IMPACTS OF A TEACHER GEOSPATIAL TECHNOLOGIES PROFESSIONAL DEVELOPMENT PROJECT ON STUDENT SPATIAL LITERACY SKILLS AND INTERESTS IN SCIENCE AND TECHNOLOGY IN GRADE 5 – 12 CLASSROOMS ACROSS MONTANA

Jeffrey Willard Crews
The University of Montana

Follow this and additional works at: https://scholarworks.umt.edu/etd
Let us know how access to this document benefits you.

Recommended Citation
Crews, Jeffrey Willard, "IMPACTS OF A TEACHER GEOSPATIAL TECHNOLOGIES PROFESSIONAL DEVELOPMENT PROJECT ON STUDENT SPATIAL LITERACY SKILLS AND INTERESTS IN SCIENCE AND TECHNOLOGY IN GRADE 5 – 12 CLASSROOMS ACROSS MONTANA” (2008). Graduate Student Theses, Dissertations, & Professional Papers. 548.
https://scholarworks.umt.edu/etd/548

This Dissertation is brought to you for free and open access by the Graduate School at ScholarWorks at University of Montana. It has been accepted for inclusion in Graduate Student Theses, Dissertations, & Professional Papers by an authorized administrator of ScholarWorks at University of Montana. For more information, please contact scholarworks@mso.umt.edu.
IMPACTS OF A TEACHER GEOSPATIAL TECHNOLOGIES PROFESSIONAL DEVELOPMENT PROJECT ON STUDENT SPATIAL LITERACY SKILLS AND INTERESTS IN SCIENCE AND TECHNOLOGY IN GRADE 5 – 12 CLASSROOMS ACROSS MONTANA

By

Jeffrey Willard Crews

B.A., The University of Montana, Missoula, MT, 1987
M.Ed, Lesley University, Cambridge, MA, 1998

Dissertation

presented in partial fulfillment of the requirements for the degree of

Doctor of Education in Curriculum and Instruction

The University of Montana
Missoula, MT

Spring 2008

Approved by:

Dr. David A. Strobel, Dean
Graduate School

Lisa M. Blank, Chair
Curriculum and Instruction

Darrell W. Stolle
Curriculum and Instruction

Trent L. Atkins
Curriculum and Instruction

Georgia Cobbs
Curriculum and Instruction

Joseph J. Kerski
Education Manager, ESRI
Impacts of a Teacher Geospatial Technologies Professional Development Project on Student Spatial Literacy Skills and Interests in Science and Technology in Grade 5 – 12 Classrooms across Montana

Chairperson: Lisa M. Blank, Ph.D.

This study utilized participants in a teacher geospatial technologies professional development project. Data was collected on the impact this professional development model, and the corresponding classroom implementation of the curriculum, had on student spatial literacy skills and students’ interest in science and technology. Twenty teachers from across Montana with demonstrated competency in the use of geospatial technologies were selected for participation in this project. These twenty teachers were broken into two cohorts, cohort one served as the experimental group and cohort two served as the control group. Students within these classrooms ranging in grades 5 – 12, took two assessments, a spatial literacy skills assessment (grades 9 – 12) and a science and technology interest survey (grades 5 - 12).

Statistical comparisons of the spatial literacy skills assessment made between pretest and posttest experimental group scores showed no significant change between scores from pretest to posttest. Post-hoc analysis of the spatial literacy data differentiated by teacher, gender, grade, level of proficiency, and teacher specific variables did reveal some interesting findings. Scores for teacher specific groupings showed a positive change between testing intervals. Positive changes also occurred for certain groups differentiated by gender, grade level, proficiency level, quantity of implementation, and teacher competency.

Frequency distributions results from the science and technology interest survey did not show an important difference between the testing intervals, nor was there an important difference between the experimental group and the control group.

Comparative analyses of two teachers varying in quantity of implementation (high and low) produced an increase in student spatial literacy scores for the high quantity implementation group and a decrease for the low quantity group. Student interest scores for the high quantity implementation group decreased while the interest scores for the low quantity group either remained the same or increased.

Changes between the two groups indicate a gain in spatial literacy skills for the high quantity group likely due to the greater amount of exposure and a decrease in interests in science and technology, possibly attributed to a point-of-saturation for students, resulting from to-much-all-at-once implementation.
DEDICATION

To my mentor and friend Dr. Doug Beed, for encouraging me to embark on this journey.

To my Mom and Dad for instilling in me a desire to continue to explore and learn.

To my amazing wife Micki and daughters, Taylor, Rayna, and Riley for your unending love, support and encouragement throughout this process.
ACKNOWLEDGEMENTS

Many people have played a role in helping me complete this journey, while I can’t mention everyone on this page, to all of you, family, friends, and colleagues; I offer my sincerest thanks for your constant encouragement, understanding, and support.

I would especially like to thank Dr. Doug Beed, for encouraging me to pursue this degree, for always taking the time to listen, and for the many intellectual discussions in his office, where he taught me that in the end, when all else is gone, the relationships that we build with others is what lasts forever. I gratefully acknowledge Dr. Lisa Blank for her unending support and patience throughout this process. Her contributions went beyond this dissertation, believing in me and the positive impacts we can have on K-12 students. I would also like to thank the members of my dissertation committee for your invaluable input and guidance throughout my graduate career. Thanks to Dr Darrell Stolle, for the many intellectual discussions in his office as he helped me to broaden my perspectives; to Dr. Georgia Cobbs, for her continued support through the CLTW project; to Dr. Trent Atkins, for his analytical eye and guidance through the muddy waters of statistics; and to Dr. Joseph Kerski, for his enthusiastic approach and dedication to the integration of geospatial technologies into education.

To all the teachers that have opened up their classrooms and have supported the use of geospatial technologies, I am grateful. Thanks for understanding the importance of challenging your students to explore their world in new and innovative ways, for believing in the vision that we need to empower today’s students with cutting edge
technologies, so they may become decision makers of tomorrow. Thank you to my friends and colleagues at EOS, for your commitment to the teachers and students of Montana.

