while another stated how convenient it was “to know that more info is just a click away [and] allows you to get into it easily.” Five of the participants mentioned that they enjoyed the subject matter and the story being told by the webpages. Also mentioned as engaging to the participants were the graphics, photos, maps, diagrams, easy to follow links, summary of text, and the ease of navigation. Recommendations given by the participants to make the site better included adding more teaching exercises and more full text articles from scientific journals.

Next, the participants shared their thoughts about what specific content was useful and not useful or difficult to understand on the website. The participants mentioned specific pages as being useful, including the geology, human health, and environmental impacts pages. Other topics stated were the background on the Navajo culture, the geology of the Colorado Plateau, overview of key issues with links to more in-depth references, general overview material, links to government pages, and links to outside sites and maps. Conversely, only three participants responded to the question about the content that was not useful or difficult to understand. These responses included the policy page was not in depth enough, the paleoclimate information was confusing, and
some links seemed too technical. Overall, the participants were satisfied with the text that was provided in the webpages, but one participant thought the test was not very helpful because it was a largely descriptive overview.

Additional recommended content additions to the site included more information on human health and environmental impacts, more information about the actual processes that are used in the mining process, more information about the positive uses of uranium (nuclear energy, medicine and electronics), and more information on the policies surrounding the issue of uranium mining. One concern identified by participants was the issue of fairness and balance in the coverage of this controversial topical issue that needs to be attended to so there is no bias apparent from the web designer.

Each of the above scenarios was also assessed on a 5-point Likert scale from 1 (strongly negative) to 5 (strongly positive) for ease-of-use (Figure 6). The questions correspond to the usability study questions in Table 5. As in the above figure, scenario one included five participants, while scenarios two and three included four participants each. Respectively, the average participant answers for the scenarios for all seven questions are 4.31, 3.93, and 3.96. The average for all of the questions, including all three scenarios, is 4.07. Because these average results are all at about 4, it can be said that the participants agree that the ease of use of website is well suited for each of the three scenarios presented.
Table 4 – Quality of content Likert scale usability study questions
1. I frequently use the internet to find resources similar to this.
2. I would use this site for research if I came across it while searching online.
3. At first glance I could identify the basic content of the website and the intended audience.
4. The site was structured so that I could easily find information that interested me.
5. After browsing through one particular section of the site, I found myself familiar with how other sections were organized.
6. Overall, I am satisfied with how easy it is to use this site.
7. I would recommend this site to colleagues.

The participants stated that they would be brought to this website mostly by Google (n = 10), or by a colleague/professor recommendation (n = 6). The most interesting pages mentioned were geology (n = 4), cultural heritage (n = 3), physiography (n = 3), climate and biota (n = 3), human health (n = 2), and uranium deposits (n = 2). One participant recommended that the references should be prioritized in order of importance. Finally the participants rated their impression of the completeness of the
document on a scale 0 (least complete) to 10 (most complete). The average of these responses was 8.6, showing that they were extremely satisfied with this website as a learning tool. As one participant stated, “[This is a] great website, well designed and planned out.” The most common recommendation to improve this website came about during the closing discussion. This included not providing enough information to inform the view of the US government and mining industry, as well as the removal of personal bias.

Conclusions

Results from the usability study show that the majority of participant comments support the webpages as they were; however some comments recommended that changes be made. These recommendations include minor text and coverage modifications on most of the webpages, more visuals be added, and that references be prioritized based on importance. From these recommendations, the researcher modified the webpages to make the website more effective as a learning module.

With an average response of 8.6 out of a possible 10 on completeness of this document, all participants were satisfied with this website as a learning module. The only major recommendation to improve this online resource had to do with the issue of bias. Most of the participants agreed that information about why the government/mining industry needed uranium was not as well represented as the impacts on the Navajo from this mining. Some agreed that my opinion as the web developer was clearly on the side of the Navajo, and that information provided to teach about the issue needed to be more
balanced. To improve the learning/teaching module based on these recommendations, the researcher added more information about why uranium mining was desired during the Cold War and about the positive aspects of uranium mining.
CHAPTER FOUR

LEARNING OUTCOMES AND RESULTS

Introduction

To discuss the results and learning outcomes of the study, a look was taken at whether students effectively used this site to learn about the impacts of uranium mining on the Navajo Nation using an Earth systems approach, as stated in Table 5. This was addressed using the content knowledge results from the pre- and the post-test. Based on these results and observations, advice was given to faculty who design similar resources and/or use this site to teach. Next, this study showed the relationship between learning styles as described by Felder (1993), and learning outcomes also illustrated in Table 5. This question is addressed by correlating the content knowledge results from the post-test to the results of the learning style preference test. Next, observations that were made during the lab activity of what students actually do when working in this environment are discussed. Following this, whether or not this thematic collection enables or hinders student research is discussed. This was analyzed by reviewing the student results in the attitude section of the post-test (Appendix B). Finally, a look was taken at whether a web-based thematic collection, such as the Impacts of Resource Development on Native American Lands, can serve as a possible motivator for learning by analyzing student results from the attitude section of the post-test (Appendix B).
Table 5: Hypotheses/questions examined in this study

<table>
<thead>
<tr>
<th></th>
<th>Hypotheses/questions examined in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Students will effectively use this site to learn about the impacts of uranium mining on the Navajo Nation using an Earth system science approach.</td>
</tr>
<tr>
<td>2.</td>
<td>What advice can be given to faculty who design similar resources and/or use this site to teach?</td>
</tr>
<tr>
<td>3.</td>
<td>This site will facilitate all of the learning style preferences described by Felder (1993).</td>
</tr>
<tr>
<td>4.</td>
<td>What do students actually do when working in this environment?</td>
</tr>
<tr>
<td>5.</td>
<td>Does this thematic collection enable or hinder student research? Does it facilitate inquiry, discovery and in-depth analysis, or does it provide too-easy access and superficial understanding? How does it impact critical thinking and information literacy?</td>
</tr>
<tr>
<td>6.</td>
<td>Does a web-based, thematic collection serve as a possible motivator for learning as suggested by Edelson’s (2001)?</td>
</tr>
</tbody>
</table>

Research Question 1: Learning Outcomes of Content Knowledge

The question, “Do students effectively use this site to learn about the impacts of uranium mining on the Navajo Nation using an Earth system science approach?” is addressed in this section. The student results were analyzed with content knowledge questions on the pre- and post-test. The pre-test results illustrate that most students participating in this study had no prior knowledge of this topic or any of the subtopics researched. Few responses illustrate any prior knowledge about the topics covered in this laboratory exercise are found (Table 6).
Table 6 – Pre-test knowledge about uranium mining on the Navajo Nation

<table>
<thead>
<tr>
<th>Subtopic</th>
<th>Student comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiography</td>
<td>- many students know that the Navajo Nation is somewhere in the southwest</td>
</tr>
<tr>
<td>Hydrology</td>
<td>“That their have been severe damage to their drinking water due to uranium mining (SIC)”</td>
</tr>
<tr>
<td>Hydrology, Human Health Impacts</td>
<td>“Only what I have learned from the movies, such as Thunder Heart, about how the govt was mining for uranium and ruined their river supply and poisoned the people (SIC).”</td>
</tr>
<tr>
<td>Climate</td>
<td>- many students know area is dry with low precipitation</td>
</tr>
<tr>
<td>Cultural Heritage</td>
<td>- three students recognize that the Navajo were the WWII code talkers</td>
</tr>
<tr>
<td>Cultural Heritage</td>
<td>“I know a little about Navajo customs and beliefs because my mom used to work there.”</td>
</tr>
<tr>
<td>Uranium Deposits</td>
<td>“Uranium deposits are common along the Dirty Devil River in Utah on or near the Navajo Nation.”</td>
</tr>
<tr>
<td>Uranium Deposits, Human Health Impacts</td>
<td>“There are uranium deposits on the Navajo Nation. I believe many of the people were forced to work in the mines and unaware of the hazards.”</td>
</tr>
<tr>
<td>Environmental Impacts</td>
<td>- seven students think that uranium or radiation is bad for the environment, but do not give specifics</td>
</tr>
<tr>
<td>Human Health Impacts</td>
<td>“Uranium mining has numerous impacts on the environment because it scars the landscape and basically leaves huge mining holes and hills.”</td>
</tr>
<tr>
<td>Human Health Impacts</td>
<td>- four students recognize that uranium can cause cancer, with no specifics on what kind</td>
</tr>
</tbody>
</table>

First, student post-test content knowledge responses were transcribed and scored (coded), according to the content knowledge rubric (Appendix B) on a scale from 0-4. These answers were expected to be brief, as the time allotted for the entire post-test was only about 10 – 15 minutes. This rubric was designed with help from the expertise of Ellen Iverson, assessment specialist at the Science Educational Resource Center (SERC) and Dave Mogk.

Students who scored at least a three (3) had very specific answers, while students with a score of two (2) were correct in their responses, but were not as specific. To earn a score of four (4), the student response had to be extremely detailed, having exceeded
what was expected of them. Students with a score of one (1) either did not provide a
detailed enough response, or were partially correct. Students with a score of zero (0) had
no response, a question mark, or an incorrect response. The students were given no
guidance in what to write for the answers on the post-test (e.g. sandstone, Colorado
Plateau). If students did not give a response to a question, it did not necessarily mean
they did not know the answer, as some students ran out of time completing the post-test,
and some students only completed the sections on the post-test that they specifically
researched.

Figure 7 represents the post-test results for all students (n=269) who participated
in this study for each of the ten subtopics covered. When grading the student responses,
an answer was not given credit if it was repeated. For example, many students discussed
the Colorado plateau in the physiography section, and then again in the geology section,
and did not receive credit twice (as this was not a correct response according to the rubric
for the geology section). For environmental impacts, if students scored a one (1), they at
least knew that the environmental effects were negative, and for human health impacts, if
students scored a one (1), they at least stated that humans were negatively affected by
mining. Results of the policy subtopic illustrates that scores are lower because many of
the students do not know what the word policy means, “policy was used to indicate
whether it was a good or bad policy to mine uranium. Hydrology and policy scores were
low because many groups did not have enough time during the allotted web discovery
portion of the lab to research these subtopics. Climate/biota received the lowest subtopic
score. This is because the role play activity did not require or even recommend that any
of the groups explore the climate and biota page. This lack of research by about half of the participants resulted in most scores indicating either ‘poor’ or ‘adequate’ performance in this subtopic.

Figure 7 shows that in every subtopic at least 51% of the students scored in the ‘average’ range, with a score of two (2) and above, and at least 24% of the students scored in the ‘good’ and ‘excellent’ range, with scores of three (3) and four (4), respectively. Scores of two (2) and above range from 51% in the climate/biota subtopic to 92% in human health impacts. Scores of three (3) and greater range from 24% in hydrology to 65% in human health impacts. The mean for students who scored at least a two (2) for all subtopics is 42%, with the mean of students scoring at least a three (3)
being 71%. Student performance was highest in human health impacts, environmental impacts and uranium deposits, while it was lowest in climate/biota.

Data about what specific pages each of the students researched was gathered from the post-test (Figure 8). On the post-test, many, but not all students self-reported what specific pages they researched. Self-reports from those students who participated in the jigsaw activity had much better documentation of who researched what page, as they were required to research certain pages.

![Post-test Performance for Students who Specifically Reported Researching a Webpage Topic](image)

Figure 8 - All student post-test results for pages that students specifically researched.

Figure 8 shows that in every subtopic at least 83% of the students scored in the ‘average’ range or better, with a score of two (2) and above, and at least 49% of the students scored in the ‘good’ and ‘excellent’ range in every subtopic, with scores of three
(3) and four (4). Scores of two (2) and above range from 83% in the geology subtopic to 100% in the climate/biota, cultural heritage, uranium deposits, and human health impacts subtopics. Scores of three (3) and greater range from 49% in hydrology to 92% in climate/biota and uranium deposits. The mean for students who scored at least a two (2) for all subtopics is 94%, with the mean of students scoring at least a three (3) being 72%. If a student was specifically assigned to research a subtopic, or as in the jigsaw activity, teach their group about the assigned subtopic, performance is extremely high. Only a mean of 6% of these students scored in the ‘poor’ and ‘adequate’ ranges.

When comparing the two classes used in this study, ESCI 111 and ESCI 112, there is little variation from class to class (Figure 9). The average performances for students in ESCI 111 and 112 consecutively are 11% and 13% ‘poor’, 15% and 18% ‘adequate’, 30% and 29% ‘average’, 32% and 29% ‘good’, and 12% and 11% ‘excellent’. The mean difference between the two classes is never more than 3%, illustrating that there is almost no difference in student performance by class.
As expected, Figure 9 shows that the students enrolled in ESCI 111, Physical Geology, performed better in the geology section, having spent half of their semester, up to this lab, learning about geology. It was expected that ESCI 112, Introduction to Geography, would have performed better on the climate section, since they studied climate prior to the study, but they did not. The two variables that may control these unexpected results are that the climate subtopic is combined with the biota category, and prior to this lab, only 1-2 week(s) of climate study was covered.

However, when comparing the two activities (the jigsaw and the role play) that the students took part in, there was a difference in student performance. As illustrated in Figure 10, average performances for students who took part in the jigsaw and role play activities consecutively are 9% and 16% ‘poor’, 14% and 22% ‘adequate’, 30% and 27% ‘average’, 34% and 26% ‘good’, and 13% and 9% ‘excellent’. There are a larger number
of role play students who performed in the ‘poor’ and ‘adequate’ categories, and more jigsaw students who performed in the ‘average’, ‘good’ and ‘excellent’ categories.

![Diagram showing post-test results for Jigsaw vs. Role Play activities](image)

Figure 10 – Comparison of student performance in the content knowledge section of post-test of the jigsaw and role play activities for all students

In aggregate, more content mastery was achieved in the jigsaw activity; however, regardless of activity, in every case except the role play climate/biota category, at least 25% of the students performed at a ‘good’ to ‘excellent’ level. The students who participated in the jigsaw performed better in culture subtopic possibly because they were specifically assigned to learn about it, whereas those taking part in the role play were simply assigned to be the ‘tribal elders’ and to be able to talk about how uranium mining affects their people. This steered them more toward learning about the environmental and human health impacts, yielding high marks in these categories regardless of activity. It is unknown why role play students performed better in the hydrology subtopic.
No matter which activity was done, if a student specifically researched a webpage, they did well according to the rubric (Figure 11). In every subtopic, at least 79% of the students scored at least in the ‘average’ range. The only considerable differences lie within the subtopics of exploration and development history and policy. Students who did the jigsaw likely performed much better in exploration and development history and policy because of the nature of the activity, which geared students to learn the material by subtopic, and then taught each reconvened group member the information. The role play activity is not as structured regarding subtopics students had to research, and the students did not ‘teach’ specific information to each other.
Figure 11 - Comparison of student performance in the content knowledge section of post-test of the jigsaw and role play activities for students who self-reported specifically researching a subtopic.