I am especially blessed with family and friends that have offered encouraging and supportive words throughout this process. Thanks to David Christensen, for the Friday morning conversations before school for the past 15 years. To my brothers and sisters-in-law for their words of encouragement and the necessary distractions that help one remain sane throughout this process. Thanks to my mom and dad for your constant and continued support, for instilling in me the importance of family, the value of education, and the power of love. To my daughters, Taylor, Rayna, and Riley, I love each one of you very much. From this experience, I hope you can begin to understand the value of hard work and the empowering effect of education. I challenge each of you to strive to be all you can be. And, to my wife Micki, thank you for your unselfish love, support, patience, and understanding. Without you I could have never made this journey. And finally, I acknowledge and thank God for His many blessings. His presence continues to be a source of strength and comfort to me.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>i</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iv</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xii</td>
</tr>
<tr>
<td>CHAPTER ONE</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Globalization</td>
<td>1</td>
</tr>
<tr>
<td>US Economy</td>
<td>1</td>
</tr>
<tr>
<td>Geospatial Workforce Development</td>
<td>3</td>
</tr>
<tr>
<td>Geospatial Technologies Education</td>
<td>4</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>7</td>
</tr>
<tr>
<td>Research Questions</td>
<td>7</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>8</td>
</tr>
<tr>
<td>Delimitations and Limitations</td>
<td>9</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>10</td>
</tr>
<tr>
<td>Outline of the Study</td>
<td>10</td>
</tr>
<tr>
<td>CHAPTER TWO</td>
<td>12</td>
</tr>
<tr>
<td>Review of Literature</td>
<td>12</td>
</tr>
<tr>
<td>Introduction</td>
<td>12</td>
</tr>
<tr>
<td>The State of the American Economy</td>
<td>12</td>
</tr>
<tr>
<td>Spatial Literacy</td>
<td>15</td>
</tr>
<tr>
<td>Geospatial Technologies</td>
<td>19</td>
</tr>
<tr>
<td>Student Interests in Science and Technology</td>
<td>22</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Geospatial Professional Development</td>
<td>26</td>
</tr>
<tr>
<td>Professional Development</td>
<td>29</td>
</tr>
<tr>
<td>Research Design</td>
<td>38</td>
</tr>
<tr>
<td>Research Questions</td>
<td>38</td>
</tr>
<tr>
<td>The Null Hypothesis</td>
<td>38</td>
</tr>
<tr>
<td>Population and Sample</td>
<td>40</td>
</tr>
<tr>
<td>External Validity</td>
<td>42</td>
</tr>
<tr>
<td>Experimental Design</td>
<td>43</td>
</tr>
<tr>
<td>Data Collection Procedures</td>
<td>44</td>
</tr>
<tr>
<td>Instruments</td>
<td>46</td>
</tr>
<tr>
<td>Reliability</td>
<td>47</td>
</tr>
<tr>
<td>Internal Validity</td>
<td>47</td>
</tr>
<tr>
<td>A Priori</td>
<td>48</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>48</td>
</tr>
<tr>
<td>Summary</td>
<td>52</td>
</tr>
<tr>
<td>CHAPTER FOUR</td>
<td>53</td>
</tr>
<tr>
<td>Results</td>
<td>53</td>
</tr>
<tr>
<td>Description of the Sample</td>
<td>53</td>
</tr>
<tr>
<td>Analysis of Spatial Literacy Skills Assessment</td>
<td>54</td>
</tr>
<tr>
<td>Reliability Coefficient for the Spatial Literacy Skills Assessment</td>
<td>55</td>
</tr>
<tr>
<td>Results of the Spatial Literacy Skills Assessment</td>
<td>56</td>
</tr>
<tr>
<td>Individual Schools Data</td>
<td>57</td>
</tr>
<tr>
<td>Gender</td>
<td>63</td>
</tr>
<tr>
<td>Grade Level</td>
<td>64</td>
</tr>
<tr>
<td>Proficiency Level</td>
<td>66</td>
</tr>
<tr>
<td>Technology Capacity</td>
<td>69</td>
</tr>
<tr>
<td>Quantity of Implementation</td>
<td>69</td>
</tr>
</tbody>
</table>
### Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary of Spatial Literacy Skills Assessment</td>
<td>74</td>
</tr>
<tr>
<td>Analysis of Students’ Interests in Science and Technology</td>
<td>75</td>
</tr>
<tr>
<td>Illustrative Analysis of Students’ Data from Two Participating Teachers</td>
<td>91</td>
</tr>
<tr>
<td>Student Scores on the Spatial Literacy Assessment</td>
<td>94</td>
</tr>
<tr>
<td>Student Responses to Science and Technology Interest Survey</td>
<td>95</td>
</tr>
<tr>
<td>Summary</td>
<td>102</td>
</tr>
<tr>
<td>CHAPTER FIVE</td>
<td>105</td>
</tr>
<tr>
<td>Findings</td>
<td>105</td>
</tr>
<tr>
<td>Finding 1 – Spatial Literacy</td>
<td>106</td>
</tr>
<tr>
<td>Finding 2 – Students’ Interests in Science and Technology</td>
<td>106</td>
</tr>
<tr>
<td>Finding 3 – Comparative Analysis of Students’ Data From Two Participating Teachers</td>
<td>107</td>
</tr>
<tr>
<td>Observations on the Study</td>
<td>109</td>
</tr>
<tr>
<td>Conclusions</td>
<td>111</td>
</tr>
<tr>
<td>Recommendations for Further Research</td>
<td>112</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>117</td>
</tr>
<tr>
<td>APPENDIX A GTEC TEACHER CONTRACT ACTIVITIES OUTLINE</td>
<td>124</td>
</tr>
<tr>
<td>APPENDIX B GTEC TEACHER PROGRAM APPLICATION</td>
<td>127</td>
</tr>
<tr>
<td>APPENDIX C ARCLESSONS TEMPLATE</td>
<td>131</td>
</tr>
<tr>
<td>APPENDIX D GTEC SUMMER INSTITUTE SCHEDULE</td>
<td>146</td>
</tr>
<tr>
<td>APPENDIX E GTEC INTERACTIVE WEBSITE</td>
<td>149</td>
</tr>
<tr>
<td>APPENDIX F HELP DESK LOG</td>
<td>156</td>
</tr>
<tr>
<td>APPENDIX G SAMPLE CHAT LOG</td>
<td>160</td>
</tr>
<tr>
<td>APPENDIX H SPATIAL LITERACY SKILLS ASSESSMENT</td>
<td>178</td>
</tr>
<tr>
<td>APPENDIX I SCIENCE AND TECHNOLOGY INTEREST SURVEY</td>
<td>208</td>
</tr>
<tr>
<td>APPENDIX J GEOSPAPTIAL TECHNOLOGIES COMPETENCIES INDEX</td>
<td>228</td>
</tr>
<tr>
<td>APPENDIX K TEACHER 1 SAMPLE CURRICULUM</td>
<td>231</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1 Teacher Capacity Matrix ................................................................. 50
Table 2 Teacher Quantity Matrix ................................................................. 51
Table 3 Teacher Competency Matrix ............................................................ 51
Table 4 Summary of Number of Students per School, Grade Levels, and Gender 55
Table 5 Summary of Pretest and Posttest Scores for all Schools ...................... 56
Table 6 Paired Sample T-test for Significance Between Pretest and Posttest Scores on Spatial Literacy Assessment ................................................................. 57
Table 7 Summary of Spatial Literacy Scores for School #1 .............................. 57
Table 8 Summary of Overall Changes in Pre-test and Post-test Scores for School #1 58
Table 9 Summary of Spatial Literacy Scores for School #3 .............................. 59
Table 10 Summary of overall changes in pre/post scores for School #3 .............. 59
Table 11 Summary of Spatial Literacy Scores for School #4 .............................. 60
Table 12 Summary of Overall Changes in Pre-test and Post-Test Scores for School #4 60
Table 13 Summary of Spatial Literacy Scores for School #5 .............................. 61
Table 14 Summary of Overall Changes in Pre-Test and Post-Test Scores for School #5 61
Table 15 Spatial Literacy Skills Assessment Data by Gender ............................ 64
Table 16 Spatial Literacy Skills Assessment Data by Grade Level ........................ 65
Table 17 Proficiency Level of Students for Pretest and Posttest Scores .............. 67
Table 18 Teacher Technology Capacity Rating ............................................. 69
Table 19 Teacher Quantity of Implementation Categories ............................ 70
Table 20 Results of Quantity of Implementation Analysis .............................. 70
Table 21 Teacher Competency Categories .................................................. 72
Table 22 Results of Teacher Competency Analysis .................................... 73
Table 23 Summary of Number of Students per School, Grade Levels, and Gender ........ 76

Table 24 Frequency Distributions of Experimental and Control Group for Beliefs About Science and Geotechnologies .......................................................................................................................... 78

Table 25 Frequency Distributions of Experimental and Control Group for Geotechnology Careers ......................................................................................................................................................... 85

Table 26 Teacher Comparison from Capacity, Quantity, and Competency .................. 92

Table 27 Implementation Comparison for Teacher 1 (high implementation) and Teacher 5 (low implementation) ................................................................................................................................. 93

Table 28 Students' Spatial Literacy Scores for Teacher 1 and 5 .................................. 94

Table 29 Student Interest Survey Questions with Difference Greater Than 10% .......... 96

Table 30 Differences for Teacher 1 and 5 for Questions 1 - 20 .................................. 98

Table 31 Differences for Teacher 1 and 5 for Questions 21 - 56 ................................. 100
LIST OF FIGURES

Figure 1. Cyclical Flow of Geospatial Information ............................................................ 5
Figure 2 Timeline of Year-Long Intensive Professional Development ............................ 31
Figure 3 GTEC Participating Schools............................................................................... 42
Figure 4 Timeline of Year-Long Intensive Professional Development with Assessment 45
Figure 5 Students Participating per School per Grade....................................................... 55
Figure 6 Change in Mean for Schools From Pre-test to Post-Test ........................................ 62
Figure 7 Percent Change for Schools From Pre-test to Post-test...................................... 63
Figure 8 Change in Mean by Gender from Pre-test to Post-test...................................... 64
Figure 9 Change in Mean by Grade Level From Pre-test to Post-test................................. 65
Figure 10 Change in Mean by Level of Proficiency from Pre-test to Post-test................. 68
Figure 11 Change in Mean by Quantity of Implementation From Pre-test to Post-test ... 71
Figure 12 Change in Mean by Teacher Competency From Pre-test to Post-test ............... 73
Figure 13 Pre - Post Experimental Group Frequency Distributions for Questions 1-20 .. 83
Figure 14 Pre - Post Control Group Frequency Distributions for Questions 1-20 .......... 84
Figure 15 Pre - Post Experimental Group Frequency Distributions for Questions 21 - 55 .................................................. 90
Figure 16 Pre - Post Control Group Frequency Distributions for Questions 21 – 55 ....... 91
Figure 17 Comparison of Mean Scores on Spatial Literacy Assessment for Teacher 1 and 5 Between Pre-Test and Post-Test ............................................................................. 95
Figure 18 Percent Difference for Student Interest Survey (Questions 1 – 20) from Pre-test to Post-test for Teacher - 1 and Teacher - 2 ................................................................. 99
Figure 19 Percent Difference for Student Interest Survey (Questions 21 - 56) from Pre- test to Post-test for Teacher - 1 and Teacher - 2 ................................................................. 101
CHAPTER ONE

“The first day or so, we all pointed to our countries. The third or fourth day we were pointing to our continents. By the fifth day we were aware of only one Earth.”

Comments from Sultan Bin Salman al-Saud, the Kingdom of Saudi Arabia as he was looking back at the Earth from space

Introduction

Globalization

America’s economic strength and global leadership depend in large measure on our Nation’s ability to generate and harness the latest in scientific and technological developments and to apply these developments to real world applications. These applications are fueled by scientific research which produces new ideas and new tools that can become the foundation for tomorrow’s products, services, and ways of doing business (Office of Science and Technology, 2006).

This statement, found in the American Competitiveness Initiative, is a strong declaration by some, of the direction they feel the United States should be heading and it doesn’t come with a small price tag: $50 billion dollars over the next ten years. But why should the US invest billions of dollars to support this type of growth? In 2005 the National Academy of Science reported, “Having reviewed trends in the U.S. and abroad, the committee is deeply concerned that the scientific and technical building blocks of our economic leadership are eroding away at a time when many other nations are gathering strength.”

US Economy

According to The American Competitiveness Initiative Strategy (2006), a federal program committed to infusing $5.9 billion in FY 2007 to increase investments in research and
development, strengthen education, and encourage entrepreneurship, our strength as a nation comes from a strong education system that equips our workforce with the skills necessary to transform ideas into goods and services that improve lives and provide our Nation with the researchers of the future; and an environment that encourages entrepreneurship, risk taking, and innovative thinking. By giving citizens the tools necessary to realize their greatest potential, The American Competitiveness Initiative (ACI) will help ensure future generations have an even brighter future.