Two questions about uranium mining of the Navajo Nation were asked on the final exam to test student knowledge and information retention. There were factors that limit the accuracy of the exam question data. The exam was required of all students in both ESCI 111 (n = 135) and 112 (n = 153) were required to answer the two exam questions pertaining to this lab on the final exam. The number of these students who participated in the lab is unknown because results are only known in aggregate. Also, there are six (6) students who were enrolled in both ESCI 111 and 112. The two exam questions are shown in Table 7.
Table 7 - Final Exam Questions

1) Which of the following best characterizes uranium deposits on the Navajo Nation?
   a) sandstone-hosted roll-front deposits
   b) erosion remnants of volcanic pipes
   c) Precambrian crystalline rocks
   d) all of the above

2) Health and environmental impacts related to uranium mining on the Navajo Nation include:
   a) water contamination
   b) high occurrence of lung cancer
   c) airborne dispersion of radioactive material
   d) all of the above

Figure 12 - ESCI 111 final exam question results
In ESCI 111, there were 155 enrolled students, 122 who participated in the lab for this study, and 135 who took the final exam and answered the two questions about uranium mining on the Navajo Nation. In question 1 (61 in Figure 12), 33% (n = 44) of the students answered correctly. The results for questions 2 (62 in Figure 12) yield much higher results, with 96% (n = 130) correct.

In ESCI 112, there were 173 enrolled students, 144 who participated in the lab for this study, and 153 who took the final exam and answered the two questions about uranium mining on the Navajo Nation. In question 1 (99 in Figure 13) 31% (n = 48) of the students answered correctly. The results of questions 2 (100 in Figure 13) yield much higher results, with 96% (n = 147) correct.
Research Question 2: Teaching Advice

Next the question, “What advice can be given to faculty who design similar resources and/or use this site to teach?” was addressed. Because it has been shown that students do learn from this website, it is apparent that faculty can use this site to teach. It is important to note, however, that explicit instructions are needed to achieve desired results, and equal emphasis on each subtopic must be given to the students prior to the activity. For example, learning goals must be clearly defined, examples of expected outcomes could be provided, and seeing how the scoring rubric is set up could help to move students towards more comprehensive learning. In other words, if an instructor wants students to look at and learn about something, they should be explicitly instructed to do so. As seen in this study, the role play activity does not specifically direct students to look at the climate/biota page, therefore many of them did not, which yielded diminished student performance in this subtopic.

As illustrated in Figures 10 and 11, if the intent of the educator is content mastery, the jigsaw activity proved to be a better teaching method to use to teach using these webpages. On the other hand, observation log role play comments support that students were able to take the knowledge they gained beyond the situation of uranium mining on the Navajo Nation, and relate it to other similar subjects, such as “the poisonous lake in Butte.” Other representative comments include, “Native Americans seem to get screwed by the government too often”; “I’m from near the Fort Belknap Reservation, and I know bad stuff happened there too. This makes me want to learn more about it”; “It’s like Erin Brockovich; this stuff really happens!”; and “Libby, MT is a superfund site right, why
isn’t the Navajo Nation?” The role play exercise may be more effective if the educator is interested in having students understand real-time environmental issues, apply the knowledge they gained from the lab to real life situations, and get them personally interested to learn more.

Because they were ‘role playing’ real people, the human aspect of the problem became more real to them, i.e. the people who played the tribal elders and the EPA showed a lot of emotion about why the mining industry should not go back in and mine again. The students who did the jigsaw showed some emotion about the situation, but the observations and comments were very few, and in most cases non-existent. They did not stay centered on the overall topic of uranium mining on the Navajo Nation, but were concentrating on the 10 subtopics instead. They did not return to the overall issue until the end of the lab during the discussion, whereas the role play students were concentrating on the overall issue most of the class period. The students who did the role play activity were the majority of students who personally wanted to know “What can I do to help?” and “What can we do to keep this from happening again?”

Research Question 3: Learning Style Preferences and Student Outcome of Content Knowledge

The question “Does this site facilitate the learning style preferences described by Felder (1993)?” is addressed in this section by using the analysis of the content knowledge questions on the pre- and post-test stratified by the student learning style preference results.
Prior to correlation to the content knowledge results, student learning style results were analyzed all together, regardless of class. By separating out the moderate-strong and mild preferences (Figure 14), the results of the Learning Style Preference test were compared to previous studies done with engineering students at Ryerson University and San Jose State University. Additional studies include social work students at Arizona State University, and Brazilian science and humanities undergraduate students (n=2,120; not including Arizona State University students) (Felder and Spurlin, 2005). Results from Felder and Spurlin (2005), in addition to the results from this thesis study can be viewed in Appendix C.
Figure 14 - Normalization of learning style preferences from thesis vs. previous research

As shown in Figure 14, the ranking of each division is very similar for participants from this study compared with the previous research done. In graph 14a, the order is mild active/reflective, active, then reflective. In graph 14b, the order is mild sensitive/intuitive, sensitive, then intuitive. Graph 14c is the only one showing the highest rank not in the mild preferences, with visual first, then mild visual/verbal, followed by verbal. Graph 14d ranks mild sequential/global first, sequential second and global last. Because the uncertainty is lower the larger the number (n) is, there is a low uncertainty (about 5%) for the previous studies, and with the thesis study being identical
in rank, the uncertainty is also low. The exact same learning style preference test was 
given to the students in the previous and current thesis studies. Results from this study 
were randomly sampled, and therefore representative of the population. All of the 
students in both ESCI 111 and ESCI 112 were used in analysis.

When comparing this thesis and previous learning preference results, all are 
within 10% of each other except for the students classified as active, intuitive and visual 
learners. Active students show a difference of 11%, intuitive students show a difference 
of 15%, and visual learners show a difference of 16%. All three of these categories show 
the larger percentage of students in the Earth sciences. This suggests that students who 
self choose an introductory Earth science may be likely to be more active, intuitive, and 
visual learners. Differences in learning style preferences between students in ESCI111 
(Physical Geology) and ESCI112 (Physical Geography) students were minor (less than 
5%); therefore, they are analyzed together as Earth science students.

The next stage of analysis correlated the student results from the content 
knowledge section of the post-test with the learning style preference results from the 
Index of Learning Styles Questionnaire (Appendix C). To analyze what learning styles 
were favored using this online educational tool, the strong and moderate learning styles 
were examined, while eliminating the results from all of the students who are considered 
by Felder (1993) and others to have a mild learning style preference (Figure 4). For this 
analysis, the students with unknown learning style preferences are also omitted. Figure 
15 represents all student participants in this study who have strong and moderate active, 
reflective, sensitive, intuitive, visual, verbal, sequential, and/or global learning style
preferences for each of the ten analyzed subtopics. Because there was only a number of four (4) verbal learning style preference students, these data was excluded from the analysis. Verbal students constitute too small a sample of the population.
Figure 15 - Post-test results for students with strong and moderate learning style preferences for all subtopics
The chi-squared statistic (Appendix C) for each of the ten subtopic areas is insignificant, and the smallest p-value is 0.3876. Consequently, there are no significant differences for any of the 10 topics in student performance for any of the learning preferences (Figure 15). The distribution of data are essentially uniform and only deviate by a few percent. In most cases ‘excellent’ and ‘good’ are 50% or greater, and ‘average’ ~75% or greater. This learning environment is independent of learning style, and addresses learning needs of students from across the learning style spectrum.

Figure 16 represents the results from average student performance on all ten subtopics of the content knowledge section of the post-test, correlated by learning style preference. With each learning style preference, at least 69% of the students received a score of at least two (2), or ‘average’. For at least 40% of the students from each learning style preference category received a score of at least three (3), or ‘good’; and at least 10% of these students received a score of four (4), or ‘excellent’. The learning styles that show the best performance in the average of all content knowledge subtopics, receiving at least a grade of two (2) or ‘average’, include reflective at 77% and intuitive at 73%. The sensitive learning style preference shows an average score of 69%, the poorest performance of all content knowledge subtopics. The learning style preference results as a whole show no significant difference from one learning style to the next in terms of student performance. The chi-squared statistic for the mean of all subtopics is insignificant (31.11) (Appendix C). Therefore, the distribution of performance by learning style preference in all cases is nearly statistically identical. For these results
with the students who have mild and unknown learning style preferences, refer to Appendix C.

![Mean Post-test Performance for Students with Strong and Moderate Learning Style Preferences](image)

**Figure 16 - Mean post-test results for students with strong and moderate learning style preferences**

**Research Question 4: Working in the Web Environment**

In this section, 41 observation logs that were kept by the researcher and the TAs are reviewed to address what the students actually did when working in the web environment section of this lab. Some questions include: do they search with purpose, wander aimlessly, jump from site to site, and/or spend time looking at a subtopic in depth? Are they motivated to explore the entire resource available? Do they show comprehension of the topic (e.g. one student explains something to another student)? What is their quality of experience (expressions on how they feel about doing this lab)? Are they engaged? Do the students reveal reactions/feeling about the subject? And, do
the students appear to be engaged in learning in a web-based environment? The TAs were given a training session, and supplied with rubrics on how to make and record their observations. The “Observations of Web Use, Discovery and Effectiveness” observation log and supplementary rubric that address this section are presented in Appendix B.

The results to the first observation topic, “ability to find useful/relevant resources for assigned task” is separated into four categories: the students are obviously finding the information they are looking for; the students are mostly finding the information they are looking for; the students are somewhat finding the information they are looking for; and the students are mostly not finding the information they are looking for. The observers kept a tally of every time they made one of these observations, and each observer spent time with the four groups in their assigned labs. These observation results show that two (2) observations were made where students were completely lost, 17 observations that students were struggling, 16 for students finding information with help or after time, and 143 for students who went right to the source and had no problems. Recorded comments generally suggest that the students did not have trouble finding their way to and around the website. They include, “Just click it [the next subtopic they are researching] from the menu on the side,” and “Check it out, all the pages are the same. That sure makes it easy to get around!”

The results of the second observation topic, “students were motivated to fully explore the resource available (pursued at least two links from the subtopic being researched)” is separated into four categories: the students went directly to multiple sources; the students were able to find more information with direction; the students were
struggling to find information; and the students are not motivated. The observers kept a tally of every time they made one of these observations, and each observer spent time with each of the four groups in their assigned labs. These observation results show that four (4) observations were made where students were completely unmotivated to check out links; six (6) observations that students were struggling; 12 for students who were able to find more information on other websites with direction; and 130 for students who went directly to multiple sources. Comments that were recorded range from “There is just too much information here” to “We could search these links for days and still keep finding more about how messed up this is [about the environmental impacts]” to “We need more time!”

The results of the third observation topic, “evidence of comprehension of the topic (e.g. one student explains something to another student)” is separated into four categories: students are discussing information learned in access, and know what they are talking about, and they are not just reading facts; students are mostly discussing the topic, using facts in their discussion, and students are equally discussing topics and listing facts; and students are mostly regurgitating facts, with little discussion. These observation results show that no observations were made where students were completely lost, ten (10) observations that students were struggling, 13 for students who were able to eventually address the content correctly, and 34 for students who showed that they mastered the material. Representative comments include examples of many of the students explaining things to other students, including, “See how it [uranium deposits] is close to the surface? This makes it easy to mine 'cause it is not to deep in the Earth”;
“It’s so sad, everything they need in their lives now is pretty much contaminated – the water, their homes, the land”; “It is mostly bad, but the Navajo did benefit with money and jobs”; and “I’m actually learning some geology without being totally confused!” Some of the observers simply noted that one student explained a topic to another, including explanations of what a roll-front deposit is, the impact of radioactive pollution on water and air quality, the Radiation Exposure Compensation Act, and a few discussions about the EPA and the impacts the Navajo people are still dealing with today.

The results of the fourth observation topic, “quality of experience (student’s express how they feel about doing this lab)” is separated into four categories including exceptional (n = 6), ‘good’ (n = 17), ‘adequate’ (n = 4) and ‘poor’ (n = 3). The few representative comments include both positive and negative experiences. Comments representative of negative experiences include, “I don’t learn well on computers. I have to hear it and see it,” “I have more important things to do,” and “I hate learning from the web.” Comments representative of positive experiences include, “This is not like the other web labs we did, I like this,” “I like learning myself like this,” “This is a cool lab,” and I like this lab, it’s different than the rest – you get into it.”

The results of the fifth observation topic, “students were engaged” are separated into not at all engaged, little engaged, mostly engaged, and extremely engaged. The two observers rated each of the four groups participating in each lab. Of the 41 collected observation logs, 9 of them did not record observations, and not all observation logs rated each group. These results show that one group was not at all engaged, 19 groups were a little engaged, 63 groups were mostly engaged and 41 groups were extremely engaged.
The results of the sixth observation topic, “students reveal reaction/feelings about the subject” are separated into no feeling, little feeling, some feeling and obvious feeling. The two observers rated each of the four groups participating in each lab. Of the 41 collected observation logs, 13 of them did not address this question, and not all observation logs rated each of the groups. The results show that 21 groups were rated with no feeling, 36 with little feeling, 25 with some feeling and 30 with obvious feeling. Comments that represent the feelings of the students include, “Dude, the government might not have known how bad it was, but they had to know it wasn’t good…maybe they didn’t know to what extent it was bad”; “All these families lost their fathers and grandfathers…it is so sad”; “The government doesn’t have too much of a cleanup program!”; “Butte looks good compared to this!”; “This is ridiculous [about children playing near abandoned mines]!” and “What can we do to help?” One student shared a story about his uncle who works in a mine, and how he and his family are always worried about safety. He stated, “Just imagine how these people felt!”

The results of the seventh observation topic, “students appear to be engaged in learning in a web-based environment” are rated by the observers based on how many of the students in each group were engaged; whether all, some, or none. Again, the two observers rated each of the four groups participating in each lab. Of the 41 collected observation logs, 10 of them did not address this question, and two observation logs did not rate each of the groups. The results show that in two groups, there is one dominant student, in 27 groups most of the students are engaged, and in 90 groups, all of the students are actively engaged in the web exploration portion of this lab.
As data from hypothesis 4 illustrate, most all of the students stayed on task, were motivated to explore beyond the website being tested (followed other links), showed comprehension of the topic, and were engaged during web exploration. The results also show that many students (mostly who participated in the role play activity) did not just do the assignment, but showed some sort of feeling toward the subject matter.

Results from the web use, discovery, and effectiveness observation logs strongly support the conclusion that student learning took place in this web environment. This is because the students were engaged in what they were learning and motivated to learn with guidance from activity directions and guided discovery worksheets.

Research Question 5: Working in the Web Environment II

In this section, we address the questions, “Does this thematic collection enable or hinder student research?”; “Does it facilitate inquiry, discovery and in-depth analysis, or does it provide too-easy access and superficial understanding?”; and “How does it impact critical thinking and information literacy?” In other words, we are investigating whether we take students too far down the path, create an environment that empowers them to learn, or just lose them. To answer these questions, we analyze data from the post-test. The specific questions we are looking at is “Compared to styles of non web-based learning (lecture, labs): a) How do you feel about learning in a web-based environment?; b) What aspects of web-based learning help you to learn better?; and c) What problems have you encountered with web-based learning?”
The first question, “How do you feel about learning in a web-based environment?” yielded 134 answers with positive feelings about it, 47 with negative feelings, and 78 students who were indifferent. The students who did not answer this question were not counted. The number of reported negative feelings was one-third that of the reported positive feelings. The majority of students have had a positive experience when working in a web-based environment. The most common reason the students gave for a negative experience is the lack of human aspect to learning. Examples are, “There is no teacher to guide you along,” “I like direct contact better,” and “I like learning from real people better.” Many students also stated that it is hard to learn in this environment because there is too much information. For example, one student said, “Sometimes harder because of so much information and the different links to go to.” The other responses seen repeatedly are that students just prefer lecture, or that the web is still new to them. Examples are, “Depends on how it’s used but I still do not remember the information as well as a lecture,” and “It’s ok, but I prefer lecture. Web-based environment is still new to me.”

Of the approximate one-third of students who were ambivalent, most of their responses were similar to the following: “It’s OK”; “It’s alright”; “Doesn’t bother me”; “About the same”; “I have mixed feelings”; “I am comfortable with it”; “OK as a supplement”; and “Alright as long as the directions are clear and detailed.” There were a few more specific comments such as, “It’s not my strongest because I hate computers, but it beats watching a guy read me this power point presentation.”
The majority of the comments were of a positive nature. The most common responses are about the students being able to work at their own pace, including, “I can work at my own pace”; “Easily learned as far as being able to read & learn at your own pace”; “It allows you to review what you learned as you need to”; “It’s better for me, I know what I have to do and I stay more focused”; and “It’s easier to be able to go at your own pace, and I like how he (Skidmore) posts his lectures.”

Many students also commented on the positive nature of an interactive and visual environment. Representative student comments include, “I like the interactiveness and how up to date the info is”; “I think you learn more because it’s more interactive than a lecture”; and “its more visual and I’m a visual learner.” Still more comments show that students believe they are more focused and retain information better when learning in this environment. For example, “I like it because it keeps me more focused”; “Works very well for remembering”; and “It helps make connections.” Students also believe that it is better because there is more information, stating that “you can get more information at one time, so it is better in that sense”; and “I like it better – more information at your fingertips.” Other positive feedback includes, “I feel more confident because material is all in front of you”; “it is more enjoyable and allows you to investigate. I would not have had the ability to say nearly anything about the subject if it was just a lecture”; and “I think that learning in a web based environment is a good and fun way to learn. I believe that someday we will have fewer books and more info online.”

Results from the next question, “What aspects of web-based learning help you to learn better?” illustrate that students in this study learn better when they are able to learn
at their own pace, use the visual aspect (maps, pictures, movies, diagrams, graphs) and interactivity of the web, have a plethora of information at their fingertips to search as far as they need, and are responsible for their own learning.

Students who like learning at their own pace made comments including, “The ability to explore and learn my own way”; “You become more focused if you have to do it yourself”; “Learn what you need to know not what you already know”; “Being able to freely look for the information my way, by roaming the web”; “Being able to spend more/less time on what I do/don't understand.” Students also reported about visuals or interactive aspects commented, “the diagrams and more specific detail rather than continuous words - restating everything”; “involves more hands on learning”; “its more interactive”; “you actually get to do something instead of just listening to someone talk”; “I have to look it up myself then I remember it, I am more focused”; “You are actually teaching yourself”; and “being involved the whole time.”

There were also many comments about how easy it is to find information on this website, and how fast they can find it. Some representative comments include, “Easier to find info”; “The speed you can search for data”; “Links that take you to different sites that immerse you in the subject”; and “There are usually always definitions and related articles right there if you want to go farther.” Still other comments that show web-based learning as a positive environment are “The sheer number of sources allows for more than one opinion on a subject”; “Easier than a book to read and pay attentions to”; “Search-easier than reading a textbook”; and “Research is more efficient than looking in textbooks.”
The third question analyzed in this section is, “What problems have you encountered with web-based learning?” The majority of responses spoke to computer/technical problems such as computers not working or going too slowly and broken links. The next most common response is not having human interaction, for example, “I can’t ask the computer questions,” and “I find web-based learning to be an excellent supplement to a class, but it cannot replace an excellent teacher.” Some students get distracted, stating that they are “easily distracted by other sites,” and they do not always “just look for what I need and nothing else.” Other students have difficulty trying to find what they are looking for. Representative comments illustrating this include, “Sometimes its difficult to find exactly what you're looking for because there is so much information on one subject”; “Cannot always find the information”; “Hard to find specific information (not w/ this exercise)”; “biased opinions”; and “unclear webpages.”

**Research Question 6: Effectiveness of Thematic Web-Based Collections as a Motivator for Learning**

The final question examined in this study is whether a web-based, thematic collection, such as the one tested in this study serves as a possible motivator for learning. In other words, we are looking at whether students are motivated to continue learning in the future about this and/or similar topics on their own (i.e. will they question society instead of taking what they hear as truth). By examining whether the students feel personally connected to this and/or similar issues, observations can be made on whether they are potentially motivated to learn more in the future. This question is addressed by
analyzing three attitudinal questions about this lab from the post-test. These questions include, “Is this a situation that affects your personal values and beliefs? Please explain,” “Has this exercise forced you to think about personal and societal values? Please explain,” and “Do you believe that the U.S. government and mining industry acted in an ethical manner? Please explain.”

As in the first question, “Is this a situation that affects your personal values and beliefs? Please explain,” by asking the students to reflect on their personal values and beliefs, we speculate that if their response is yes, the students are more personally attached to issues such as uranium mining on the Navajo Nation. The results show that many students were not aware of such issues occurring because it was not directly happening to them. Also, because this is happening in their own country, it seems to affect them greatly.

Through student responses, it was illustrated that an activity such as this shows the majority of students were affected, and therefore possibly willing to learn more, supporting that this thematic collection serves as a motivator for learning. The results from the question “Is this a situation that affects your personal values and beliefs?” shows that 191 students self-reported that their values and beliefs are personally affected; 50 report they are not; and 28 reported neither or both. Of the 191 students who reported they were affected, most of the reasons revolved around how the environment and humans were treated. Representative comments include, “Yes- anytime people are misled & mistreated & the env is affected I feel affected”; “Yes, because I do not believe in taking land from some one to benefit yourself or in destroying mother nature”;
“everyone should have the right to play in a clean environment as well a drink uncontaminated water”; “yes - the gov ruined land, environment and health of these people and didn’t bother to clean it up”; “yes, because I believe the environment needs to be kept clean in order to protect future generations”; “Yes, I would not want to live in an area contaminated- so they shouldn't have to!”; “Yes, would you like to live in the way they live? I say no more”; “yes because we should never destroy the lives and land of people especially to make nuclear weapons (which kill and hurt even more people)”;
“i believe a respect toward all people and land is necessary and disrespect is incredibly immoral”; “yes I believe it is our responsibility as a country and as human beings to educate our people about potentially hazardous situations that we place them in, also it is our responsibility to find environmentally safe alternatives of power and life”; “Yes, people were taken advantage of and now as a country we should try our best to repair that”; “yes because I’m a human, they're humans, its my earth and its their earth”; “I feel economic issues far too often take priority over the humanities”; “yes I believe it is our responsibility as a country and as human beings to educate our people about potentially hazardous situations that we place them in, also it is our responsibility to find environmentally safe alternatives of power and life”; and “Yes, we need to look at it to prevent future instances of such env/health problems.” Many students also responded about the U.S. government. Some of these comments include, “It supports my belief that the US government will exploit anyone no matter what the cost, without informing of the dangers, in order to make a profit”; “This situation further doubts my trust in the gov’t”; “Yes, because as an American, I feel that my country is taking their power & using it (not
for the good of the people) but for their own gov't behinds”; “yes, what the US gov did was wrong and they should all go to jail”; and “yes, it angers me that our government continues to abuse native people.” Most responses from students who were affected were about environmental and human health issues or the government, however other comments show that they not only are affected, but they relate to the issue, including, “I feel really bad about the Navajo. I can slightly relate because of the mining @ the Berkely Pit which washed sediment to Milltown Dam in Missoula. That is a really big problem. I'm from Missoula so I kind of got an idea of what is happening,” and “I’m Native American (full blooded), all natives are my brothers and sisters, I'll help them stand up for what’s right.”

The majority of the 50 students who state they were not affected go on to state that it did bother them in some way, which might show they may be motivated to learn more. For example, “Not personally. But it is wrong that this place was not investigated before harming so many people & the land”; “No, it doesn't affect me but I still think it was wrong”; “No, but don't feel right about it happening”; “Not directly, but it makes me want to help the situation”; “Though it doesn't affect me personally, I am shocked and angered at this unethical situation”; “it doesn’t directly affect me, but its an outrage that not only do we just let something like this slip by, but we instigated it”; “no, but it would if I were Native American though”; and “no, but I do believe the government should be doing more to compensate for their mistake.” The remaining 14 students who stated that they were not affected either simply stated “no” or gave a reason to show they were definitely not affected. Some representative comments include, “No, I'm not involved
with it so it doesn't effect me”; “No, I'm not culturally tied to the land”; “No, because I don't live in the area, am not Navajo, and am relatively unaffected by these activities”; “Not really, I enjoy the world we live in today & these mines helped build this world”; “Not much, I feel bad but can't see problem fully unless you're a Navajo living there”; “no, it does not affect my values and beliefs because I was in no way involved and/or affected”; and “no really it is far removed from me.” These students may not be affected because they simply have accepted that these situations happen, and there is nothing we can do to change it.

Twenty-eight students either did not answer the question, or could not be put into either the “yes” or “no” categories. Student comments in this category include, “Yes & no, yes because it’s a horrible thing that’s happening & no because its happening so many places & it will keep on happening”; “I don't think it affects me, I feel sorry for them but I can't do anything for them”; “I didn't know anything about mining in Navajo Nation, but it's not surprising to know that Navajo suffered. Sadly, society is always built upon people who are weak”; “it is a double sided issue, it has caused terrible problems for the people but it could help the nation achieve fuel independence”; “Kind of, mining is necessary for a number of reasons and if done properly is not an environmental hazard. Many people ignorantly assume the worst w/ out checking facts”; and “not really sure, try not to have strong opinions.”

It is possible that students who are personally affected indicate a willingness to learn more, and therefore this thematic collection does raise the possibly of motivating
learning. This affects future research, questioning and learning the students might pursue about similar environmental issues.

The next post-test question is “Has this exercise forced you to think about personal and societal values? Please explain.” These results show that 160 students did think about personal and societal values, 61 state they did not because they already thought this way, or that these values were reinforced, 25 did not think about these values, and 23 did not answer the question, were “unsure”, or were “somewhat” forced to think about their values. It is possible that if the students think about personal and societal values, they indicate a willingness to learn more, and are possibly motivated to learn more in the future. These results show 221 of the 269 students are now or already were thinking about personal and societal values.

Of the students who answered “no,” all but three simply stated no without explanation, so it is possible that they may actually be students who already thought about the same personal and societal values this exercise addresses. These three student responses are, “No, because it is happening so many places & that's just the way it is,” “Not really the history of the US is filled with things like this,” and “No, I think this was done primarily in an era that didn't accept much responsibility & I hope we've moved past that.” Of the 23 who either did not answer the question or did not say either way, most were blank and four students simply stated “a little” or “somewhat.” The few other comments include, “A little. Again I am more or less unaffected by these activities, but I know I would feel much different if uranium mining came to Bozeman,” and “A little,
past is past, Americans have done a hell of a lot worse than this over the history of this nation.”

This thematic collection did force the majority of students (n = 160) to think about personal and societal values, with many more (n = 61) stating their beliefs were reinforced, or that they previously agreed with the personal and societal values this exercise got them thinking about. These two categories can be grouped in to students who are possibly motivated to learn more in the future. Representative comments of the students whose beliefs were reinforced include, “It has only reinforced what I already see happening”; “Not really, they hold true, this just reinforced them”; “No more than usual”; “I've always held this view on such matters”; “No- already had them, but good reflection”; “I already thought this way- I just didn't know about the Navajo people specifically”; “No, I already think about such topics, this just gave me another specific incident to study”; “No because I already question our society and that we don't always do what is right for people”; and “not really, I knew about other cases similar to this.”

Of the 160 students who state that this exercise has forced them to think about personal and societal values, most highlight disbelief or disgust because this happened, specifically in their own country. Representative comments include, “It just opened my eyes so that I realized things like this are still occurring in the US”; “yes, it makes you think of all the horrible things that can happen when things are not researched”; “I had never heard of this problem before and I had no idea it was so bad. It really does make me think & I think the government should tell people about consequences. Since they don't, we have to do more research on our own”; “Well, it brought to my attention a
serious matter which I was unaware of”; “yes, this has opened my eyes to other issues that are not a promanate as the ones in the news”; “I think it helped raise awareness of an issue I had no idea about”; “yes, I really haven’t thought about this until it was brought to my attention”; “Yes, I think this was an excellent lab that really opened my eyes to how these people were treated”; “Yes, it makes me think about where else this could be going on if it is happening in here”; “yes, I had no idea about any of this and now I do”; and “makes me realize what’s going on in this country that I never knew before, and its not right.”

Some students were obviously affected emotionally or saddened by learning about uranium mining of the Navajo Nation. For example, “Yes, it hurt my heart knowing this was going on”; “yes, again if I was in their shoes how would I feel?”; “Yes- it made me think about my own beliefs regarding this tragic situation”; “yes, I want to make a difference”; “Yes, makes you sad to think about how this has happened in many different places to many different people in similar situations”; “yes because it makes you think about what other things could be happening right now to affect the environment and more importantly human health”; “Yes, id be angry if this was my home that really should not be lived on”; “yes, I had no idea of these occurrences and will always think about these issues along with issues like Chernobyl and asbestos”; and “yes makes me think about what if I were in that situation.”

The last question we look at from the post-test is “Do you believe that the U.S. government and mining industry acted in an ethical manner?” This question is meant to open the students’ eyes to their own ability to make judgments about how issues such as
this are handled, and not just assume the ones ‘in charge’ are handling it in a way that is ethical and beneficial to the people involved. If students can see for themselves that those ‘higher up,’ such as the government, do not always make decisions with everyone’s well being in mind, or can state why they agree with them, they will be potentially more motivated to learn the facts about issues, instead of just believing what they are told.

The results from this question show that 18 students think the U.S. government and the mining industry did act in an ethical manner, 228 believe they did not, and 23 are neutral, unsure, or did not answer the question. Of the students who think the U.S. government and mining industry did act in an ethical manner, only 8 did not state a reason why, simply stating, “yes”. The reasons students gave for why they agree with how the U.S. government handled the issues include answers about needing uranium for the war/nuclear weapons, not having been aware of the full long-term affects of the uranium, and that they did set up new regulations and compensate the Navajo. Comments illustrating these reasons include, “Yes, needed uranium for war”; “Yes, because our nation was in danger”; “yes we need to mine because of society's demand”; “Yes, they needed the weapons & they meant no harm (I think) they just didn't know the affects”; “they may not have been aware of the full affect of the uranium at the time”; “No one really knew long term effects of radiation”; “I believe so because at that time no one knew the amount of danger the mining was causing”; “yes, they realized there was problems and set up new regulations”; “Yes, they did compensate, but they should have been smarter when they started”; and “More research could have been done but I think that this was done for the greater good of this country.” It can not be said the 23 students
who were neutral, unsure or did not answer are motivated to learn more. Representative comments from the students in this category who did answer the question include, “I don't make the decision to determine what is ethical, not enough information,” “In part,” and “I don’t know.”

Two-hundred and twenty-eight students do not think the U.S. government and the mining industry acted in an ethical manner. These students are likely to be motivated in the future to learn more, or question what they are told by others, i.e. the government. Most responses address how the well-being of humans was sacrificed for economic benefit. Some comments that show this are, “No! The government used the Navajo, didn't warn them of the after-affects, & then left them w/out cleaning up. Now they have health problems instead of jobs”; “Absolutely not. They exploited an uneducated native people (what's new) to gain a resource, and had no intention of protecting the lives of those employed to serve their purpose”; “No, because people are more important than money”; and “No, they acted in an economic manner. Temporary demand does not justify the wrongful treatment of a people.”