But what should educators teach as they work to prepare their students for the “Flattened World?” In the latest version of his bestselling book The World is Flat, Thomas Friedman (2007) points to Princeton Economist Alan Blinder’s argument that “how we educate our children is more important than how much we educate them.” This simple, but profound, statement resonates amongst educators as they struggle to decide how and what to teach, preparing the next generation of decision makers. Freidman dedicates a chapter in his latest version titled “The Right Stuff” where he addresses the five abilities he feels are helpful in preparing young people for jobs in a flattened world. According to Friedman, the first and most important ability is for students to learn how to learn. This skill will help students adapt to new technologies and develop new skills that will likely be the norm in the future workforce. Secondly, students should have the ability to navigate the virtual world. This becomes increasingly important as students interact with each other and all that resides on the web, filtering through information, separating facts from fiction. Third is passion and curiosity. Friedman suggests, in a flattened world where there are infinite resources at the fingertips of the workforce, there are so many more tools that allow students’ curiosity to go so much farther and deeper. Fourth, is placing emphasis on liberal
Friedman argues that the new workforce will have to be great synthesizers which require individuals to think horizontally. Because liberal arts education tends to stress the connections between the subject areas, this can serve to help students find connections between disciplines. Finally, Friedman argues for right brain thinking, the ability to think creatively, connect the dots, mesh together different perspectives to produce an individual that can forge relationships rather than execute transactions, tackle novel challenges instead of solving routine problems, and analyze the big picture rather than analyze a single component. Friedman’s anecdotal comments addressing globalization and the need to have a well educated workforce are summed up in a dinner conversation he had with his daughters:

“Girls, when I was growing up, my parents used to say to me, ‘Tom, finish your dinner – people in China and India are starving.’ My advice to you is: Girls, finish your homework – people in China and India are starving for your jobs.”

**Geospatial Workforce Development**

The U.S. Department of Labor (2003) published a list identifying 14 job sectors that fit the following criteria: (1) Add substantial numbers of new jobs to the economy or affect the growth of other industries; or, (2) They are existing or emerging businesses being transformed by technology and innovation requiring new skill sets for workers. One of the job sectors identified is the geospatial technology industry. Gaudet, Annulis, and Carr (2003) completed an analysis of the worldwide geospatial technologies market. They estimated it to be a $5 billion market in 2003 and projected it to be a $30 billion market in 2005. By 2008, the market continues to grow as new industries realize the inherent benefits geospatial technologies have on their industry.
**Geospatial Technologies Education**

In September 2004, U.S. Secretary of Labor Elaine L. Chao issued a report announcing a series of investments totaling more than $6.4 million to address the workforce needs of the geospatial technology industry (U.S. Department of Labor, 2004). According to Gaudet, Annulis, and Carr (2003) there is a serious shortfall of professionals and trained specialists who can utilize geospatial technologies in their jobs. Furthermore, they suggest development of a strategy to meet the challenges of providing a well trained workforce ready to apply geospatial technologies when solving societal issues. In the same U.S. Department of Labor report identified above, a set of priorities were developed to address industry needs. **The first priority listed recommends expanding the pipeline of youth entering the geospatial technology industry: education.** Shortly after Chao released her report addressing workforce needs another report emerged from the National Research Council addressing the need for K-12 schools to teach spatial thinking - skills that are facilitated when solving real-world problems using geospatial technologies. According to the National Research Council (2006), instruction in spatial thinking would help to foster a new generation of spatially literate students who are proficient in terms of spatial knowledge, spatial ways of thinking and acting, and spatial capabilities. With this proficiency, students will have established the habit of mind of thinking spatially, seeing opportunities for approaching problems by using their knowledge of concepts of space. They should be able to practice spatial thinking in an informed way, drawing on their knowledge of tools of representation. They will adopt a critical stance to spatial thinking, using the appropriate processes of spatial reasoning. The figure below is a visual representation of the circular flow of information within the geospatial domain.
In the recently released proceedings from the National Science Teachers Association an alarming trend was noted:

New and emerging technologies, which help shape the future of science and discovery, are making their way into the K-12 curriculum in a belated or “back-door fashion,” if at all. Technologies that are developed for business applications are being adapted, at best, in a makeshift fashion for educational use. . . For the US to maintain its leadership position in the new information-based world economy . . . emerging technologies with science education potential must be made available to students and teachers (National Science Teachers Association, 2004).
In a series of recommendations delivered by the National Research Council (2006), it was made clear that spatial literacy was not an add-on to an already overburdened school curriculum, but rather a missing link across the curriculum and a lever to enable students to achieve a deeper and more insightful understanding of subjects across the curriculum. The council also concluded: …

Spatial thinking must be recognized as a fundamental part of K-12 education and as an integrator and a facilitator for problem solving across the curriculum. With advances in computing technologies and the increasing availability of geospatial data, spatial thinking will play a significant role in the information-based economy of the 21st-century. Using appropriately designed support systems tailored to the K-12 context, spatial thinking can be taught formally to all students. A geographic information system (GIS) offers one example of a high-technology support system that can enable students and teachers to practice and apply spatial thinking in many areas of the curriculum.

Other researchers are prompting the education community to take note of how geospatial technologies impact all aspects of our lives. *Wired Magazine* (2007) reported on a story that the amount of digital data moving around the world today is something on the order of 161 exabytes. Just to put that number into perspective, one exabyte = 1,000 petabytes or 1,000,000 terabytes or 1 billion gigabytes (again, slightly different in base 2). They even estimate we’re likely to hit slightly under 1,000 exabytes (or one zettabyte) by 2010. While this number is astounding and somewhat incomprehensible, estimates are that between 70 to 80 percent of all data is spatial, meaning it can be fixed to a specific location or xy coordinate, giving added value to the use of geospatial technologies since its primary function is to work with spatial data sets (U.S. Department of Labor, 2005).

Not only is spatial data becoming more prevalent, the tools used to manipulate spatial data are becoming much more intuitive and easy to use. In the wake of hurricane
Katrina, Google Earth played an unexpectedly useful role. In a matter of days, The National Oceanic and Atmospheric Administration (NOAA) had over 8000 post-disaster aerial photos of the flooded areas. These images allowed disaster area workers the opportunity to scan for open roads. Biologists, epidemiologists, and disaster workers are also discovering the power of Google Earth as a geospatial tool (Dworschak, 2006). Still others demand a new approach to education in which spatial literacy is recognized along with other basic sets of skills – that maps, pictures, and spatial data need to rank with numbers, text, and logic as essential ways in which humans function, the fourth “R” (Goodchild, 2006). It is clear that geospatial technologies are interwoven into the very fabric of everyday life. Educators should capitalize on the robustness of the technology in order to build spatial literacy skills in the current population so they become the problem-solvers of tomorrow.

**Purpose of the Study**

The purpose of this research project was to measure the relationship between the implementation of a year-long inservice teacher geospatial technologies professional development and corresponding classroom curriculum instruction on two assessment measures: 1) Students’ spatial literacy skills; and, 2) student interests in science and technology.

**Research Questions**

Does the implementation of a teacher geospatial technologies professional development project in school science classroom improve students’ spatial literacy skills in grades 9-12? Does the implementation of an inservice teacher geospatial
technologies professional development project in grades 5 - 12 school science classrooms increase students’ interests in science and technology?

Hypotheses

The implementation of a teacher geospatial technologies professional development project in grades 9 - 12 school science classrooms will increase students’ spatial literacy skills. Students’ interests in science and technology will increase after their teachers have completed the teacher geospatial technologies professional development project.

Definition of Terms

GTPDP - Geospatial Technologies Professional Development Project

Geospatial Technology – Three specific technologies, GIS, GPS, and Remote Sensing, which together are regarded core of geospatial technologies.

GIS – Geographic Information Systems: A mapping system used to layer spatial data to better understand relationships between data sets.

GPS – Global Positioning System: A satellite-based system used to reference a location on the surface of the Earth, providing a latitude and longitude to a high degree of accuracy.

Remote Sensing – The process by which humans or instruments obtain information about something without touching it. In this context, it will primarily be referred to as satellite imagery (orbiting remote sensors).

Spatial Literacy – The ability of an individual to critically analyze a spatially referenced data set and be able to ascertain certain types of information from the data.
Google Earth – A virtual 3D globe program (GIS) that allows users to explore all parts of the Earth in order to better understand the many layers that make up our planet.

**Delimitations and Limitations**

The treatment student sample selected for this study was limited to students whose teachers participated in a year-long geospatial summer institute (quasi-experimental design) and was limited to teachers from Montana; thus the ability to generalize to populations outside of Montana is limited to states with similar demographics. The sample represents the rural nature of Montana and will be generalizable, in this respect, to similar areas across Montana. Another limiting factor of generalizability for this study was the large grade range, grades 5 -12, within which this study took place. The differences in cognitive abilities of students that fall within this grade range can be significant, however, this large range yields the researcher with interesting results when the data were disaggregated.

This study examined the changes in students’ spatial literacy skills and interests in science and technology; therefore, prior spatial literacy skills and interests were not significant to the outcome. While this researcher could not control the skills and interests of the control and treatment groups, it was assumed the two groups were homogenous in their skills, interests, and other factors. While the teachers teaching the students within the control group did not participated in the geospatial summer workshops, the researcher did not intend to control whether or not these teachers investigated and implemented, on their own, some geospatial technology. The focus of this study was to assess the impact a teacher geospatial technologies professional development project has on students’ spatial literacy skills and students’ interests in science and technology. Efforts were made to
preserve the treatment and control groups; however, the nature of K-12 education is such that some attrition during the course of the study did occur.

**Significance of the Study**

This study served to inform educators, administrators, and professional development experts about the efficacy of implementing a geospatial technology curriculum and the impact technology had on spatial literacy skills and science and technology interests. As technology continues to be infused into our schools, it is imperative that we understand how to effectively implement technology and measure the impact professional development trainings can have on student learning. As educators seek to find technology rich curriculum designed to engage students in higher level thinking skills, this research can guide the decision making process. As pieces of geospatial technology like Google Earth make their way into mainstream education, it is imperative to understand the impacts these technologies have on student learning. It is also important for teachers and researchers alike to put forth curriculum that captures the power of these technologies and at the same time aligns with national standards and best practices research.