Many students also commented on the condition of the environment and health problems now, as well as cleanup issues. Some comments addressing this include, “No, they did not clean up all their mess leaving radioactive waste everywhere”; “I don’t think we did enough, we waiting about 20 years before providing medical compensation for employees - we also should have cleaned everything up”; “I think its very unethical to still have playgrounds with radioactive stuff where children are playing around open pits”; and “no, if they had compensated the workers w/ free health care, and cleaned up
their mess, then yes.” Still others commented on their opinion of the U.S. government. For example, “No, but when has the US government had ethics,” “no, do they ever? I believe that money runs our country, not ethics. Unless our president is having an affair, we let him do anything and ask no questions,” and “no, they hardly ever do. Exploitation of natives seems to be no problem for our government.”
CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

Finally, this thesis addresses 1) whether students effectively use this site to learn about the impacts of uranium mining on the Navajo Nation using an Earth system science approach, and 2) what learning style preferences this site facilitates, as described by Felder (1993). We also discuss guidelines for the future development of digital teaching resources, and give advice for their effective use in the classroom.

Learning Outcomes

Data from the students enrolled in ESCI 111 and ESCI 112 was used to compare learning outcomes in ESCI 111 vs. ESCI 112, the instructional style of the jigsaw vs. role play exercises, and to determine if learning style preferences made a difference. The extent of learning outcomes in this environment (via pre and post-tests) is demonstrated in this experiment. In every case, results show that, regardless of class or activity, learning did occur and the majority of students were engaged. Most students did very well despite lack of background knowledge or class time devoted to class preparation. Also, most students who spent time researching any webpage excelled in that area. Because students show that they do use this site to learn about the impacts of uranium mining on the Navajo Nation using an Earth system science approach, teachers can also use this site to teach this topic in a lab setting.
ESCI 111 vs. ESCI 112

Pre- and post-test data was analyzed to compare students enrolled in ESCI 111 and ESCI 112. Observations were made on if background material from the two courses made a difference, and if the teaching styles of two professors made a difference (established vs. new faculty). Regardless of the class instructor, the majority of students learned at least what was expected of them. The students from both classes did not have any prior knowledge of most covered subtopics, resulting in almost no difference in learning outcomes between the two classes. This outcome supports the idea that learning outcomes are not affected by the difference between the two professors’ teaching styles, whether they are established or new faculty.

The topics that were covered in either class before the lab include geology, by ESCI 111, and climate, by ESCI 112. As expected, the ESCI 111 student results show they performed better in the geology section, having spent all of their semester (9 weeks) prior to this lab learning about geology. The ESCI 112 class spent 1-2 weeks prior to this lab covering climate, but did not perform better in the climate/biota section. These results are possible because in the labs, climate is combined with biota, or the data is skewed because only about half of the students (those performing the jigsaw activity) were required to research the climate/biota page, and were therefore not asked about climate or biota on the guided activity worksheets.

Jigsaw Activity vs. Role Play Activity

Also tested was whether the instructional style of the jigsaw vs. role play exercises made a difference in learning outcomes and student attitudes. Although all
students did well regardless of instructional style, the results show that the students who participated in the jigsaw activity did master more content knowledge overall. Student attitude results illustrate that those who participate in the role play activity show that students were influenced more emotionally by the topic of uranium mining on the Navajo Nation. This may be because the role play activity helped the students feel personally connected to the issue. In conclusion, if the learning goal is content mastery, the jigsaw activity is shown to be more affective; but if the goal is to show relevance of geology to society and personal lives, the role play activity was more effective in this study.

**Exam Question Results**

Based on exam question results, 96% of the students retained the information having to do with environmental and human health impacts, most likely because this is an area they could personally relate to, and therefore remember. Of the 288 students who took the final exam, there were 277 students who answered this question correctly. Performance on this question may also be influenced because both the jigsaw and role play activities required students to participate in a general discussion at the end of the lab about the impacts and benefits of uranium mining on the Navajo Nation.

The question about what type of deposit is found on the Navajo Nation yielded much poorer results. Of the 288 students who took the final exam, there were 92 students who answered this question correctly. Only 32% of the students answered correctly, showing that a third of the students retained this information. Perhaps the students did not have any personal connection to this information because it does not directly affect
the health of people, or the environment they live in, and so they did not retain this information.

The results of both of these questions illustrate that the students may not remember specific facts about what they learned, but they knew that the impacts from uranium mining were negative. ESCI 111 and 112 students had almost identical outcomes in testing. This suggests that the test question results are more fundamental than course preference.

**Learning Style Preferences**

Correlation of the student results from the content knowledge section of the post-test with the learning style preference results from the Index of Learning Styles Questionnaire (Appendix C) show that there is no apparent difference in performance in any of the subtopic areas for any of the learning preferences, excluding the verbal learning preference due to paucity of data. This study shows that the web-based module tested is indifferent to learning style. For example, all learning style preferences performed at about the same level across many subtopics, with the same distribution of abilities. The distribution shows very little difference from one learning style to the next in terms of student performance, deviating by only a few percent.

Earth science students have higher visual learning preferences than the general population (Figure 14), perhaps because the nature of the science is visual, including the understanding of topographic and geologic maps, hands on rock and mineral samples, cross-sections and visual aspects of landscape. Because of the abundance of visual imagery that is present in a web medium, it is expected that students whose learning
preference is visual will excel when learning from such a tool. Visual learning is preferred by not only Earth science students, but most students in general; therefore, teachers should be aware of webpages similar to the one being tested in this study to provide visuals when teaching, or to provide a supplement to traditional lecture. It also may be the case that students may not actually learn more in a visual medium, as this study suggests, but maybe they are just more comfortable working in that environment.

Recommendations for the Future Development of Digital Teaching/Learning Resources

Learning in the web environment is only on the edge of universal use in the school systems from high school to the graduate level. To create a learning environment similar to the Native Lands collection, it is recommended to follow the steps outlined in this study. For those looking to design such digital resources in this emerging web environment; these key steps or methods are recommended:

• follow “best practices” in web design, mentioned throughout this document (SERC, 2006),
• conduct a series of usability studies as described in Chapter 3,
• work closely with other professionals in the specific area of study, scientific or pedagogic, to enhance credibility,
• present information in a clear, concise way that is easy to follow,
• simplify navigation, and
- clearly establish learning goals, and develop activities based on web resources that optimize use of the resources to meet goals.

Future developers of digital teaching/learning resources should try to design resources that facilitate and appeal to all learning style preferences as described by Felder (1993). This includes having the students learn by interacting with the information, while also giving them tasks that allow reflection on what they are learning. Additionally, making sure both visual and verbal styles are represented by including text along with photos, graphs, charts, maps, etc should be considered. In addition, sequential and global learning style preferences can be addressed by presenting information in both step-by-step and holistic manners. It is also essential that designers present their information in an unbiased manner, while establishing and following a clear set of objectives of what they want the students to learn.

As this learning/teaching module example of an Earth system science approach illustrates, students learn when they interact with information that is situated in real environments, with all the pieces of the story there so the student can see how the information fits into the entire story (see how it fits into real life situations). Students enjoy learning in this environment because they are able to learn at their own pace, benefit from the visual aspect (maps, pictures, movies, diagrams, graphs) and interactiveness of the web, have a plethora of information at their fingertips to search as far as they need, and are responsible for their own learning.
Before starting a web page, it is important to establish learning goals and expected outcomes, and design an activity that speaks to these outcomes. For example, if content mastery is the goal, an activity such as the jigsaw is shown in this study to be most effective; or if the goal is to show relevance to society and personal lives, the role play activity may be a better strategy. Secondly, no matter what the learning goals are, the students need clear, concise directions and examples of outcomes and scoring rubrics so they know what is expected. Also, learning assessments must track the learning goals and actual activities. If the instructor wants the students to do something, they have to explicitly tell them. As illustrated in this study, the students who did the role play did not look at all of the 10 webpages because they were not specifically directed to do so.

This study has established that student learning took place in the web environment because the students were engaged in what they were learning and motivated to learn with proper guidance from the activity directions and the guided discovery worksheets. Because the majority of students have had a positive experience when working in this web-based environment, students would most likely have a positive experience when working in similar web environments.

Based on data gathered from the two research questions about working in the web environment, there are recommendations for faculty and other educators to be used as “best practices.” Most importantly, more than half of the students participating in this study reported that they were engaged in learning in a web-based environment when compared to traditional lab/lectures. Educators should be aware of, and facilitate, student
learning to the best of their ability, whether web-based, traditional lab/lecture style or a combination of both. From this study, it is speculated that using only the traditional lab/lecture is not the most effective environment to facilitate student learning, and not how most student would prefer to learn. Using web-based activities with proper guidance, along with traditional lab/lecture teaching methods would speak to most of the students in this study. Only the small number of students who are not yet familiar with the web would still have a problem with this, but with proper guidance from the teacher, this problem could be fixed as the students become more familiar navigating in the web-based environment.

Qualitative data from this study shows that students like learning, and therefore will learn more, when they are able to process the information at their own pace. With traditional lecture, the instructor is choosing the way the students learn regardless of their learning style preference. When students are learning on the web, they are learning “at their own pace,” hence able to facilitate their own specific learning styles. For example, if a student is verbal, the web provides text; however if he/she is more visual, as most of the population is, many visuals are there to supplement or even speak for the text. If a student is sequential, he/she can learn the material in a logical progression, but if a student is more global, he/she has all the information right in front of him/her and can learn it in a more holistic manner.
Conclusions

From this experiment and by using an Earth system approach, the students gained a useful level of knowledge on uranium mining on the Navajo Nation, illustrating that learning was achieved in this web-based environment by the majority of students. Observations show that this learning was mostly independent of larger course context including the instructor and material already covered; and students enrolled in ESCI 111 performed slightly better in the geology subtopic. Through student outcomes, all of the learning style preferences exhibited facilitation. Learning in the web environment adequately served students of all learning style preferences, and there was very little difference in performance by these preferences. Although this is true, knowing the distribution of learning styles in an instructor’s class can still guide development of course materials to track these learning styles.

There was a slight difference in learning outcomes by activity. For content mastery, the jigsaw activity is preferred; and for the affective domain, role playing may be better to engage students, and show relevance and connections to their lives. In all cases, clear instructions and expectations are essential to achieve learning goals; and regardless of learning activity, the learning goals must be clearly defined first to achieve learning outcomes, and perhaps as motivators to encourage students to learn more.

The use of these web pages with related activities may help students develop research skills because they access digital resources, critically evaluate their content, and prioritize their use in the case study. They can also develop interpersonal skills by
working in small groups and develop communication skills, including both written
activities and oral presentations.

Learning in the web environment is an emerging resource that is becoming more
valuable as more students are proficient in using the internet, and as the use of computers
in schools develops. Since resources such as the one tested in this study are fairly new,
and not much research has been done on their effectiveness as teaching/learning
resources yet, this study serves as the starting point for future research to be done.

Future Work

Additional questions came out of this study that could be addressed in future
work. Three questions that came out of this study involve large scale research. These
include first, is it better to create a whole course built around the web environment with
no lecture or classroom work (only labs), or would more learning occur when traditional
lecture and classroom work is supplemented with learning in the web environment?
Second, would students learn less, the same amount, or more if they were given the same
lab, but were not allowed to use the collection designed for this study? For example, if
an instructor set a group of students loose on the web (i.e. Google™) with the same tasks
and activities as the lab in this study, how would student learning outcomes differ? And
third, do students pre-select introductory Earth science classes based on their learning
styles, or are the students randomly attracted to the subject? For example, compared to
the learning style preferences of the population in previous studies (Figure 14), there are
more visual, active and intuitive students who enrolled in introductory Earth science
courses. When comparing these results to other introductory courses, do these results still hold true?

In addition, a few smaller scale questions came out of this study, including:

- Does a topic with pre-knowledge reduce student performance due to misconceptions, misunderstandings or pre-conceived knowledge?;
- Are students attracted to the Earth sciences by using environmental justice to teach?; and
- Could general pre-knowledge or misconceptions about nuclear weapons and/or Native Americans have affected learning outcomes in this study?


Scardamalia, M., 2006, Creative Work with Ideas: A Luxury?


Teed, R., 2005, SERC: Starting Point: Role-Playing Exercises.


Winn, W., 1995, Learning in Interactive and Immersive Environments.
APPENDICES
APPENDIX A:

INSTITUTIONAL REVIEW BOARD

PERMISSION
INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects

Chair:  Mark Quinn
406-994-3721
mmquin@montana.edu

Administration:
Stephanie Groggbehn
406-994-4411
groggeb@montana.edu

MEMORANDUM

TO: Erin Klauck

FROM:  Mark Quinn, Ph.D. Chair
Institutional Review Board for the Protection of Human Subjects

DATE: January 12, 2005

SUBJECT: Assessing Student Learning and Digital Media: A Case Study Approach of Resource Exploitation on Native American Lands

The above research, described in your submission of January 11, 2005 is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is

X  (b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices.

X  (b)(2) Research involving the use of educational tests, survey procedures, interview procedures or observation of public behavior.

(b)(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these specimens are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified.

Other

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.
APPENDIX B:

ASSESSMENT TOOLS

AND

LEARNING ACTIVITIES
**PRE-TEST**

Please make sure to neatly print your initials, and circle your lab section.

**Initials ______________**

**Your Lab Section (circle one)**

- Monday 8:00 – 9:50
- Monday 11:00 – 12:50
- Monday 1:10 – 3:00
- Monday 3:10 – 5:00
- Tuesday 8:00 – 9:50
- Tuesday 10:00 – 11:50
- Wednesday 8:00 – 9:50
- Wednesday 11:00 – 12:50
- Wednesday 6:10 – 8:00
- Thursday 10:00 – 11:50
- Thursday 12:00 – 1:50
- Thursday 2:10 – 4:00

**Directions:** The following is a pre-test for the lab exercise you are about to complete. This will be used for research purposes, and **not as a part of your grade.**

**Part I: Demographic Information**

- M ____ F ____
- Age ____
- Nationality: White____
- Hispanic or Latino____
- African American____
- Asian____
- Native Hawaiian or Pacific Islander____
- Alaskan Native or American Indian____ Please specify tribe_________________
- Freshman____ Sophomore____ Junior____ Senior____ Graduate____ Non-Degree____

What is your major?

Have you taken other earth science courses? Yes____ No____

If yes, please list: __________________________________________________________

What is your home town/state?

**Note:** This is for research purposes, so please answer honestly. We need to know the extent of your knowledge on this subject going into this exercise. If you know nothing about what is being asked, please simply state that.

**Part II: Content Knowledge**

What (if anything) do you know about the **physiography** (physical geography), **geology, uranium deposits** (including the exploration/development history), **hydrology, climate** and/or **biota** on the Navajo Nation?

What (if anything) do you know about the **cultural heritage** of the Navajo peoples?

What (if anything) do you know about the **environmental and human health** impacts, and/or **policy issues** from uranium mining on the Navajo Nation?
Part III: Attitudes

Compared to styles of non web-based learning (lecture, labs), how do you feel about learning in a web-based environment?

What aspects of web-based learning help you to learn better?

What problems have you encountered with web-based learning?
POST-TEST

Please make sure to neatly print your initials, and circle your lab section.

Initials ______________

Your Lab Section (circle one)

<table>
<thead>
<tr>
<th>Monday 8:00 – 9:50</th>
<th>Tuesday 8:00 – 9:50</th>
<th>Wednesday 6:10 – 8:00</th>
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</thead>
<tbody>
<tr>
<td>Monday 11:00 – 12:50</td>
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<tr>
<td>Monday 3:10 – 5:00</td>
<td>Wednesday 11:00 – 12:50</td>
<td>Thursday 2:10 – 4:00</td>
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</tbody>
</table>

Directions: This post-test is for research purposes, so please answer honestly. We need to know the extent of your knowledge coming out of the activity. This will not be graded, BUT to receive credit for this lab exercise, you must turn this sheet in at your next lab. Please answer each question to the best of your ability without going back to website for information. A simple list of bullets is sufficient.

Part I: Content Knowledge

Please circle the specific pages you researched: Physiography Geology Hydrology Climate and Biota Cultural Heritage Uranium Deposits Expl/Dev History Environmental Impacts Human Health Impacts Policy

1. What do you know about the physiography (physical geography) of the Navajo Nation?

2. What do you know about the geology of the Navajo Nation?

3. What do you know about the hydrology of the Navajo Nation?

4. What do you know about the climate and biota of the Navajo Nation?

5. What do you know about uranium deposits on the Navajo Nation?

6. What do you know about the exploration/development history of uranium mining on the Navajo Nation?

7. What do you know about the cultural heritage of the Navajo peoples?

8. What do you know the environmental impacts from uranium mining on the Navajo Nation?

9. What do you know about the human health impacts from uranium mining on the Navajo Nation?

10. What do you know about policy issues from uranium mining on the Navajo Nation?
Part II: Attitudes

1. Please reflect upon your own attitudes about uranium mining on the Navajo Nation:
   (a) Is this a situation that affects your personal values and beliefs? Please explain.
   (b) Do you believe that the U.S. government and mining industry acted in an ethical manner? Explain.
   (c) Has this exercise forced you to think about personal and societal values? Please explain.

2. Compared to styles of non web-based learning (lecture, labs):
   (a) How do you feel about learning in a web-based environment?
   (b) What aspects of web-based learning help you to learn better?
   (c) What problems have you encountered with web-based learning?

3. Was this case study effective in pulling all the pieces of the story together? Please explain.

4. Do you enjoy learning in a collaborative environment (working in groups)? Why or why not?

Part III: Usability

Please rate each of the statements using the one to five scale.

<table>
<thead>
<tr>
<th>Quality of Content on the Website</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>No Opinion</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>The content is written at the right level for me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>The content is engaging to me.</td>
<td>1</td>
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<td>The website presented complete and balanced coverage of the subject.</td>
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<td>I could easily distinguish sources of information that were external to this site.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>If I wanted additional information about this topic, this site provided relevant and easy to find links to additional resources.</td>
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<td>2</td>
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<tr>
<td>The site appeared to provide sufficient information for others to understand the topic.</td>
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<td>4</td>
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<td>Overall, I believe the content is sufficiently engaging to motivate me to read and use its content.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>I frequently look for internet resources in my courses.</td>
<td>1</td>
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<td>The site was structured so that I could easily find information that interested me.</td>
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<td>Overall, I am satisfied with how easy it is to use this site.</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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<tr>
<td>I would recommend this site to others.</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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</table>
Quality of content questions:

1. Was the glossary a useful tool?

2. What specific content did you find most useful on this site?

3. What parts of the website did you find confusing or difficult to understand?

4. What additional content, topics or features, if any, would you like to see incorporated into this site?

5. How do you feel about using this website compared to other websites and web-based learning tools?

Are you willing to participate in a follow up study for one hour? (Pizza and pop will be provided!)

If yes, please NEATLY PRINT your email address ____________________________
**POST-TEST CONTENT KNOWLEDGE RUBRIC**

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<th>Excellent</th>
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<td>need for uranium</td>
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<td>Hydrology</td>
<td>- contaminated (ex. Churchrock)</td>
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<td></td>
<td>- water is scarce</td>
<td>- water is scarce</td>
<td>- Colorado River main source</td>
<td>- correct, but is too broad about or does not specify water source; scarcity, contamination or aquifers</td>
<td>- incorrect</td>
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<td>- Colorado River main source</td>
<td>- aquifers</td>
<td>- aquifers</td>
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<tr>
<td>Discuss 3</td>
<td>4 (A)</td>
<td>3 (B)</td>
<td>2 (C)</td>
<td>1 (D)</td>
<td>0 (F)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Climate and Biot</th>
<th>- correct, detailed statements about both climate and biota</th>
<th>- correct statements about climate and biota; or very detailed about climate</th>
<th>- partially correct</th>
<th>- no answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 (A)</td>
<td>3 (B)</td>
<td>2 (C)</td>
<td>1 (D)</td>
</tr>
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<thead>
<tr>
<th>Cultural Heritage</th>
<th>- correct, very specific detailed answer</th>
<th>- correct, detailed answer</th>
<th>- partially correct</th>
<th>- no answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 (A)</td>
<td>3 (B)</td>
<td>2 (C)</td>
<td>1 (D)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Impacts</th>
<th>- discusses at least three correct negative impacts</th>
<th>- discusses at least two correct negative impacts</th>
<th>- partially correct</th>
<th>- no answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 (A)</td>
<td>3 (B)</td>
<td>2 (C)</td>
<td>1 (D)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Human Health Impacts</th>
<th>- discusses at least three correct negative impacts (must be specific)</th>
<th>- discusses at least two correct negative impacts (must be specific)</th>
<th>- partially correct</th>
<th>- no answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 (A)</td>
<td>3 (B)</td>
<td>2 (C)</td>
<td>1 (D)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Policy</th>
<th>- understands RECA (Radiation Exposure Compensation Act) in detail; in addition to other policies</th>
<th>- understands RECA (Radiation Exposure Compensation Act)</th>
<th>- partially correct</th>
<th>- no answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 (A)</td>
<td>3 (B)</td>
<td>2 (C)</td>
<td>1 (D)</td>
</tr>
</tbody>
</table>


JIGSAW ACTIVITY

As the price of oil exceeds $70/barrel, nuclear energy is once again becoming a viable energy alternative. One of the major domestic sources of uranium in the United States is found in the southwest, on the lands of the Navajo Nation. More than fifteen thousand people have mined uranium or worked in ore processing mills in the Southwest since the 1940’s, and some 13 million tons of uranium ore was mined while the mines were in operation ([Ali, 2003]).

What are the benefits from uranium mining on these lands?

Who benefits from uranium mining on these lands?

What are the impacts (e.g. health, economic) on the Navajo peoples and the local environment?

To explore these issues, you will use webpages that provide essential information about numerous topics that address these questions at http://serc.carleton.edu/research_education/nativelands/navajo/index.html.

Assignment:

You will use the “jigsaw” technique to explore many dimensions of uranium mining on the Navajo Nation. You will be divided into 4 groups. Each group will take about 30 minutes to explore your assigned parts of the website. In each group, you will become “experts” on your assigned topics. Then, your groups will disperse and reassemble into new groups that will include one member from each of the former groups. For about the next 25 minutes of the class, as “experts” in your topic, you will provide a brief summary of the essential information about the topics you were assigned to your new group. Each of you should complete the activity worksheet (these will be handed in) with the key points about what is particularly interesting and/or important about these issues. We will end the class period with a general discussion about the overall issue of uranium mining on the Navajo Nation addressing the bold questions above.

Group 1:
Explore the geology, physiography, and hydrology of the Navajo Nation.

Group 2:
Explore the climate, biota, and culture heritage of the Navajo Nation.

Group 3:
Explore the types of uranium deposits, and the exploration and development history of this area.

Group 4:
Explore the environmental and health, and related policy issues related to uranium mining on the Navajo Nation.
JIGSAW ACTIVITY WORKSHEET

Please make sure to neatly print your initials, and circle your lab section.

Initials ______________

Your Registered Lab Section (circle one)

<table>
<thead>
<tr>
<th>Monday 8:00 – 9:50</th>
<th>Tuesday 8:00 – 9:50</th>
<th>Wednesday 6:10 – 8:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday 11:00 – 12:50</td>
<td>Tuesday 10:00 – 11:50</td>
<td>Thursday 10:00 – 11:50</td>
</tr>
<tr>
<td>Monday 1:10 – 3:00</td>
<td>Wednesday 8:00 – 9:50</td>
<td>Thursday 12:00 – 1:50</td>
</tr>
<tr>
<td>Monday 3:10 – 5:00</td>
<td>Wednesday 11:00 – 12:50</td>
<td>Thursday 2:10 – 4:00</td>
</tr>
</tbody>
</table>

Directions:  
1. Using evidence you find from the webpages, fill in your assigned sections in detail.
2. When meeting with your second groups, complete the worksheets.
3. A list of bullets is sufficient.
4. This will not be graded, BUT to receive credit for this lab exercise, you must turn in this completed sheet.
5. All Groups: be sure to answer question 20.

GROUP 1

Physiography of the Navajo Nation:
1. Using the resources provided, briefly describe the physiography of the Navajo Nation. Be sure to include overall landscape and specific landforms that can be found there.

Geology of the Navajo Nation:
2. Describe the general geologic setting and history of the Navajo Nation.
3. Describe the types of rocks, rock units and major rock structures/features that are found on the Navajo Nation.

Hydrology of the Navajo Nation:
4. Describe the aquifers of the Colorado Plateau.
5. What is the quality and quantity of water resources on the Colorado Plateau?

GROUP 2

Climate and Biota of the Navajo Nation:
6. Describe the climate of the Navajo Nation (be sure to include information about precipitation and temperature).
7. Describe the biota of the Colorado Plateau.

Cultural Heritage of the Navajo Nation:
8. Describe the culture of the Navajo peoples including their history, traditional land and lifestyle, and modern land and lifestyle.
9. What is the Navajo people’s relationship with the land they live on?
GROUP 3
Uranium Deposits on the Navajo Nation:
10. Name, describe, and sketch the type of uranium deposit found on the Navajo Nation.

11. Why is this type of uranium deposit mined?

Exploration and Development of Uranium Mining on the Navajo Nation:
12. Why did we begin mining uranium?

13. Why and when did mining begin on the Navajo Nation?

14. Describe the conditions of mining on the Navajo Nation (How were the miners treated?).

GROUP 4
Environmental Impacts from Uranium Mining on the Navajo Nation:
15. What are the environmental risks from uranium mining?

16. What is the present environmental condition of the Navajo Nation?

17. What happened in Church Rock, New Mexico on July 16, 1979, and how did this affected the Navajo?

Human Health Impacts from Uranium Mining on the Navajo Nation:
18. How does uranium affect the health of humans (effect of radiation exposure on the human body)?

19. What human health concerns affect the people of the Navajo Nation today?

Policy Issues from Uranium Mining on the Navajo Nation:
20. Briefly describe policy issues from uranium mining on the Navajo Nation.

ALL GROUPS
21. What the benefits from mining uranium on these lands? Who benefits from uranium mining on these lands? What are the impacts (e.g. health, economic) on the Navajo peoples and the local environment?
ROLE PLAY ACTIVITY

As the price of oil exceeds $70/barrel, nuclear energy is once again becoming a viable energy alternative. One of the major domestic sources of uranium in the United States is found in the southwest, on the lands of the Navajo Nation. More than fifteen thousand people have mined uranium or worked in ore processing mills in the Southwest since the 1940’s, and some 13 million tons of uranium ore was mined while the mines were in operation ([Ali, 2003]).

What are the benefits from uranium mining on these lands?

Who benefits from uranium mining on these lands?

What are the impacts (e.g. health, economic) on the Navajo peoples and the local environment?

To explore these issues, you will use webpages that provide essential information about numerous topics that address these questions at http://serc.carleton.edu/research_education/nativelands/navajo/index.html.

Assignment:

You will use a "role-play" approach to explore many dimensions of uranium mining on the Navajo Nation. You will be divided into 4 groups representing 1) consulting geologists, 2) the mining industry, 3) tribal elders, and 4) public health officials/Environmental Protection Agency. Each group will take about 30 minutes to find information on the website pertaining to your assigned roles. In the next 10 minutes, each group will decide on the essential evidence that informs your point of view (at least 5 key points) making sure to address the above questions. Next, each group will have about 5 minutes to report out this information to the class during the ‘town meeting’. Each of you should complete the activity worksheet with the key points about what is particularly interesting and/or important about each topic covered (these will be handed in). We will end the class period with a general discussion about the overall issue of uranium mining on the Navajo Nation addressing the bold questions above.

Each group should start their investigation with the recommended pages below, but feel free to explore the entire website.

Group 1: Consulting Geologists: Be sure to explore the geology, physiography, and hydrology of the Navajo Nation.

Group 2: Mining Industry: Be sure to explore the types of uranium deposits, and the exploration and development history of this area.

Group 3: Tribal Elders: Be sure to explore the culture heritage of the Navajo Nation, and the environmental and health impacts from uranium mining.

Group 4: Public Health Officials/Environmental Protection Agency: Be sure to explore the environmental and health impacts, and policy issues related to uranium mining on the Navajo Nation.
ROLE PLAY ACTIVITY WORKSHEET

Please make sure to neatly print your initials, and circle your lab section.

Initials ______________

Your Registered Lab Section (circle one)

Monday 8:00 – 9:50  Tuesday 8:00 – 9:50  Wednesday 6:10 – 8:00
Monday 11:00 – 12:50 Tuesday 10:00 – 11:50 Thursday 10:00 – 11:50
Monday 1:10 – 3:00  Wednesday 8:00 – 9:50  Thursday 12:00 – 1:50
Monday 3:10 – 5:00  Wednesday 11:00 – 12:50 Thursday 2:10 – 4:00

Directions:
1. Using evidence you find from the webpages, fill in your assigned sections in detail.
2. During report outs, complete the worksheet.
3. A list of bullets is sufficient.
4. This will not be graded, BUT to receive credit for this lab exercise, you must turn it in.
5. All Groups: be sure to answer question 23.

CONSULTING GEOLOGISTS
1. Using the resources provided, briefly describe the physiography of the Navajo Nation. Be sure to include overall landscape and specific landforms that can be found there.

2. Describe the general geologic setting of the Navajo Nation.

3. Describe the types of rocks, rock units and major rock structures/features that are found on the Navajo Nation.

4. Describe the geologic history of the Navajo Nation.

5. Describe the hydrology on the Navajo Nation. What is the quality and quantity of water resources on the Colorado Plateau?

MINING INDUSTRY
6. Name, describe, and sketch the type of uranium deposit found on the Navajo Nation.

7. Why did we begin mining uranium on the Navajo Nation?

8. Describe the conditions of mining on the Navajo Nation (How were the miners treated?).

9. How will you interact with the Navajo Nation if you go in and mine again?

10. How would the Navajo benefit from mining uranium again (jobs, profits, tax base, etc.)?
TRIBAL ELDERS: You are responsible for the well-being of your people.
11. Describe the culture of the Navajo people including their history, traditional land and lifestyle, and modern land and lifestyle.

12. What is the present environmental condition from uranium mining on the Navajo Nation?

13. What happened in Church Rock, New Mexico on July 16, 1979. How did this affect the Navajo?

14. What impacts were experienced by the last generation who mined uranium?

15. What human health concerns affect the people of the Navajo Nation today?

16. Looking to the future, what impacts or benefits might you expect? How will you balance potential jobs and revenues against environmental and health impacts?