**Outline of the Study**

The second chapter of this study reviews the related research on geospatial technologies and spatial literacy and includes a portion on effective professional development. The third chapter describes the quantitative procedures used in this study. Chapter four presents the findings from the study including output tables of statistical analysis. Chapter five summarizes the findings, outlines the implications of these results,
and makes recommendations for implementing geospatial technologies into classroom instruction. Finally, future research ideas are discussed.
CHAPTER TWO

Review of Literature

Introduction

This chapter is divided into five major sections. The first section will address globalization, the state of the American economy and how they relate to the geospatial workforce, and, more specifically, how they relate to geospatial education. Second is a review of the research on spatial literacy as it relates to education and the case for its inclusion in educational practices. Third is a thorough examination of the research conducted on the use of geospatial technologies in educational settings. Fourth is research on the integration of science and technology and how this integration impacts students’ interests. Last is a summary of a professional development (PD) model used for this project. Evidence will be provided to support the use of this model as a proven and effective strategy for providing professional development in math and science (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003).

The State of the American Economy

In 2004, President Bush released a report entitled, *A New Generation of American Innovation*” (The White House, 2004). The report addressed a series of specific measures to inspire an atmosphere where innovation thrives and spurred further documents from the Bush administration identifying several key areas as vital for keeping America competitive in the global economy. One such document, *The American Competitiveness Initiative* (2006) further addressed the need for a strong economy,
“America’s economic strength and global leadership depend in large measure on our nation’s ability to generate and harness the latest in scientific and technological developments and to apply these developments to real world applications” (Office of Science and Technology, 2006).

The National Science and Technology Council’s Report, *Science for the 21st Century* (2004) addressed the need for a vigorous science and technology enterprise with the following statement,

Through science we generate new knowledge and discovery, become inspired as we coax nature to reveal her myriad secrets, and expand our understanding of the physical and living world. A strong scientific enterprise produces new tools for analysis and investigation and increases our capacity to question, learn, and build on previous accomplishments. Science points us toward innovative solutions to today’s major challenges, provides the foundation for economic growth and development, and enhances our quality of life.

This report supports the execution of four major responsibilities of the federal science enterprise:

1. Promote discovery and sustain the excellence of the National scientific research enterprise.
2. Respond to the Nation’s challenges with timely, innovative approaches.
3. Invest in and accelerate the transformation of science into national benefits.
4. Achieve excellence in science and technology education and in workforce development.

The need for a highly educated and skilled workforce is a common theme among several documents that spawned from the *American Innovation Report*. Science, engineering, and mathematics education and workforce preparation are top priorities of the
current administration (National Science and Technology Council, 2004). Of the four recommendations that resulted from a joint report from The National Academy of Science, The National Academy of Engineering, and The Institute of Medicine, the first was to increase America’s talent pool by vastly improving K-12 science and mathematics education (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2005). Second, the need for a system of education through the secondary level that equips each new generation of Americans with the educational foundation for future study and inquiry in technical subjects and that inspires and sustains their interests (Office of Science and Technology, 2006).

Workforce development is one of the avenues addressed for creating the next generation of highly skilled workers. In 2003, The U.S. Department of Labor released a report titled, *The President’s High Growth Job Training Initiative* which identified the fourteen industry sectors that fit the following two criteria;

1. They are projected to add substantial numbers of new jobs to the economy or affect the growth of other industries.

2. They are existing or emerging businesses being transformed by technology and innovation requiring new skills sets for workers (U.S. Department of Labor, 2003).

One of the industries identified as “high growth” was geospatial technologies. In a follow-up report, the U.S. Department of Labor specifically addressed the need for a geospatial workforce and made several recommendations for meeting the increasing need.
First on their list was the need to expand the pipeline of youth entering the geospatial technology industry (U.S. Department of Labor, 2004). They also included the need for the development of curriculum and tools for enhancing the skills of geospatial professionals and increasing the capacity of educational institutions to train the future workforce.

The U. S. Department of Labor released a more extensive report in 2005 addressing the challenges of creating a stronger geospatial technology workforce. Within the proposed solutions in meeting the growing need for skills, competencies, and training in the use of geospatial technologies, the report suggested fostering the development of a geospatial curriculum. The report cited examples of how such curriculum development was already underway by several entities and suggested how these efforts might aide in linking with workforce development (U.S. Department of Labor, 2005).

In summary, the need for a competent, well trained geospatial workforce is necessary to meet the needs of a growing industry. As is outlined above, it is critical for educators to help meet the growing demand for geospatial workers by introducing their students to geospatial technologies. The introduction of geospatial curriculum models and professional development opportunities for teachers will help support the implementation of geospatial technologies into K-12 education and serve to continue to meet the needs for a highly skilled workforce for generations to come.

Spatial Literacy

Humans must often maneuver in new environments, integrate prior spatial knowledge with unfamiliar environmental inputs (terrestrial, atmospheric, celestial), and constantly interpret the spatial behaviors of others (human, animal) in order to make
decisions in real-time. The responses required in these decisions take place within environmental settings, aided by mental representations of the settings. In other words, we are always trying to interpret from multiple frames (Alibrandi, 2003).

Spatial thinking, one form of thinking, is a collection of cognitive skills. The skills consist of declarative and perceptual forms of knowledge and some cognitive operations that can be used to transform, combine, or otherwise operate on this knowledge. The key to spatial thinking is a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning (National Research Council, 2006).

In the book, *Learning to Think Spatially*, the National Research Council identified three components of spatial thinking and included examples for each component. They propose thinking spatially entails knowing about:

1. Space – for example, the relationships among units of measurement, different ways of calculating distances, the basis of coordinate systems, and the nature of spaces.

2. Representation – for example, the relationship among views, the effect of projections, the principles of graphic design.

3. Reasoning – for example, the different ways of thinking about shortest distances, the ability to extrapolate and interpolate, and make decisions.

Spatial thinking is a complex, powerful, and challenging process. Support systems provide an interactive environment within which spatial thinking can take place by helping students to spatialize data sets, visualize working and final results, and perform analytic functions. Support systems for spatial thinking must meet three requirements. They must:
1) Allow for the spatialization of data; 2) facilitate the visualization of working and final results; and, 3) perform a range of functions (transformations, operations, and analyses).

Research on spatial ability and spatial visualization skills has been an active field for at least four decades (Libarkin & Brick, 2002). Mathewson (1999) proposed that visual-spatial thinking include vision – using the eyes to identify, locate, and think about objects and ourselves in the world; and imagery – the formation, inspection, transformation, and maintenance of images in the “mind’s eye” in the absence of visual stimulus. More importantly, Mathewson suggested that a spatial image preserves relationships among a complex set of ideas as a single chunk in working memory, increasing the amount of information that can be maintained in consciousness at a given moment. The idea of holding information in memory is further addressed by Bunch and Lloyd (2006) as they described cognitive load theory and how it applies to spatial information. They suggested that in working with geographic information, when the cognitive load is high for a map task, it is more likely to be difficult and take longer to complete. This information becomes extremely important as the use of computer technology for displaying spatial information becomes increasingly prevalent, especially in the areas of education (Bunch & Lloyd, 2006).

Libarkin and Brick (2002) have found spatial skills research traditionally focused on the impact of incorporating visual materials into educational settings that were verbal environments. However, over time, visual pedagogies have evolved to include technology intensive techniques. According to Libarkin and Brick, most researchers agreed that visual stimulation, if used correctly, can help students move information from short term to long term memory, and hence, students have engaged in learning.
Spatial intelligence represents a set of behaviors that have, at different times, been deemed important but have been neglected in contemporary education. Changes in society, particularly related to computer technology, have challenged us to revisit the significance of spatial intelligence (Deizmann & Watters, 2000). According to the National Research Council (NRC), the time is now. Spatial thinking is not being systematically taught to K–12 students at present. We need to do so, across the curriculum and for all K–12 students, because it is fundamental to everyday life, the workplace, and science (National Research Council, 2006).

The NRC committee views spatial thinking as a basic and essential skill that can be learned, taught formally to all students, and supported by appropriately designed tools, technologies and curricula. With appropriate instruction and commensurate levels of low and high-tech support, spatial thinking can become an invaluable, lifelong habit of mind. Spatial thinking must be recognized as a fundamental and necessary part of the process of K–12 education (National Research Council, 2006).

The committee does not view spatial thinking as one more piece to be added on to an already overburdened curricular structure. In contrast, spatial thinking is viewed as an integrator and a facilitator for problem solving across the curriculum. Spatial thinking does not, and should not, stand alone. Spatial thinking must be recognized as a fundamental part of K-12 education and as an integrator and a facilitator for problem solving across the curriculum. With advances in computing technologies and the increasing availability of geospatial data, spatial thinking will play a significant role in the information-based economy of the 21st-century. Using appropriately designed support systems tailored to the K-12 context, spatial thinking can be taught formally to all students. A geographic information system (GIS) offers one example of a high-technology support system that can enable students and teachers to practice and apply spatial thinking in many areas of the curriculum (National Research Council, 2006).
Geospatial Technologies

Forest fires ravaging southern California, foot-and-mouth disease devastating the British livestock industry, the recent outbreak of severe acute respiratory syndrome (SARS) — all of these disasters have at least one thing in common - the role played by geospatial analysts, mining satellite images for information to help authorities make crucial decisions. By combining layers of spatially referenced data, called geographic information systems (GIS), with remotely sensed aerial or satellite images, these high-tech geographers have turned computer mapping into a powerful decision-making tool (Gewin, 2004).

Geospatial technologies and their products have become ever more common in our everyday lives. One can argue that the ability to use maps, images, and spatial technologies intelligently and critically is becoming a requirement to participate effectively as a citizen in modern society. Consider these four developments highlighted by Bednarz, Acheson, & Bednarz (2006) as evidence of the increasing use of geospatial technologies in the everyday lives of people:

1. Travelers, hikers, hunters, and fishers frequently use GPS systems to find their locations and to assist them in getting to their destination. These systems are also becoming more common in automobiles.

2. Google, the most popular internet search utility, now offers users maps at virtually any scale desired and, recently, through Google Earth, remotely sensed images that users can view from any direction or angle.

3. Governments and non-governmental organizations (NGOs) typically make information available via printed and, increasingly, online maps.

4. Static and animated maps are much more common in today's newspapers, magazines, and electronic media than they were 20 years ago.
In a report from the National Science Foundation, titled, *Complex Environmental Systems: Synthesis for Earth, Life, and Society in the 21st Century* the committee points to the advances seen in technology. They are quick to point to the abundance of spatially explicit information becoming available to researchers and the new opportunities being created by this spatial information (Pfirman & AC-ERE, 2003). The NRC recently published a book focused on spatial literacy which recommends GIS as a support system for spatial thinking. Compared with other high-tech support systems, current versions of GIS rate well in terms of their ability to address three fundamental requirements of a system to support spatial thinking across the curriculum. They have the capacity to: (1) Spatialize data sets by providing spatial data structures and coding systems for spatial and nonspatial data; (2) visualize by creating multiple forms of representation; and (3) perform functions by manipulating the structural relations of spatial data sets (National-Research-Council 2006). GIS, as a technology tool, moves beyond the surface level use of technology by giving students the opportunity to ask questions, solve problems, and analyze data. More teachers are realizing the potential GIS may have for their students. According to Audet and Abegg (1996), the feature of GIS that fascinates educators is its ability to swiftly and dynamically represent the world and its issues from a variety of spatial perspectives. Because anything that can be referenced to a specific geographic position becomes a candidate for investigation with GIS, the technology expands the scope of topics students can explore, promotes interdisciplinary learning, and changes the way students learn to reason about space. While there remains little published research on the use of GIS in classrooms, one study did find modest improvements. In Baker and White (2003), GIS was
shown to modestly improve integrated scientific process skills, especially data analysis.

Audet and Paris (1997) found the following:

Participants reported that introducing GIS fosters a classroom atmosphere that is more student-centered, presumably because problem-based learning activities are emphasized. Teachers who used GIS technology seemed less concerned about transmitting information than guiding student discovery. The teachers surveyed believed that GIS is a valuable educational tool because it enhanced problem solving, enabled spatial data analysis, supported interdisciplinary connections, and was enjoyable to students.

GIS is a powerful data visualization tool that can help students understand complex data by making maps and looking for patterns. Students hone their critical thinking skills by using this software to make decisions about particular problems or issues (Kolvoord & Keranen, n.d.). Geographic information systems (GIS) … those with a problem-based component, provide opportunities for students to interact with real-world data, to help solve complex problems. GIS can “stimulate students' intellectual development and enable learners to create, revise, and reconstruct what they know to create new frameworks of knowledge” (Burns, 2006).

Indeed, GIS is used daily in so many aspects of human activity that many predict it will one day be a required basic skill set just as word processing is today (Alibrandi, 2003). What does all this mean for GIS education? It demands a new education approach in which spatial literacy is recognized along with other basic skills – that maps, pictures and spatial data need to rank with numbers, text, and logic as essential ways in which humans function, the fourth R as Goodchild (2006) claims.
With so much potential for integration into existing curriculum, there still remain a low number of teachers choosing to implement GIS into their classroom instruction. Studies have found several reasons why more teachers are not choosing to implement GIS. Despite a growth in GIS implementation in education, these studies revealed several patterns that signify restraints on its expansion. These include the lack of time to develop GIS-based lessons, few curricular materials to help with integration process, lack of support for training and implementation, and the perceived complexity of the software (Kerski 2003, Bednarz S. W., 2003, Meyer, Olin, & Zack, 1999).

With this in mind, more research needs to be conducted on the use of GIS in K-12 instruction in order to determine its effect on student learning, spatial literacy skills, and interests about science and technology. Proper implementation of GIS is also critical to a successful program. Through this research, these questions are considered.

**Student Interests in Science and Technology**

In the past decade, technology has gained significant momentum in the education enterprise. In 2002 alone, schools increased spending on classroom technology to an all time high of $5 billion (Foltos, 2002). Not only has the amount of money schools spent on technology increased, but there is also a push to create a more technologically literate population. The National Academies of Engineering and The NRC (2002) suggested a broad-based effort to increase technological literacy of all Americans. Increasing technological literacy will have many benefits including: 1) More informed decision-making by citizens and business and government leaders about the development and use of technology; and 2) a more erudite population that will be better prepared for the demands
of today’s high-tech work environment. This report suggests the natural place to begin to develop technology literacy is in the public schools. They have come up with several recommendations to help make this happen:

1. Encouragement for the integration of technology from federal and state agencies;
2. Better alignment of standards that connect core subjects and technology;
3. Introduction of the word “technology” into core content standards;
4. Incentives for institutions of higher education to better equip all teachers to teach with technology throughout the curriculum;
5. Support the development of assessment tools for monitoring technological literacy;
6. Fund research on how people learn about technology (National Academies of Engineering and National Research Council, 2002).

While the use of computers is still divided along demographic and socioeconomic lines, it was found that schools help bridge the digital divide by providing access to technology within the school environment to those that don’t have access at home (National Center for Education Statistics, 2006). Researchers also found evidence that technology, when properly implemented, could have a positive impact on student achievement and the development of more positive student attitudes toward themselves and learning (Stratham & Torell, 1996, Sivin-Kachala, Bialo, & Rosso, 2000). Waddoups (2004) reviewed hundreds of research studies on technology education and found 34 that conformed to the NCLB scientifically based research (SBR) criteria for gold or silver
status. These studies were all designed to identify the impact technology integration had on teaching and learning and student achievement. He formed four principles based on his analysis:

1. Teachers, not technology, are the key to unlocking student potential. A teacher’s training in, knowledge of, and attitude toward technology and related skills are central to effective technology integration;

2. Curriculum design is critical for successful integration;

3. Technology design largely determines the impact of integration efforts on student achievement;

4. Ongoing formative evaluations are necessary for continued improvements in technology integration (Waddoups, 2004).

A comprehensive look at the 34 research articles identified by Waddoups as meeting the SBR guidelines for gold and silver status revealed research critical to identifying the four principles listed above. Teachers’ attitudes about technology, their skill in using it as a tool, and their knowledge of integration principles are central to effective classroom technology use (Knezek, Christensen, and Fluke, 2003). Christensen (2002) also explored the extent to which targeted teacher training promotes classroom technology use and fosters positive student attitudes toward technology. The author concluded that training teachers to use technology strongly influences their attitudes about its use in the classroom and a direct effect on students’ computer enjoyment.

Additional research focused on curriculum design found that open-ended technology integration allows for a tighter fit to curriculum and provides students with multiple
opportunities to engage in content (Brush, Armstrong, Barbrow, and Ulintz, 1999). Other research studies had similar findings. Matthew (1997) found open-ended, interactive technology design, those that moved away from a prescriptive path, improved students’ motivation and comprehension.

Hopson, Simms, and Knezak (2001) examined the effect of a technology-enriched classroom on the development of higher-order thinking skills and found that a technology-enriched classroom environment had a positive effect on students’ acquisition of higher-order thinking skills. As is summarized by Waddoups (2004), technology designed to be flexible, provide adequate feedback, and support multiplicity facilitates effective integration.

Results based on a gold SBR study found that students that received immediate feedback and online help scored significantly higher than other groups in regards to student achievement, retention, attitudes, and homework time (Wong, 2001).

Technology research specific to science education provides a series of recommendations for successful integration. NSTA (2004) suggested a new research agenda should be defined to better clarify the next generation of technology applications and their ties to teaching and learning 21st century science. NSTA made six recommendations to help move along this cause:

1. Student access;
2. Curriculum designed to integrate appropriate technologies;
3. Teacher preparation “Professional Development;”
4. Appropriate assessments (what works);
5. Support from school administrators;

Other researchers offered additional strategies for the successful implementation of technology into science education. Flick and Bell (2000) proposed five guidelines for using technology in the preparation of science teachers:

1. Technology should be introduced in the context of science content;
2. Technology should address worthwhile science with appropriate pedagogy;
3. Technology instruction in science should take advantage of the unique features of technology;
4. Technology should make scientific views more accessible;
5. Technology instruction should develop students’ understanding of relationships between technology and science;

This information is critical in helping to better understand how technology should be implemented into educational settings, specifically science, in order to impact students in positive ways.

Geospatial Professional Development

There have been few attempts to merge current research in spatial thinking and geography to develop curriculum or instruction in spatial analysis and problem solving. This new field of interest has broad implications for a number of industries, including workforce development issues (Bednarz S. W., Spatial Thinking, 2007). The implementation of GIS into K-12 education appears to be a new endeavor due to the lack of research that exists for this topic, however, there are a few researchers that could be
considered the “trail-blazers” for the implementation of a geospatial technologies professional development model.

In the final report from the EdGIS conference (1995), it was found that for GIS to have broader impacts on education there was a need for quality teacher training. In an early study regarding GIS implementation in schools, researchers found several characteristics of successful innovative projects. One of the primary concerns voiced by participating teachers was the availability of quality in-service support (Audet & Paris, 1997). In a survey they conducted of teachers using GIS, 77% of them strongly agreed that teacher training was necessary before introducing GIS into the classroom.

Additional research studies have been conducted to explore the effectiveness of a GIS professional development program. In a study conducted in Wyoming with 19 teachers, researchers conducted pre/post surveys of teacher participants to determine if a teacher professional development project had lasting effects on the implementation of GIS into 5-12 classrooms. It was found that teachers’ confidence in their ability to use GIS grew significantly after successive GIS in-service opportunities (Buss and McClurg, 2000).