PUBLIC HEALTH OFFICIALS/ENVIRONMENTAL PROTECTION AGENCY
17. What is the environmental legacy of uranium mining on these lands? What are the environmental risks from uranium mining?

18. What is the present environmental condition of the Navajo Nation?

19. What is the legacy of uranium mining on the health of the Navajo people? How does uranium affect the health of humans (effect of radiation exposure on the human body)?

20. What are your concerns about public health if the mines were to be reopened? What would you require to protect these lands and waters if the mines were to be reopened?

21. Briefly describe policy issues from uranium mining on the Navajo Nation.

ALL GROUPS

22. What are the benefits from mining uranium mining on these lands? Who benefits from uranium mining on these lands? What the impacts (e.g. health, economic) on the Navajo peoples and the local environment?
OBSERVATION LOGS OF WEB USE, DISCOVERY AND EFFECTIVENESS

Directions: Please make a tick every time you make an observation that applies to the bold topics. Also, please write comments from the students that apply to the bold topic.

1. Ability to find useful/relevant resources for assigned task.

<table>
<thead>
<tr>
<th>Student’s are:</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely lost</td>
<td></td>
</tr>
<tr>
<td>Struggling</td>
<td></td>
</tr>
<tr>
<td>Found information with help/after time</td>
<td></td>
</tr>
<tr>
<td>Went right to source; No problems</td>
<td></td>
</tr>
</tbody>
</table>

Representative comments (Please include group number who made comments):

2. Students were motivated to fully explore the resource available (pursued at least 2 links).

<table>
<thead>
<tr>
<th>Student’s are:</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely unmotivated</td>
<td></td>
</tr>
<tr>
<td>Struggling to find information</td>
<td></td>
</tr>
<tr>
<td>Able to find more info with direction</td>
<td></td>
</tr>
<tr>
<td>Went directly to multiple sources</td>
<td></td>
</tr>
</tbody>
</table>

Representative comments (Please include group number who made comments):

3. Evidence of comprehension of topic (i.e. Student explains something to another student).

<table>
<thead>
<tr>
<th>Student’s are:</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completely lost</td>
<td></td>
</tr>
<tr>
<td>Struggling</td>
<td></td>
</tr>
<tr>
<td>Eventually address content correctly</td>
<td></td>
</tr>
<tr>
<td>Mastered material</td>
<td></td>
</tr>
</tbody>
</table>

Representative comments (Please include group number who made comments):

4. Quality of experience (Student’s express how they feel about doing this lab)

<table>
<thead>
<tr>
<th>Student’s are:</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Adequate</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Exceptional</td>
<td></td>
</tr>
</tbody>
</table>

Representative comments (Please include group number who made comments):
Overall Assessment of Student Participation (To be completed at the end of the web discovery)

Please circle section:

<table>
<thead>
<tr>
<th>Monday 8:00 – 9:50</th>
<th>Tuesday 8:00 – 9:50</th>
<th>Wednesday 6:10 – 8:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday 11:00 – 12:50</td>
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</tr>
<tr>
<td>Monday 1:10 – 3:00</td>
<td>Wednesday 8:00 – 9:50</td>
<td>Thursday 12:00 – 1:50</td>
</tr>
<tr>
<td>Monday 3:10 – 5:00</td>
<td>Wednesday 11:00 – 12:50</td>
<td>Thursday 2:10 – 4:00</td>
</tr>
</tbody>
</table>

5. Students were engaged (circle one for each group).

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all engaged</td>
<td>Not at all engaged</td>
<td>Not at all engaged</td>
<td>Not at all engaged</td>
</tr>
<tr>
<td>Little engaged</td>
<td>Little engaged</td>
<td>Little engaged</td>
<td>Little engaged</td>
</tr>
<tr>
<td>Mostly engaged</td>
<td>Mostly engaged</td>
<td>Mostly engaged</td>
<td>Mostly engaged</td>
</tr>
<tr>
<td>Extremely engaged</td>
<td>Extremely engaged</td>
<td>Extremely engaged</td>
<td>Extremely engaged</td>
</tr>
</tbody>
</table>

Comments:

6. Students reveal reactions/feelings about subject (circle one for each group).

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>No feeling</td>
<td>No feeling</td>
<td>No feeling</td>
<td>No feeling</td>
</tr>
<tr>
<td>Little feeling</td>
<td>Little feeling</td>
<td>Little feeling</td>
<td>Little feeling</td>
</tr>
<tr>
<td>Some feeling</td>
<td>Some feeling</td>
<td>Some feeling</td>
<td>Some feeling</td>
</tr>
<tr>
<td>Obvious feeling</td>
<td>Obvious feeling</td>
<td>Obvious feeling</td>
<td>Obvious feeling</td>
</tr>
</tbody>
</table>

Comments:

7. Students appear to be engaged in learning in a web-based environment (check 1 for each group).

<table>
<thead>
<tr>
<th>All students are actively engaged</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most of group was engaged most of the time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One dominant student</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:
### RUBRIC FOR WEB USE, DISCOVERY AND EFFECTIVENESS OBSERVATION LOGS

<table>
<thead>
<tr>
<th>Ability to Find Useful/Relevant Resources</th>
<th>Exemplary</th>
<th>Quality</th>
<th>Adequate</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The students are obviously finding the information they are looking for</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Motivation to Explore the Resource Available</td>
<td>- The students went directly to multiple sources</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Comprehension of Topic</td>
<td>- Students are discussing information learned in access, and know what they are talking about</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Content is Engaging</td>
<td>- Students overall experience is exceptional</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Feeling about Subject Matter</td>
<td>- Students are obviously engaged by the subject matter</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Learning in a Web-based Environment</td>
<td>- Students are obviously engaged in learning in this environment</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
**OBSERVATION LOGS OF REPORT OUTS**

**Directions:** Please make a tick every time you make an observation that applies to the bold topics. Also, please write comments from the students that apply to the bold topic.

1. **Students are able to report out concepts and content that is substantially accurate.**

<table>
<thead>
<tr>
<th>Student’s are:</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Adequate</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td></td>
</tr>
</tbody>
</table>

Representative comments and misconceptions (Please include group number who made comments):

2. **Students are able to prioritize essential information (watch out for nonessential ‘facts’ that don’t address the topic).**

<table>
<thead>
<tr>
<th>Student’s are:</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Adequate</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td></td>
</tr>
</tbody>
</table>

Representative comments (Please include group number who made comments):

3. **Students are able to make connections among and between content areas.**

<table>
<thead>
<tr>
<th>Student’s are:</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not making connections</td>
<td></td>
</tr>
<tr>
<td>Make few connections</td>
<td></td>
</tr>
<tr>
<td>Make some connections</td>
<td></td>
</tr>
<tr>
<td>Obviously making connections</td>
<td></td>
</tr>
</tbody>
</table>

Representative comments (Please include group number who made comments):

Please **circle** section:

- Monday 8:00 – 9:50
- Tuesday 8:00 – 9:50
- Wednesday 6:10 – 8:00
- Monday 11:00 – 12:50
- Tuesday 10:00 – 11:50
- Thursday 10:00 – 11:50
- Monday 1:10 – 3:00
- Wednesday 8:00 – 9:50
- Thursday 12:00 – 1:50
Monday 3:10 – 5:00    Wednesday 11:00 – 12:50    Thursday 2:10 – 4:00

4. **Students are able to transfer ideas to larger contexts (i.e. beyond the immediate case)**
   Representative comments (Please include group color that made comments):

5. **Students freely commented on personal and societal values.**
   Representative comments (Please include group color that made comments):

6. **Students are engaged (Sought deeper answers and understanding, motivated to dig deeper).**
   Representative comments (Please include group color that made comments):

7. **Students appear to be engaged in learning in a collaborative environment (check 1 for each group).**

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>All students are actively engaged</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most of group was engaged most of the time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One dominant student</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:
RUBRIC FOR REPORT OUT OBSERVATION LOGS

<table>
<thead>
<tr>
<th></th>
<th>Exemplary</th>
<th>Quality</th>
<th>Adequate</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Able to report out concepts and content that is substantially accurate</td>
<td>-The content within the conversation is fully accurate and discussed in excess 3</td>
<td>-The content within the conversation is fully accurate 2</td>
<td>-The content within the conversation is mostly accurate 1</td>
<td>-The content within the conversation is lacking, but has some accuracy 0</td>
</tr>
<tr>
<td>Able to prioritize essential information</td>
<td>- Students are discussing information learned in access, and know what they are talking about, not just reading facts 3</td>
<td>- Students are mostly discussing topic, using facts in their discussion 2</td>
<td>- Students are equally discussing topics and listing facts 1</td>
<td>- Students are mostly regurgitating facts, with little discussion 0</td>
</tr>
<tr>
<td>Are able to make connections among and between content areas</td>
<td>- Students are obviously making connections between content areas 3</td>
<td>- Students are making some connections between content areas 2</td>
<td>- Students are making few connections between content areas 1</td>
<td>- Students are not making connections between content areas 0</td>
</tr>
<tr>
<td>Able to transfer ideas to larger contexts</td>
<td>- Students show obvious evidence that they are able to transfer ideas to larger contexts 3</td>
<td>- Students show some evidence that they are able to transfer ideas to larger contexts 2</td>
<td>- Students show little evidence that they are able to transfer ideas to larger contexts 1</td>
<td>- Students do not show evidence that they are able to transfer ideas to larger contexts 0</td>
</tr>
<tr>
<td>Able to freely comment on personal and societal value systems ethics</td>
<td>- Student attitudes about the subject are extremely apparent 3</td>
<td>- Student attitudes about the subject are apparent 2</td>
<td>- Student attitudes about the subject are somewhat apparent 1</td>
<td>- Student attitudes about the subject are not apparent 0</td>
</tr>
<tr>
<td>Content is engaging</td>
<td>- Students are obviously engaged by the subject matter 3</td>
<td>- Students are mostly engaged by the subject matter 2</td>
<td>- Students are somewhat engaged by the subject matter 1</td>
<td>- Students are not engaged by the subject matter 0</td>
</tr>
<tr>
<td>Learning in a collaborative environment</td>
<td>- Students are obviously engaged in learning in this environment 3</td>
<td>- Students are mostly engaged in learning in this environment 2</td>
<td>- Students are somewhat engaged in learning in this environment 1</td>
<td>- Students are not engaged in learning in a collaborative environment 0</td>
</tr>
</tbody>
</table>
EXAM QUESTIONS

Which of the following best characterizes uranium deposits on the Navajo Nation?

a) sedimentary (sandstone) hosted roll-front deposits
b) erosion remnants of volcanic pipes
c) Precambrian crystalline rocks underlying the Colorado Plateau
d) all of the above

Health and environmental impacts related to uranium mining on the Navajo Nation include:

a) water contamination
b) high occurrence of lung cancer
c) airborne dispersion of radioactive material
d) all of the above
APPENDIX C:

LEARNING STYLE PREFERENCES (LSP’s)
Index of Learning Styles Questionnaire

Barbara A. Soloman
First-Year College
North Carolina State University
Raleigh, North Carolina 27695

Richard M. Felder
Department of Chemical Engineering
North Carolina State University
Raleigh, NC 27695-7905

Directions - Please provide us with your full name. Your name will be printed on the information that is returned to you.

Full Name

For each of the 44 questions below select either "a" or "b" to indicate your answer. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. When you are finished selecting answers to each question please select the submit button at the end of the form.

1. I understand something better after I
   (a) try it out.
   (b) think it through.

2. I would rather be considered
   (a) realistic.
   (b) innovative.

3. When I think about what I did yesterday, I am most likely to get
   (a) a picture.
   (b) words.

4. I tend to
   (a) understand details of a subject but may be fuzzy about its overall structure.
   (b) understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to
   (a) talk about it.
   (b) think about it.

6. If I were a teacher, I would rather teach a course
7. I prefer to get new information in
   (a) pictures, diagrams, graphs, or maps.
   (b) written directions or verbal information.
8. Once I understand
   (a) all the parts, I understand the whole thing.
   (b) the whole thing, I see how the parts fit.
9. In a study group working on difficult material, I am more likely to
   (a) jump in and contribute ideas.
   (b) sit back and listen.
10. I find it easier
    (a) to learn facts.
    (b) to learn concepts.
11. In a book with lots of pictures and charts, I am likely to
    (a) look over the pictures and charts carefully.
    (b) focus on the written text.
12. When I solve math problems
    (a) I usually work my way to the solutions one step at a time.
    (b) I often just see the solutions but then have to struggle to figure out
        the steps to get to them.
13. In classes I have taken
    (a) I have usually gotten to know many of the students.
    (b) I have rarely gotten to know many of the students.
14. In reading nonfiction, I prefer
    (a) something that teaches me new facts or tells me how to do
        something.
    (b) something that gives me new ideas to think about.
15. I like teachers
    (a) who put a lot of diagrams on the board.
    (b) who spend a lot of time explaining.
16. When I'm analyzing a story or a novel
    (a) I think of the incidents and try to put them together to figure out
        the themes.
    (b) I just know what the themes are when I finish reading and then I
have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
   (a) start working on the solution immediately.
   (b) try to fully understand the problem first.

18. I prefer the idea of
   (a) certainty.
   (b) theory.

19. I remember best
   (a) what I see.
   (b) what I hear.

20. It is more important to me that an instructor
   (a) lay out the material in clear sequential steps.
   (b) give me an overall picture and relate the material to other subjects.

21. I prefer to study
   (a) in a study group.
   (b) alone.

22. I am more likely to be considered
   (a) careful about the details of my work.
   (b) creative about how to do my work.

23. When I get directions to a new place, I prefer
   (a) a map.
   (b) written instructions.

24. I learn
   (a) at a fairly regular pace. If I study hard, I'll "get it."
   (b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
   (a) try things out.
   (b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
   (a) clearly say what they mean.
   (b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
   (a) the picture.
   (b) what the instructor said about it.
28. When considering a body of information, I am more likely to
   (a) focus on details and miss the big picture.
   (b) try to understand the big picture before getting into the details.
29. I more easily remember
   (a) something I have done.
   (b) something I have thought a lot about.
30. When I have to perform a task, I prefer to
   (a) master one way of doing it.
   (b) come up with new ways of doing it.
31. When someone is showing me data, I prefer
   (a) charts or graphs.
   (b) text summarizing the results.
32. When writing a paper, I am more likely to
   (a) work on (think about or write) the beginning of the paper and
       progress forward.
   (b) work on (think about or write) different parts of the paper and then
       order them.
33. When I have to work on a group project, I first want to
   (a) have "group brainstorming" where everyone contributes ideas.
   (b) brainstorm individually and then come together as a group to
       compare ideas.
34. I consider it higher praise to call someone
   (a) sensible.
   (b) imaginative.
35. When I meet people at a party, I am more likely to remember
   (a) what they looked like.
   (b) what they said about themselves.
36. When I am learning a new subject, I prefer to
   (a) stay focused on that subject, learning as much about it as I can.
   (b) try to make connections between that subject and related subjects.
37. I am more likely to be considered
   (a) outgoing.
   (b) reserved.
38. I prefer courses that emphasize
   (a) concrete material (facts, data).
39. For entertainment, I would rather
   (a) watch television.
   (b) read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
   (a) somewhat helpful to me.
   (b) very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,
   (a) appeals to me.
   (b) does not appeal to me.

42. When I am doing long calculations,
   (a) I tend to repeat all my steps and check my work carefully.
   (b) I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been
   (a) easily and fairly accurately.
   (b) with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
   (a) think of the steps in the solution process.
   (b) think of possible consequences or applications of the solution in a wide range of areas.

When you have completed filling out the above form please click on the Submit button below. Your results will be returned to you. If you are not satisfied with your answers above please click on Reset to clear the form.

Submit  Reset
Learning Styles Results

Results for: Erin Klauk

<table>
<thead>
<tr>
<th>ACT</th>
<th>X</th>
<th>REF</th>
</tr>
</thead>
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<td>6 7 8 9 10 11 12</td>
<td></td>
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</tbody>
</table>

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<td></td>
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</tbody>
</table>

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<th>VRB</th>
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<td>6 7 8 9 10 11 12</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<td>1 2 3 4 5</td>
<td>6 7 8 9 10 11 12</td>
<td></td>
</tr>
</tbody>
</table>

- If your score on a scale is 1-3, you are fairly well balanced on the two dimensions of that scale.
- If your score on a scale is 5-7, you have a moderate preference for one dimension of the scale and will learn more easily in a teaching environment which favors that dimension.
- If your score on a scale is 9-11, you have a very strong preference for one dimension of the scale. You may have real difficulty learning in an environment which does not support that preference.

We suggest you print this page, so that when you look at the explanations of the different scales you will have a record of your individual preferences.

For explanations of the scales and the implications of your preferences, click on Learning Style Descriptions.

For more information about learning styles or to take the test again, click on Learning Style Page.
### Table 8 - Active/Reflective results for LSP’s (Felder and Spurlin, 2005)

<table>
<thead>
<tr>
<th>University</th>
<th>Students</th>
<th>Number (n)</th>
<th>Moderate-Strong Active</th>
<th>Mild</th>
<th>Moderate-Strong Reflective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montana State University</td>
<td>ESCI 111</td>
<td>104</td>
<td>34.6%</td>
<td>55.8%</td>
<td>9.6%</td>
</tr>
<tr>
<td>Montana State University</td>
<td>ESCI 112</td>
<td>134</td>
<td>39.6%</td>
<td>48.5%</td>
<td>11.9%</td>
</tr>
<tr>
<td>Ryerson University, 2000</td>
<td>Engineering</td>
<td>87</td>
<td>27%</td>
<td>58%</td>
<td>15%</td>
</tr>
<tr>
<td>Ryerson University, 2001</td>
<td>Engineering</td>
<td>119</td>
<td>32%</td>
<td>50%</td>
<td>18%</td>
</tr>
<tr>
<td>Ryerson University, 2002</td>
<td>Engineering</td>
<td>132</td>
<td>30%</td>
<td>55%</td>
<td>15%</td>
</tr>
<tr>
<td>San Jose State University</td>
<td>Materials Engineering</td>
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<tr>
<td>San Jose State University</td>
<td>Engineering</td>
<td>196</td>
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<td>55%</td>
<td>-</td>
</tr>
<tr>
<td>San Jose State University</td>
<td>Freshman Engineering</td>
<td>693</td>
<td>-</td>
<td>61%</td>
<td>-</td>
</tr>
<tr>
<td>San Jose State University</td>
<td>Engineering</td>
<td>183</td>
<td>24%</td>
<td>61%</td>
<td>15%</td>
</tr>
<tr>
<td>Arizona State University</td>
<td>Social Work</td>
<td>?</td>
<td>31%</td>
<td>54%</td>
<td>15%</td>
</tr>
<tr>
<td>Brazilian</td>
<td>Science</td>
<td>214</td>
<td>25%</td>
<td>69%</td>
<td>6%</td>
</tr>
<tr>
<td>Brazilian</td>
<td>Humanities</td>
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<td>65%</td>
<td>16%</td>
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### Table 9 - Sensitive/Intuitive results for LSP’s (Felder and Spurlin, 2005)

<table>
<thead>
<tr>
<th>University</th>
<th>Students</th>
<th>Number (n)</th>
<th>Moderate-Strong Sensitive</th>
<th>Mild</th>
<th>Moderate-Strong Intuitive</th>
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</thead>
<tbody>
<tr>
<td>Montana State University</td>
<td>ESCI 111</td>
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<td>26%</td>
<td>49%</td>
<td>25%</td>
</tr>
<tr>
<td>Montana State University</td>
<td>ESCI 112</td>
<td>134</td>
<td>35.1%</td>
<td>37.3%</td>
<td>27.6%</td>
</tr>
<tr>
<td>Ryerson University, 2000</td>
<td>Engineering</td>
<td>87</td>
<td>38%</td>
<td>52%</td>
<td>11%</td>
</tr>
<tr>
<td>Ryerson University, 2001</td>
<td>Engineering</td>
<td>119</td>
<td>38%</td>
<td>50%</td>
<td>12%</td>
</tr>
<tr>
<td>Ryerson University, 2002</td>
<td>Engineering</td>
<td>132</td>
<td>36%</td>
<td>49%</td>
<td>15%</td>
</tr>
<tr>
<td>San Jose State University</td>
<td>Materials Engineering</td>
<td>261</td>
<td>-</td>
<td>52%</td>
<td>-</td>
</tr>
<tr>
<td>San Jose State University</td>
<td>Engineering</td>
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<td>47%</td>
<td>-</td>
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<tr>
<td>San Jose State University</td>
<td>Freshman Engineering</td>
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<td>-</td>
<td>52%</td>
<td>-</td>
</tr>
<tr>
<td>San Jose State University</td>
<td>Engineering</td>
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<td>43%</td>
<td>46%</td>
<td>11%</td>
</tr>
<tr>
<td>Arizona State University</td>
<td>Social Work</td>
<td>?</td>
<td>48%</td>
<td>38%</td>
<td>14%</td>
</tr>
<tr>
<td>Brazilian</td>
<td>Science</td>
<td>214</td>
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<td>46%</td>
<td>5%</td>
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<tr>
<td>Brazilian</td>
<td>Humanities</td>
<td>235</td>
<td>33%</td>
<td>51%</td>
<td>16%</td>
</tr>
</tbody>
</table>
Table 10 - Visual/Verbal results for LSP’s (Felder and Spurlin, 2005)

<table>
<thead>
<tr>
<th>University</th>
<th>Students</th>
<th>Number (n)</th>
<th>Moderate-Strong Visual</th>
<th>Mild</th>
<th>Moderate-Strong Verbal</th>
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<tr>
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<td>Montana State University</td>
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<td>134</td>
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<tr>
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<td>69%</td>
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<td>3%</td>
</tr>
<tr>
<td>Ryerson University, 2001</td>
<td>Engineering</td>
<td>119</td>
<td>64%</td>
<td>32%</td>
<td>5%</td>
</tr>
<tr>
<td>Ryerson University, 2002</td>
<td>Engineering</td>
<td>132</td>
<td>62%</td>
<td>35%</td>
<td>3%</td>
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<tr>
<td>San Jose State University</td>
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<td>36%</td>
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<tr>
<td>San Jose State University</td>
<td>Engineering</td>
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<td>-</td>
<td>36%</td>
<td>-</td>
</tr>
<tr>
<td>San Jose State University</td>
<td>Freshman Engineering</td>
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<td>-</td>
<td>45%</td>
<td>-</td>
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<tr>
<td>San Jose State University</td>
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<td>61%</td>
<td>34%</td>
<td>5%</td>
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<tr>
<td>Arizona State University</td>
<td>Social Work</td>
<td>?</td>
<td>38%</td>
<td>45%</td>
<td>17%</td>
</tr>
<tr>
<td>Brazilian</td>
<td>Science</td>
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<td>46%</td>
<td>48%</td>
<td>6%</td>
</tr>
<tr>
<td>Brazilian</td>
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<td>61%</td>
<td>29%</td>
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Table 11 - Visual/Verbal results for LSP’s (Felder and Spurlin, 2005)

<table>
<thead>
<tr>
<th>University</th>
<th>Students</th>
<th>Number (n)</th>
<th>Moderate-Strong Sequential</th>
<th>Mild</th>
<th>Moderate-Strong Global</th>
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<tbody>
<tr>
<td>Montana State University</td>
<td>ESCI 111</td>
<td>104</td>
<td>16.3%</td>
<td>65.4%</td>
<td>18.3%</td>
</tr>
<tr>
<td>Montana State University</td>
<td>ESCI 112</td>
<td>134</td>
<td>22.4%</td>
<td>64.9%</td>
<td>12.7%</td>
</tr>
<tr>
<td>Ryerson University, 2000</td>
<td>Engineering</td>
<td>87</td>
<td>34%</td>
<td>52%</td>
<td>15%</td>
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<td>Ryerson University, 2001</td>
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<td>63%</td>
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<td>62%</td>
<td>14%</td>
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<tr>
<td>San Jose State University</td>
<td>Materials Engineering</td>
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<td>-</td>
</tr>
<tr>
<td>San Jose State University</td>
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<td>-</td>
<td>62%</td>
<td>-</td>
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<tr>
<td>San Jose State University</td>
<td>Freshman Engineering</td>
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<td>-</td>
<td>64%</td>
<td>-</td>
</tr>
<tr>
<td>San Jose State University</td>
<td>Engineering</td>
<td>183</td>
<td>31%</td>
<td>58%</td>
<td>11%</td>
</tr>
<tr>
<td>Arizona State University</td>
<td>Social Work</td>
<td>?</td>
<td>20%</td>
<td>69%</td>
<td>11%</td>
</tr>
<tr>
<td>Brazilian</td>
<td>Science</td>
<td>214</td>
<td>29%</td>
<td>64%</td>
<td>7%</td>
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<tr>
<td>Brazilian</td>
<td>Humanities</td>
<td>235</td>
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<td>57%</td>
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</tbody>
</table>
Active/Reflective Learning Style Preference
Distribution for All Students (n = 238)

Sensitive/Intuitive Learning Style Preference
Distribution for All Students (n = 238)

Visual/Verbal Learning Style Preference
Distribution for All Students (n = 238)

Figure 17 - Active/Reflective LSP distribution for all students

Figure 18 - Sensitive/Intuitive LSP distribution for all students

Figure 19 - Visual/Verbal LSP distribution for all students
Figure 20 - Sequential/Global LSP distribution for all students

Figure 21 - Active/Reflective LSP distribution for ESCI 111 students

Figure 22 - Sensitive/Intuitive LSP distribution for ESCI 111 students
Visual/Verbal Learning Style Preference Distribution in ESCI 111 (n = 104)

![Visual/Verbal LSP distribution for ESCI 111 students](image)

Sequential/Global Learning Style Preference Distribution in ESCI 111 (n = 104)

![Sequential/Global LSP distribution for ESCI 111 students](image)

Active/Reflective Learning Style Preference Distribution in ESCI 112 (n = 134)

![Active/Reflective LSP distribution for ESCI 112 students](image)
Figure 26 - Sensitive/Intuitive LSP distribution for ESCI 112 students

Figure 27 - Visual/Verbal LSP distribution for ESCI 112 students

Figure 28 - Sequential/Global LSP distribution for ESCI 112 students
Active/Reflective Learning Style Preference
Distribution for Jigsaw Activity Participants (n = 126)

Figure 29 - Active/Reflective LSP distribution for students who participated in jigsaw activity

Sensitive/Intuitive Learning Style Preference
Distribution for Jigsaw Activity Participants (n = 126)

Figure 30 - Sensitive/Intuitive LSP distribution for students who participated in jigsaw activity

Visual/Verbal Learning Style Preference
Distribution for Jigsaw Activity Participants (n = 126)

Figure 31 - Visual/Verbal LSP distribution for students who participated in jigsaw activity
Sequential/Global Learning Style Preference Distribution for Jigsaw Activity Participants (n = 126)

Active/Reflective Learning Style Preference Distribution for Role Play Activity Participants (n = 112)

Sensitive/Intuitive Learning Style Preference Distribution for Role Play Activity Participants (n = 112)

Figure 32 - Sequential/Global LSP distribution for students who participated in jigsaw activity

Figure 33 - Active/Reflective LSP distribution for students who participated in role play activity

Figure 34 - Sensitive/Intuitive LSP distribution for students who participated in role play activity
Visual/Verbal Learning Style Preference Distribution for Role Play Activity Participants (n = 112)

Sequential/Global Learning Style Preference Distribution for Role Play Activity Participants (n = 112)

Figure 35 - Visual/Verbal LSP distribution for students who participated in role play activity

Figure 36 - Sequential/Global LSP distribution for students who participated in role play activity
Active/Reflective Learning Style Preferences and Physiography Post-test Performance for All Students (n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>(n=89; 33%)</td>
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<tr>
<td>Mild Act/Ref</td>
<td>(n=123; 46%)</td>
</tr>
<tr>
<td>Reflective</td>
<td>(n=26; 10%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 37 - Active/Reflective LSP’s and physiography post-test performance for all students

Sensitive/Intuitive Learning Style Preferences and Physiography Post-test Performance for All Students (n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive</td>
<td>(n=74; 28%)</td>
</tr>
<tr>
<td>Mild Sen/Int</td>
<td>(n=101; 38%)</td>
</tr>
<tr>
<td>Intuitive</td>
<td>(n=63; 23%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 38 - Sensitive/Intuitive LSP’s and physiography post-test performance for all students

Visual/Verbal Learning Style Preferences and Physiography Post-test Performance for All Students (n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>(n=157; 58%)</td>
</tr>
<tr>
<td>Mild Vis./Ver</td>
<td>(n=77; 29%)</td>
</tr>
<tr>
<td>Verbal</td>
<td>(n=4; 1%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 39 - Visual/Verbal LSP’s and physiography post-test performance for all students
Global/Sequential Learning Style Preferences and Physiography Post-test Performance for All Students (n=269)

Figure 40 - Sequential/Global LSP’s and physiography post-test performance for all students

Active/Reflective Learning Style Preferences and Geology Post-test Performance for All Students (n=269)

Figure 41 - Active/Reflective LSP’s and geology post-test performance for all students

Sensitive/Intuitive Learning Style Preferences and Geology Post-test Performance for All Students (n=269)

Figure 42 - Sensitive/Intuitive LSP’s and geology post-test performance for all students
Figure 43 - Visual/Verbal LSP’s and geology post-test performance for all students

Figure 44 - Sequential/Global LSP’s and geology post-test performance for all students

Figure 45 - Active/Reflective LSP’s and hydrology post-test performance for all students
Figure 46 - Sensitive/Intuitive LSP’s and hydrology post-test performance for all students

Figure 47 - Visual/Verbal LSP’s and hydrology post-test performance for all students

Figure 48 - Sequential/Global LSP’s and hydrology post-test performance for all students
Active/Reflective Learning Style Preferences and Climate/Biota Post-test Performance for All Students

(n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>(n=89; 33%)</td>
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<tr>
<td>Mild Act/Ref</td>
<td>(n=123; 46%)</td>
</tr>
<tr>
<td>Reflective</td>
<td>(n=26; 10%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 49 - Active/Reflective LSP’s and climate/biota post-test performance for all students

Sensitive/Intuitive Learning Style Preferences and Climate/Biota Post-test Performance for All Students

(n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
</tr>
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<tbody>
<tr>
<td>Sensitive</td>
<td>(n=74; 28%)</td>
</tr>
<tr>
<td>Mild Sen/Int</td>
<td>(n=101; 38%)</td>
</tr>
<tr>
<td>Intuitive</td>
<td>(n=63; 23%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 50 - Sensitive/Intuitive LSP’s and climate/biota post-test performance for all students