While these results are promising, there remained variability in the confidence level of teachers to use different GIS features (Buss and McClurg, 2000). In a follow-up article, McClurg and Buss (2007), found that the pacing of instruction with immediate opportunities to apply the skills was an essential component needed by most participants in order to integrate the professional development experience into meaningful integration in their classroom. To better accommodate teacher needs, McClurg and Buss adjusted their workshop schedule to three two-day sessions, extended over a six-month period in order to
provide participants with opportunities to test and reflect on their experiences in the classroom (McClurg and Buss, 2007). Within their professional development model, McClurg and Buss developed a set of support structures for teacher participants. This multiple level approach model served to make the professional development experience more effective for participants. The teacher scaffolding included,

- Maintaining a website for participants to share ideas and problem-solve concerns;
- Providing individual e-mail or phone access to participants who had questions;
- Making personal on-site visits upon participant request;
- Distributing support manuals and handouts detailing and generalizing the skills covered in each workshop session.

From this professional development project several essential components for successful implementation of GIS into 5-12 education were identified:

- Pacing professional development activities to provide time for practice and application of knowledge and skills, including a conceptual introduction to GIS;
- Providing relevant, accessible data sets, developing skill in file management, using relevant examples to introduce skills; and,
- Implementing an array of support structures and participant motivators.

Another geospatial technologies project, currently taking place in New York, is called the GIT Ahead project. The focus of this project is to provide in-service teachers with professional development opportunities to implement geospatial information technologies into science classrooms. While this project is still collecting data regarding the
effectiveness of their professional development model, they have identified several critical factors that aid in the successful implementation of these technologies. Crucial aspects of GIT–related professional development appear to be intensive summer training, ongoing technological and curricular support throughout the school year, promotion of a supportive learning community, assistance in development and implementation of individual curricular plans, and program flexibility to meet teacher interests and needs (Trautmann and MaKinster, 2008)

Professional Development

There is little dispute in the research community that improving teaching and learning depends on sustained, high-quality professional development; however, there still seems to be a gap between common knowledge and common practice (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). Loucks-Horsley, et. al. suggest professional development is moving in a new direction:

The paradigm shift in professional development suggests a change in emphasis from transmission of knowledge to experiential learning, from reliance on existing research findings to examining one’s own teaching practice, from individual-focused to collaborative, and from mimicking best practices to problem-focused learning.

Loucks-Horsley, et. al. identified five core values underlying their beliefs about sound professional development:

1. Professional development experiences need to have all students and their learning at their core.
2. Excellent science and math teachers have a special and unique kind of knowledge that needs to be developed through their professional learning experiences.

3. Principles that guide the reform of student learning should also guide professional learning for educators.

4. The content of professional learning must come from both inside and outside the learner, and from both research and practice.

5. Professional development must both align with and support system-based changes that promote student learning.

The Teacher Geospatial Technology Professional Development Program (GTPDP)

Given that teachers, and not technology, are the key to unlocking student potential (Waddoups, 2004), this research project focused on providing inservice teachers with professional development opportunities to implement geospatial technologies into their science classrooms and understand the impact the professional development had on participating teachers’ classrooms. As was reported earlier, Christensen (2002) concluded that training teachers to use technology strongly influences their attitudes about its use in the classroom and a direct effect on students’ computer enjoyment. Additionally, Teachers’ attitudes about technology, their skill in using it as a tool, and their knowledge of integration principles are central to effective classroom technology use (Knezek, Christensen, and Fluke, 2003).
Based on the goals mentioned previously, GTEC project directors created a year-long professional development which included a one-week intensive institute, along with several follow-up activities designed to help teachers integrate geospatial technologies into their individual classrooms. See Appendix A for the GTEC Teacher Contract Activities Outline.

**Phase 1: Recruitment**

In order to create an effective professional development program for the implementation of geospatial technologies into K-12 education, project leaders first determined where teachers were in their beliefs and understandings of the aforementioned technologies (Loucks-Horsley, et. al., 2003). The beliefs and knowledge held by individual teachers helped project directors develop a program that was geared to meet the needs of participants and helped them to create meaningful curriculum that was used in classroom instruction. While geospatial technologies have the potential to be used as a technology tool that changes the way we teach, it should also be noted that these technologies also require skills different from the more mainstream technologies found in the Microsoft suite. In order to ascertain participant skills, knowledge and beliefs a teacher program application was used, see Appendix B.

The program application helped project directors determine where teachers were in their understanding of technology, specifically geospatial technologies. The application also served to create a benchmark to help determine how much growth occurred as the TGTPDP project was implemented throughout the project.
Phase 2: Summer Institute

The week long institute emphasized the introduction of technology into the context of science content, as recommended by Flick and Bell, 2000. The summer institute consisted of a five day intensive project designed to immerse teachers in the use and implementation of geospatial technologies into K-12 education. This week long institute focused on learning various skills associated with geospatial technologies and the application of those skills to classroom settings. The model used for this professional development project was based on the work done by Buss and McClurg, 2001, 2007, which identified several essential components for successful implementation of GIS into 5-12 education were identified:

- Pacing professional development activities to provide time for practice and application of knowledge and skills, including a conceptual introduction to GIS;
- Providing relevant, accessible data sets, developing skill in file management, using relevant examples to introduce skills; and,
- Implementing an array of support structures and participant motivators.

During the course of the week-long summer institute participants were immersed in the use of geospatial technologies. Lessons were designed to teach participants certain skills, beginning with more basic skills and moving to more advanced skills. Proceeding in this manner served to move teachers from the more basic skills of geospatial technologies into more advanced skills. Along with the skill lessons, project directors created a geospatial module focused on global climate change designed to give teachers a sample curriculum.
module they would be required to complete as part of the project and to monitor the consistency with existing GIS curriculum resources. As the week progressed, less time was used for teaching and more time was provided for development of curriculum by individual teachers. A lesson template was retrieved from the ESRI website (Appendix C) and was used as a guide for the sample lesson.

Research scientists and others working in the geospatial technologies field were brought in to share their experiences with geospatial technologies and provide insight in how geospatial technologies are used in each of their fields of work. Topics ranged from precision agriculture to global climate change. See Appendix D for the summer institute agenda.

Throughout the institute, teachers were presented with samples of how teachers across the country were using these technology tools to change the way they teach and how children learn. After each day, workshop evaluation forms were used to assess effectiveness of the day’s activities.

Phase 3: Module Development

During this part of TGTPDP teachers spent time finishing up their module and prepared it for implementation into their classroom. Project directors were available to assist teachers with module development.

Phase 4: Module Implementation
This portion of TGTPDP took place in the fall and involved teachers implementing their module into their curriculum. Teachers took students through all aspects of the project and used data sets and curriculum created in the summer institute to facilitate students through the learning process. At least one project director was on hand to observe the implementation of the project and evaluate engagement on the part of the students. Teachers collected all student work and artifacts and submitted them to TGTPDP project leaders as an informal evaluation piece. Teachers filled out a reflection form to help assess the implementation of the module. Project leaders provided at least three synchronous chats through the course of the implementation period to provide a venue for teachers to share ideas, frustrations, and other concerns. To provide participants with an opportunity to test and reflect on their experiences this project incorporated the several support structures.

One of the support structures GTEC project put in place to help support the implementation of geospatial datasets was our interactive website (Appendix E). This site was designed as a one-stop portal for teachers working with geospatial datasets. The site housed recent research on geospatial technologies, contained several spatial datasets readily available for download and used online video tutorials, links to other data resources on the web, and even an online chat feature that provided opportunities for GTEC participants to come together via the Internet to discuss ideas, issues, and concerns that arose from geospatial technologies integration (held three times during the year as a support mechanism for teachers).
An additional support structure implemented by the GTEC project team was a teacher help desk. Teachers could email or call the GTEC help desk and receive help from a staff member. The scope of the questions ranged from installation issues to problems finding relevant data sets. See Appendix F for help desk log.

To provide additional support for teacher participants GTEC project staff conducted three synchronous chat sessions throughout the year. Using the GTEC interactive website, chat sessions gave teachers the opportunity to ask relevant questions about geospatial technologies. See Appendix G for a sample chat log.

As an additional measure of the implementation of geospatial technologies into participants’ classrooms, site visits were conducted to observe the level to which the curriculum was being implemented.

A geospatial competition was also introduced in the spring of the following year in order to engage students from the participating teachers’ classrooms in a practical application of geospatial technologies. GTEC project leaders designed a series of questions, based around global climate change, which students used geospatial technologies to help answer the question. This competition served to help strengthen the applicability of geospatial technologies as a tool for solving problems.

Geospatial technologies have the potential to change the way teachers teach and the way students learn about the world around them. However, in order for these new technologies to find their way into the classroom we must provide opportunities for teachers to experience the power these tools have in engaging students, and in turn helping
students to connect to the world around them in new and meaningful ways. The information found in this review addresses the gap that exists in the research literature pertaining to the implementation of geotechnologies into K-12 education.

Because geospatial technologies have so recently emerged in the educational arena, limited numbers of professional development opportunities for teachers exist. As well, few research studies on the effect of these professional development opportunities are available. Therefore, this project will make an important contribution on what kinds of geospatial professional development models best supports teachers.

Chapter three presents the research methodology used to understand the effects this geospatial technologies professional development project had on students’ spatial literacy skills and students’ interests in science and technology.
CHAPTER THREE

Methodology

Research Design

This research study examined an existing program, Geotechnology in the Science Classroom (GTEC), a teacher professional development project, as described in Chapter Two.

Research Questions

This research study investigated the integration of science and technology, specifically, how a teacher geospatial technologies professional development project (GTPDP) increased student spatial literacy skills and students’ interests in science and technology in 5-12 classrooms across Montana. Research Question 1. Does the implementation of a teacher GTPDP improve students’ spatial literacy skills in 9-12 classrooms across Montana? Research Question 2. Does the implementation of a teacher GTPDP increase students’ interest in science and technology in 5-12 classrooms across Montana?

The Null Hypothesis

The null hypotheses for this study were:

1. There will be no significant difference found in scores between pre – post treatment group performance on the Spatial Literacy Skills Assessment due to the implementation of a teacher geospatial technologies professional development model.
2. There will be no experimentally important or consistent difference found in student science interest scores between treatment and control group, as measured by the student science interest survey, due to the implementation of a teacher geospatial technologies professional development model.

*Independent Variable.* The independent variable for this research study was the implementation of a teacher geospatial technology professional development project. For the purposes of this study the teacher geospatial technology professional development project was a year-long, immersive experience, in which teachers learned how to use and apply geospatial technologies into classroom settings and worked to develop curriculum modules, unique to each community’s makeup that would be implemented into their classroom instruction.

*Dependent Variables.* The dependent variables for this research study were spatial literacy skills and student interests in science and technology as measured by the spatial literacy skills assessment and the student interests in science and technology survey. The intent of this research was to examine the relationship between the implementation of a teacher geospatial technology professional development project and the effect this project had on the two dependent variables: spatial literacy skills and student interests in science and technology.

For this study, the assessment data gathered from the spatial literacy skills assessment were raw scores and were treated as ratio level data. Data gathered from the science interest survey were Likert scale data and therefore were treated as nominal level data.
Population and Sample

In 2001, The University of Montana, Earth Observing System Education Project (EOSEP), funded by a congressional earmark through The National Aeronautics and Space Administration (NASA), began the GIS4MT project. The goal of this project was to introduce Montana teachers to geospatial technologies and provide support for efforts to implement these new technologies into classroom instruction. In all, EOSEP provided training for over 230 teachers across the state. However, in follow-up program evaluation studies of the geospatial training, it was found that teachers struggled to fully implement geotechnology into their science classrooms, citing a lack of access to spatial data sets appropriate for school-aged audiences and onsite support.

For this study, teachers from this pool of 230 were invited to apply for a position in the project. From this pool of teachers, geotechnology educator leadership teams were selected for the GTEC project based on their proficiency in the use of geospatial technologies and strong commitment to the development of geospatial curriculum. In selecting the teacher candidates, applicants were asked to:

1. Outline the number and type of geospatial workshops, courses, or programs they had participated in during the last five years.

2. Describe the spatial data sets they had used with teachers.

3. Provide evidence of using geotechnologies with students by writing a 1 – 3 page essay on how they used geospatial technologies in their teaching.
4. Include one example of a geospatial technology lesson, with student work samples, they had used with students; and,

5. Seek a letter of support from their administrator (Blank, Crews, Loehman, & Knuth, 2006).

From the completed applications, 20 teachers were selected for participation in the GTEC project and were split into two groups; cohort one and cohort two. Teachers were selected based on the following criteria:

1. Number of years as a classroom teacher

2. Amount and depth of training in the use of geotechnologies

3. Evidence of successful use of geotechnologies with students

4. Support and recognition by administration

Another goal of the teacher recruitment process was to select a geographically diverse set of Montana teachers that were identified as leaders in their respective teaching communities. Figure 3 below shows the locations of the teachers participating in the GTEC project.
Figure 3 GTEC Participating Schools

External Validity

The experimental student sample selected for this study was limited to students whose teachers participated in the GTEC professional development and was limited to teachers from Montana; thus the ability to generalize to populations outside of Montana are limited. The sample did represent the rural nature of Montana and can be generalized, in this respect, to similar rural areas in Montana and across the northwest. Another limiting factor of generalizability for this study was the large grade range within which this study took place: grades 5 -12. The differences in cognitive abilities of students that fall within
this grade range can be significant; however, when disaggregated, this large age span provided this researcher with valuable insights into how spatial learning develops over time. Multiple treatment interference was reduced for pre/post test assessment by using alternate forms of the spatial literacy skills assessment. Due to the fact a pre/post test design was used, some pretest sensitization could have occurred between the two assessments, causing some of the students within the groups to explore geospatial technologies on their own.

**Experimental Design**

A quasi-experimental design was used in this research study with a non-equivalent (pretest and posttest) control-group design. The research took place in schools around Montana, with both urban and rural populations represented, and included students in grades 5 - 12.

A control group was used in this study to provide comparative data between groups. The control group was based on a non-equivalent control group design, in which classes did not completely align with those of the treatment group, but rather paralleled those groups. A control group was selected based on similarities in demographics present in the treatment groups; i.e. rural and urban, grade level, gender, ethnicity, along with others. In order to not withhold treatment from the control group, this group served as cohort two. For the first year of the project cohort two students took the pre/post spatial literacy skills assessment and student interests in science and technology survey at the same interval as cohort one, however, they were not introduced to a geospatial curriculum during the first year of the project. In the second year of the project cohort two teachers participated in the
summer institute and were responsible for implementing their geospatial curriculum into their classrooms the following school year. For the purposes of the study, only first year data were used to determine the effectiveness of the teacher geospatial technologies professional development and to inform project directors in future years.

While the teachers selected for the GTEC project were a purposeful sample, the student sample was not randomly assigned, as the students in all classes for cohort one and two were assigned to classes based on traditional methods used in schools across Montana. Because it was impossible to randomly assign students to different groups, attempts to randomly assign teachers to cohort one and two were made. However, random assignment of teachers was not completely possible due to the nature of schedules and conflicts with summer institute dates. Because cohort one and two teachers represent typical Montana classrooms, in terms of geographic diversity and ethnic makeup, it was reasonable to assume there are similarities between the two cohorts.

Data Collection Procedures

Data for this research was collected at two different times during the course of the study, see Figure 4 for project timeline with assessment dates. Pre-test data for students’ spatial literacy skills and student interests in science and technology, from the treatment group and the control group, was collected prior to the implementation of the geospatial curriculum. Post-test data for the two measures was collected after the geospatial curriculum was implemented for both the treatment and control groups. Each of the instruments was taken in a web-based environment and the results were tabulated using the Perseus Survey Solution Software.
Figure 4 Timeline of Year-Long Intensive Professional Development with Assessment
Instruments

A spatial literacy assessment, developed by the Association of American Geographers (AAG), was used pre/post on the treatment group to assess students’ spatial literacy skills (percent correct). Alternate forms (Form A and Form B) of the spatial literacy test was used pre/post in order to avoid the possibility of confounding effects of using the same test for pre/post test measures. Pretest data was gathered at the beginning of the school year, prior to the implementation of the curriculum, and posttest data was gathered prior to the end of the school year, following the implementation of the curriculum.

The spatial literacy skills assessment (Appendix H) contained 16 items measuring skills in spatial literacy. The test had two forms A and B, which served as equivalent versions. Form A was administered as a pre-assessment and form b was administered as a post-assessment. Both forms of the test measured the same concepts. The use of two forms helped to prevent multiple treatment interference, which can impact external validity.

A science and technology student interests survey (Appendix I) was used to assess pre/post student interests in science and technology, based on a five-point Likert Scale. This survey research complemented the experimental research findings and provided multiple measures to better understand any behavior (Cozby, 2007). The survey was developed by GTEC staff and content domain experts in the field based on a variety of sources dealing with standards in geosciences, and asked students a series of questions which yielded beliefs about science and technology and interests in geospatial content and careers. The first part of the survey contained 20 questions about beliefs with respect to
science (10 items) and geospatial technologies (10 items). The second part of the survey contained 36 questions about careers in science and geospatial technologies, 18 relating to geospatial careers and 18 relating to biotechnology careers. All items used a Likert scale (1 = disagree strongly, 2 = disagree, 3 = no opinion, 4 = agree, 5 = agree strongly). Items dealing with biotechnology content were also included to encourage students to respond thoughtfully to each question since items with two different content areas were alternately presented (Blank, Crews, Loehman, & Knuth, 2006).

Reliability

The spatial literacy assessment used in this study was developed by Jongwon Lee, a researcher for the Association of American Geographers (AAG), and was used to assess 160 different college students from different universities around the country. The following are the reliability test results for Form A and Form B: Reliability Test (Alpha): 0.714 (Form A) and 0.675 (Form B). This instrument was developed for pre-service teacher candidates, therefore some threats to validity and reliability may exist.

Internal Validity

In order to prevent problems of test recognition, Form A and Form B were used for pre and post test assessment. Due to the short nature of the study loss of participants was a limiting factor for collecting data. Other threats to internal validity were also considered during this study. For example, selection bias within groups, dropout, history, reliability of measures and procedures, and small sample size.
A Priori

Statistical consistency was set at $\alpha=0.05$ (Cozby, 2007). A practical importance of the findings was determined by an experimental difference of 10%.

Data Analysis

There were two quantitative components to the research study: 1) The implementation of a teacher geospatial technologies professional development project and students’ spatial literacy skills, and, 2) the implementation of a teacher geospatial technologies professional development project and students’ interests in science and technology. A quasi-experimental design was used in this research study with a non-equivalent (pretest and posttest) control-group design.

The first quantitative research question studied was the impact a teacher geospatial technologies professional development had on students’ spatial literacy skills. A spatial literacy assessment, developed by the Association of American Geographers (AAG), was used pre/post on the treatment group to assess students’ spatial literacy skills (percent correct). Alternate forms (Form A and Form B) of the spatial literacy test were used pre/post in order to avoid possible confounding effects of using the same test for pre/post test measures. Pretest data was gathered at the beginning of the school year, prior to the implementation of the curriculum and posttest data was gathered prior to the end of the school year, following the implementation of the curriculum. See timeline (Figure 2) in literature review section.
The first quantitative research question (spatial literacy skills) was analyzed using a paired sample T-test. This statistical technique was used to examine whether the two groups are significantly different from each other (Cozby, 2007). Pre-post test scores on the spatial literacy test were analyzed using SPSS software 13.0 to determine statistical significance ($\alpha = .05$ level). A post-hoc analysis was conducted on the spatial literacy data to investigate relationships between certain descriptive variables found within the experimental group. The following variables were disaggregated from the data: gender, grade, teacher, student proficiency level, technology capacity, quantity of implementation, and teacher competency.

Gender, grade and teacher are important variables that are often used to stratify data into subgroups in order to look for trends within the larger group. Along with those variables, technology capacity, quantity of implementation, and teacher competency were included in the post-hoc analysis.

Technology capacity plays an important role in computer access issues, which are a constant challenge in schools around the country. How much is enough technology? According to Stratham and Torrell, (1999), a 1:5 computer to student ratio is enough to offer near universal access for students. Another critical issue facing schools is technology support. Recent research suggests that in larger businesses, there should be one support person for every 50 computers and a budget of $142 per computer per year should be encumbered as a tech support budget (Stansbury, 2008). For the purposes of this study, we considered one technology support person per school sufficient to meet the needs of participating teachers. The other critical issue faced in schools is not just the number but
also the access to such computers. The structure and resources of traditional classrooms often provide poor support for learning, whereas technology – when used effectively – can enable ways of teaching that are much better matched to how children learn (Roschelle, Pea, Hoadley, Gordin, & Means, 2000). Teachers with computers available in their classrooms have an easier time integrating technology into classroom instruction. For the purposes of this study, these three variables were collected from each participating teacher in order to establish a capacity rating. Each of the three items was worth one point for a maximum score of three. A score of zero was awarded if the individual teacher did not meet the stated criteria. See matrix below.

Table 1 Teacher Capacity Matrix

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td></td>
</tr>
<tr>
<td>If student to computer ratio in school is at 5:1 or better then score = 1. If ratio is greater than 5:1 then score = 0</td>
<td></td>
</tr>
<tr>
<td>If student to computer ratio in classroom is at 5:1 or better then score = 1. If ratio is greater than 5:1 then score = 0</td>
<td></td>
</tr>
<tr>
<td>Tech support person present then score = 1, no tech support person present then score = 0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

Additionally, the quantity of implementation was measured in order to analyze the relationship between the amount of implementation and student spatial literacy scores. Teachers were surveyed to assess the level of geospatial technologies implementation their students engaged in during the course of the year. Teachers rated themselves as high (3),
implementation happened throughout the school year; medium (2), implementation occurred for more than 1 month but less than the entire school year; or low (1), implementation was less than one month. See Table 2 below.

Table 2 Teacher Quantity Matrix

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Across school year (3)</th>
<th>More than 1 month (2)</th>
<th>Less than one month (1)</th>
<th>Total</th>
</tr>
</thead>
</table>

A third variable analyzed was pre-assessment of teacher competencies in using geospatial technologies, taken by GTEC project staff during the summer institute. Teachers rated themselves on the use of geospatial technologies in four categories. Each category was scored as high competency (3), medium competency (2), or low competency (1). See Table 3 below. See Appendix J for the questions and descriptions used in the competency matrix.

Table 3 Teacher Competency Matrix

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Expertise in using geotechnologies (1, 2, 3)</th>
<th>Expertise in locating datasets (1, 2, 3)</th>
<th>Expertise in creating datasets (1, 2, 3)</th>
<th>Expertise in the use of ArcGIS (1, 2, 3)</th>
<th>Total</th>
</tr>
</thead>
</table>
The second quantitative research question was the impact of a geospatial curriculum on student interests in science and technology. The student interest survey data (five point Likert Scale) were collected prior to the implementation of the geospatial curriculum and following the implementation. Frequencies in student interests were analyzed to assess the changes that occurred between groups pre/post. Experimental difference was set at 10% for this study. Frequency distributions were used to visually display the results of the interest survey of participating students’ pre/post. Table and graphs were used to display students’ responses in order to better understand the changes in interests between the control and treatment groups pre/post. If the experimental difference of 10% is met, further analysis was conducted using Pearson’s Chi-square tests.

Summary

Geospatial technologies are new to educational systems around the country and are slowly working their way into mainstream education, thanks to applications like Google Earth. This research study focused on such technologies and how they can be successfully implemented into a K-12 school environment. Specifically, this study examined the impact geospatial technologies professional development had on student spatial literacy skills and students attitudes about science and technology. This section served to describe the methodology used within this study and identified the instruments used in order to assess the effectiveness a geospatial technologies professional development model has on student learning.
CHAPTER FOUR

Results

The purpose of this study was to identify the impacts a teacher geospatial technologies professional development project had on student spatial literacy skills and interests in science and technology. Two research questions were addressed in this study: 1) does the implementation of a teacher GTPDP improve students’ spatial literacy skills in 9-12 classrooms across Montana? 2) does the implementation of a teacher GTPDP increase students’ interest in science and technology in 5-12 classrooms across Montana?

Data for this study were collected with a spatial literacy skills instrument and a student science interest survey. Using a pretest-treatment-posttest design, student data were collected for spatial literacy skills and students’ interests in science. The data from the student spatial literacy skills assessment and the student interest survey were analyzed using Microsoft Excel and Statistical Package for Social Sciences (SPSS 13.0 for PC).

Chapter four is divided into the following sections: a) Description of the Sample, b) Analysis of Spatial Literacy Skills Assessment, c) Analysis of Student Interest in Science and Technology Survey, and d) Summary of Results.

Description of the Sample

Data for this research project were collected from students in grades 5 – 12 from schools across Montana. Student involvement was based on individual teachers’ participation in the Geotechnology in the Science Classroom (GTEC) Project, a Toyota
Foundation sponsored grant. In all, 429 students responded to the spatial literacy skills assessment and student interest survey.

**Analysis of Spatial Literacy Skills Assessment**

A total of 429 students responded to the spatial literacy skills assessment. Of these, 377 were not included in the statistical analysis for the following reasons:

- From the total population, 271 of the participants identified were in grades 5-8 thus making them an ineligible entity in the analysis of this assessment. Based on the analysis of scores on the pre-test assessment by the external evaluator, grades 5 – 8 were eliminated from the sample because of concerns that the reading level of the test was developmentally inappropriate for students below ninth grade. There were 106 of the cases that were invalid response sets or submitted incomplete instruments.

Following the reduction in participants there were 52 individuals left in the sample. The remaining participants represented four schools. See Table 4 for breakdown of the number of students and grade level for each school.
Table 4 Summary of Number of Students per School, Grade Levels, and Gender

<table>
<thead>
<tr>
<th>School</th>
<th>Number of Students Participating</th>
<th>Grade Levels</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cohort</td>
<td>9th</td>
</tr>
<tr>
<td>School #1</td>
<td>15</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>School #3</td>
<td>11</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>School #4</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>School #5</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 5 Students Participating per School per Grade

Reliability Coefficient for the Spatial Literacy Skills Assessment

The reliability of the spatial literacy skills assessment was established through a Guttman Split-half analysis using SPSS 13.0. The reliability coefficient, which
was generated from the pretest and posttest scores from the treatment group, was \( r = 0.62 \). This reliability calculation approximates earlier reliability measures performed by the instrument creator.

**Results of the Spatial Literacy Skills Assessment**

The first research question addressed for this project was to determine if a geospatial technologies teacher professional development project and the resulting implementation of a model curriculum into classroom instruction impacted student spatial literacy skills. Combined pre and post test scores on the spatial literacy skills assessment for all schools are listed in the tables that follow.

Table 5 Summary of Pretest and Posttest Scores for all Schools

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>10.23</td>
<td>3.0</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Posttest</td>
<td>10.12</td>
<td>2.6</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

The pretest average for all schools was 10.23, the posttest average for all schools was 10.12, resulting in a difference of −0.12 or a negative percent change of 1%.

An initial paired sample T-test was performed across the pretest and posttest raw scores for the student spatial literacy assessment for the treatment group. For this test a t ratio of 0.287 was reported, producing a value of \( p = 0.775 \), indicating students’ spatial literacy skills did not significantly change over the instructional time period.
Table 6 Paired Sample T-test for Significance Between Pretest and Posttest Scores on Spatial Literacy Assessment

<table>
<thead>
<tr>
<th></th>
<th>Mean Pre</th>
<th>Std</th>
<th>Mean Post</th>
<th>Std</th>
<th>N</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Post Scores</td>
<td>10.23</td>
<td>2.935</td>
<td>10.12</td>
<td>2.572</td>
<td>52</td>
<td>.287</td>
<td>.775</td>
</tr>
</tbody>
</table>

A post hoc analysis of student spatial literacy scores was conducted. Student data was disaggregated based on the following categories: school, gender, grade level, level of proficiency, and teacher specific variables; technology capacity, quantity of implementation, and competency.

Individual Schools Data

Scores on the spatial literacy skills assessment for individual schools are listed in the tables that follow. For each of the schools, pre/post scores are recorded, along with overall change.

School #1

Table 7 Summary of Spatial Literacy Scores for School #1

<table>
<thead>
<tr>
<th>ID</th>
<th>Cohort</th>
<th>Teacher</th>
<th>School</th>
<th>Grade</th>
<th>Gender</th>
<th>Pre (out of 16)</th>
<th>Post (out of 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>193906</td>
<td>1</td>
<td>Teacher - 1</td>
<td>School - 1</td>
<td>11</td>
<td>1</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>293906</td>
<td>1</td>
<td>Teacher - 1</td>
<td>School - 1</td>
<td>11</td>
<td>1</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>393906</td>
<td>1</td>
<td>Teacher - 1</td>
<td>School - 1</td>
<td>12</td>
<td>2</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>493906</td>
<td>1</td>
<td>Teacher - 1</td>
<td>School - 1</td>
<td>11</td>
<td>1</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Assessment</td>
<td>Mean</td>
<td>Std Dev</td>
<td>Minimum</td>
<td>Maximum</td>
<td>Diff</td>
<td>% Change</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>-------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>9.07</td>
<td>3.1</td>
<td>3</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td>9.87</td>
<td>2.7</td>
<td>5</td>
<td>15</td>
<td>