Visual/Verbal Learning Style Preferences and Climate/Biota Post-test Performance for All Students

(n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>(n=157; 58%)</td>
</tr>
<tr>
<td>Mild Vis./Ver</td>
<td>(n=77; 29%)</td>
</tr>
<tr>
<td>Verbal</td>
<td>(n=4; 1%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 51 - Visual/Verbal LSP’s and climate/biota post-test performance for all students
Sequential/Global Learning Style Preferences and Climate/Biota Post-test Performance for All Students

(n=269)

% of Students

0% 25% 50% 75% 100%

Sequential Mild Seq/Glo Global Unknown
(n=47; 17%) (n=155; 58%) (n=36; 13%) (n=31; 12%)

Figure 52 - Sequential/Global LSP’s and climate/biota post-test performance for all students

Active/Reflective Learning Style Preferences and Cultural Heritage Post-test Performance for All Students

(n=269)

% of Students

0% 25% 50% 75% 100%

Active Mild Act/Ref Reflective Unknown
(n=89; 33%) (n=123; 46%) (n=26; 10%) (n=31; 12%)

Figure 53 - Active/Reflective LSP’s and cultural heritage post-test performance for all students

Sensitive/Intuitive Learning Style Preferences and Cultural Heritage Post-test Performance for All Students

(n=269)

% of Students

0% 25% 50% 75% 100%

Sensitive Mild Sen/Int Intuitive Unknown
(n=74; 28%) (n=101; 38%) (n=63; 23%) (n=31; 12%)

Figure 54 - Sensitive/Intuitive LSP’s and cultural heritage post-test performance for all students
Visual/Verbal Learning Style Preferences and Cultural Heritage Post-test Performance for All Students (n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
</tr>
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<tbody>
<tr>
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<td>(n=4; 1%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
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Figure 55 - Visual/Verbal LSP’s and cultural heritage post-test performance for all students

Sequential/Global Learning Style Preferences and Cultural Heritage Post-test Performance for All Students (n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
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<tbody>
<tr>
<td>Sequential</td>
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<tr>
<td>Global</td>
<td>(n=36; 13%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 56 - Sequential/Global LSP’s and cultural heritage post-test performance for all students

Active/Reflective Learning Style Preferences and Uranium Deposits Post-test Performance for All Students (n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
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<tbody>
<tr>
<td>Active</td>
<td>(n=89; 33%)</td>
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<tr>
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<td>(n=26; 10%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 57 - Active/Reflective LSP’s and uranium deposits post-test performance for all students
Sensitive/Intuitive Learning Style Preferences and Uranium Deposits Post-test Performance for All Students

Learning Style Preference
- Sensitive (n=74; 28%)
- Mid Sen/Int (n=101; 38%)
- Intuitive (n=63; 23%)
- Unknown (n=31; 12%)

Visual/Verbal Learning Style Preferences and Uranium Deposits Post-test Performance for All Students

Learning Style Preference
- Visual (n=157; 58%)
- Mid Vis.Ver (n=77; 29%)
- Verbal (n=4; 1%)
- Unknown (n=31; 12%)

Sequential/Global Learning Style Preferences and Uranium Deposits Post-test Performance for All Students

Learning Style Preference
- Sequential (n=47; 17%)
- Mid Seq/Glo (n=155; 58%)
- Global (n=36; 13%)
- Unknown (n=31; 12%)

Figure 58 - Sensitive/Intuitive LSP’s and uranium deposits post-test performance for all students

Figure 59 - Visual/Verbal LSP’s and uranium deposits post-test performance for all students

Figure 60 - Sequential/Global LSP’s and uranium deposits post-test performance for all students
Active/Reflective Learning Style Preferences and Exp/Dev History Post-test Performance for All Students (n=269)

Learning Style Preference
- Active (n=89; 33%)%
- Mild Act/Ref (n=123; 46%)
- Reflective (n=26; 10%)
- Unknown (n=31; 12%)

Figure 61 - Active/Reflective LSP’s and exp/dev history post-test performance for all students

Sensitive/Intuitive Learning Style Preferences and Exp/Dev History Post-test Performance for All Students (n=269)

Learning Style Preference
- Sensitive (n=74; 28%)
- Mild Sen/Int (n=101; 38%)
- Intuitive (n=63; 23%)
- Unknown (n=31; 12%)

Figure 62 - Sensitive/Intuitive LSP’s and exp/dev history post-test performance for all students

Visual/Verbal Learning Style Preferences and Exp/Dev History Post-test Performance for All Students (n=269)

Learning Style Preference
- Visual (n=157; 58%)
- Mild Vis.Ver (n=77; 29%)
- Verbal (n=4; 1%)
- Unknown (n=31; 12%)

Figure 63 - Visual/Verbal LSP’s and exp/dev history post-test performance for all students
Sequential/Global Learning Style Preferences and Exp/Dev History Post-test Performance for All Students 
(n=269)

<table>
<thead>
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<tbody>
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<tr>
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</tbody>
</table>

Figure 64 - Sequential/Global LSP’s and exp/dev history post-test performance for all students

Active/Reflective Learning Style Preferences and Environmental Impacts Post-test Performance for All Students (n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
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<tbody>
<tr>
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<td>(n=26; 10%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 65 - Active/Reflective LSP’s and environmental impacts post-test performance for all students

Sensitive/Intuitive Learning Style Preferences and Environmental Impacts Post-test Performance for All Students (n=269)

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
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<tbody>
<tr>
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<tr>
<td>Intuitive</td>
<td>(n=63; 23%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 66 - Sensitive/Intuitive LSP’s and environmental impacts post-test performance for all students
Visual/Verbal Learning Style Preferences and Environmental Impacts Post-test Performance for All Students (n=269)

Learning Style Preference

<table>
<thead>
<tr>
<th>Percentage of Students</th>
<th>Poor</th>
<th>Adequate</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
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<tr>
<td>Visual</td>
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<td></td>
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<td>Unknown</td>
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</tr>
<tr>
<td>(n=31; 12%)</td>
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</tbody>
</table>

Figure 67 - Visual/Verbal LSP’s and environmental impacts post-test performance for all students

Sequential/Global Learning Style Preferences and Environmental Impacts Post-test Performance for All Students (n=269)

Learning Style Preference

<table>
<thead>
<tr>
<th>Percentage of Students</th>
<th>Poor</th>
<th>Adequate</th>
<th>Average</th>
<th>Good</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Sequential</td>
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<td></td>
<td></td>
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<tr>
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<tr>
<td>(n=155; 58%)</td>
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<tr>
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</tr>
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<tr>
<td>(n=31; 12%)</td>
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</tbody>
</table>

Figure 68 - Sequential/Global LSP’s and environmental impacts post-test performance for all students

Active/Reflective Learning Style Preferences and Human Health Impacts Post-test Performance for All Students (n=269)

Learning Style Preference

<table>
<thead>
<tr>
<th>Percentage of Students</th>
<th>Poor</th>
<th>Adequate</th>
<th>Average</th>
<th>Good</th>
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</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<tr>
<td>(n=89; 33%)</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>(n=123; 46%)</td>
<td></td>
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<td></td>
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<tr>
<td>Reflective</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=26; 10%)</td>
<td></td>
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<td></td>
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<tr>
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<tr>
<td>(n=31; 12%)</td>
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Figure 69 - Active/Reflective LSP’s and human health impacts post-test performance for all students
Sensitive/Intuitive Learning Style Preferences and Human Health Impacts Post-test Performance for All Students (n=269)

Learning Style Preference

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
<th>% of Students</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>Unknown</td>
<td>(n=31; 12%)</td>
</tr>
</tbody>
</table>

Figure 70 - Sensitive/Intuitive LSP’s and human health impacts post-test performance for all students

Visual/Verbal Learning Style Preferences and Human Health Impacts Post-test Performance for All Students (n=269)

Learning Style Preference

<table>
<thead>
<tr>
<th>Learning Style Preference</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>Mid Vis.Ver</td>
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<tr>
<td>Verbal</td>
<td>(n=4; 1%)</td>
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<td>(n=31; 12%)</td>
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</tbody>
</table>

Figure 71 - Visual/Verbal LSP’s and human health impacts post-test performance for all students

Sequential/Global Learning Style Preferences and Human Health Impacts Post-test Performance for All Students (n=269)

Learning Style Preference

<table>
<thead>
<tr>
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<tbody>
<tr>
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<tr>
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</tr>
</tbody>
</table>

Figure 72 - Sequential/Global LSP’s and human health impacts post-test performance for all students
Active/Reflective Learning Style Preferences and Policy Post-test Performance for All Students (n=269)

Figure 73 - Active/Reflective LSP’s and policy post-test performance for all students

Sensitive/Intuitive Learning Style Preferences and Policy Post-test Performance for All Students (n=269)

Figure 74 - Sensitive/Intuitive LSP’s and policy post-test performance for all students

Visual/Verbal Learning Style Preferences and Policy Post-test Performance for All Students (n=269)

Figure 75 - Visual/Verbal LSP’s and policy post-test performance for all students
Sequential/Global Learning Style Preferences and Policy Post-test Performance for All Students (n=269)

- Sequential: 47 (17%)
- Mild Seq/Glo: 155 (58%)
- Global: 36 (13%)
- Unknown: 31 (12%)

Figure 76 - Sequential/Global LSP’s and policy post-test performance for all students
Chi-squared Test Results

category = Physiography

Pearson's Chi-squared test

data: dat
X-squared = 21.1563, df = 24, p-value = 0.6295

category = Geology

Pearson's Chi-squared test

data: dat
X-squared = 15.5891, df = 24, p-value = 0.9023

category = Hydrology

Pearson's Chi-squared test

data: dat
X-squared = 21.7824, df = 24, p-value = 0.5923

category = Climate

Pearson's Chi-squared test

data: dat
X-squared = 23.0338, df = 24, p-value = 0.5178

category = Cultural Heritage

Pearson's Chi-squared test

data: dat
X-squared = 16.8748, df = 24, p-value = 0.854

category = Uranium Deposits

Pearson's Chi-squared test

data: dat
X-squared = 17.5692, df = 24, p-value = 0.8234
Chi-squared Test Results (continued)

category = Exploration and Development History

    Pearson's Chi-squared test

data:   dat
X-squared = 21.457, df = 24, p-value = 0.6116

category = Environmental Impacts

    Pearson's Chi-squared test

data:   dat
X-squared = 13.6794, df = 24, p-value = 0.9536

category = Human Health Impacts

    Pearson's Chi-squared test

data:   dat
X-squared = 20.4431, df = 24, p-value = 0.6713

category = Policy

    Pearson's Chi-squared test

data:   dat
X-squared = 25.3379, df = 24, p-value = 0.3876

category = Mean

    Pearson's Chi-squared test

data:   dat
X-squared = 31.11, df = 24, p-value = 0.1506
APPENDIX D:

USABILITY STUDY
Thank you for participating in this usability study. Your contribution is greatly appreciated! Please remember that you are volunteers, and are free to leave at any time. The object of inquiry is the webpages, not you, your performance or intelligence.

To protect your privacy, please do not include your name on the papers you fill out for this study. An ID number has been assigned to you, and can be found below.

**ID of Participant:**

**Demographics**

- [ ] M      [ ] F      [ ] Age

**Nationality:**
- Caucasian [ ]
- Hispanic American [ ]
- African American [ ]
- Asian American [ ]
- Alaskan Native [ ]
- Native Hawaiian or Pacific Islander [ ]
- Native American [ ] If Native American, please specify tribe ______________________
- Other [ ]

- [ ] Freshman      [ ] Sophomore      [ ] Junior      [ ] Senior
- [ ] Graduate      [ ] Non-Degree      [ ] Other (Please specify) ______________________

What is your major if you are a student?

What places have lived (cities, states, countries)?

**Scenario One**

You have been assigned to teach an introductory course for environmental geology. This is a new course for you. A friend mentioned this site to you as a good resource for a unit about resource development. You have decided to check it out to see if you can find some ideas that you can adapt to your course…

**http://serc.carleton.edu/research_education/nativelands/index.html**

**Scenario Two**

You have just done an internet search using Google. The results from the search linked you to a site called Impacts of Resource Development on Native American Lands. This site seems to have interesting geoscience teaching materials. You have some time and decide to check out the site to see if you can find additional ideas that you can adapt for teaching your introductory earth science courses…

**http://serc.carleton.edu/research_education/nativelands/index.html**

**Scenario Three**

You are a student in an introduction to geology course. As one of your assignments, you have been asked to research the impacts of any resource on a Native American land of your choice. Being from the four corners area, you have decided to research the Navajo Nation. While searching on the internet, you have come across the site **http://serc.carleton.edu/research_education/nativelands/index.html** and decide to check it out to see if you can apply it to your assignment…
### EXAMPLE OF USABILITY STUDY OBSERVATION LOG

<table>
<thead>
<tr>
<th>Webpage:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Spent:</td>
<td></td>
</tr>
<tr>
<td>Questions/Concerns/Comments:</td>
<td></td>
</tr>
</tbody>
</table>

### EXAMPLE OF USABILITY STUDY LOGS FOR LINKS

<table>
<thead>
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<th>TITLE OF WEBSITE LINKED TO</th>
<th>TIME SPENT</th>
<th>COMMENTS ON USEFULNESS OF WEBSITE</th>
</tr>
</thead>
<tbody>
<tr>
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</table>
ID Number:

Educational background – or highest degree earned:

Please rate each of the statements using the one to five scale.

<table>
<thead>
<tr>
<th>Quality of Content</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>The content is engaging to me.</td>
<td>1 2 3 4 5</td>
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<tr>
<td>The content is complete.</td>
<td>1 2 3 4 5</td>
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</tr>
<tr>
<td>The tone of the content is appropriate.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Overall, I am satisfied with the quality of the content presented on this site (no noticeable typos, clear visuals, clearly written).</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>The terminology used appeared to match the stated scenario.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I could easily distinguish sources of information that were external to this site.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>If I wanted additional information about this topic, this site provided relevant and easy to find links to additional resources.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>The site appeared to provide sufficient instruction for faculty to implement the presented material into their class.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Overall, I believe the content is sufficiently engaging to motivate faculty/students to read and use its content.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

Quality of content questions:

Did the content compel you to want to explore further?

How was the content engaging to you?

In terms of attracting users like yourself, what additional content/services would draw you to this site?

What specific content did you find most useful on this site?

What specific content did you not find useful or difficult to understand?

How useful did you find the text that was provided (is there any text in particular worth noting)?

What additional content, topics or features, if any, would you like to see incorporated into this site?
Please rate each of the statements using the one to five scale.

<table>
<thead>
<tr>
<th>Ease of Use</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I frequently use the internet to find resources similar to this.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I would use this site for research if I came across it while searching online.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>At first glance I could identify the basic content of the website and the intended audience.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>The site was structured so that I could easily find information that interested me.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>After browsing through one particular section of the site, I found myself familiar with how other sections were organized.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Overall, I am satisfied with how easy it is to use this site.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I would recommend this site to colleagues.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

**Additional questions:**

What would bring you to this site (in terms of how would you get there – colleague recommendation, google search, link from related portal)?

What would you hope to gain from time spent on a site like this one and how much time would you expect to spend?

How do you foresee using the content of this site and how might it impact your learning?

What were the most interesting sections to you? Why?

Rate your impression of the completeness of this document, on a scale of 0 (least complete) to 10 (most complete):

Do you have any suggestions for improvements?

Other comments: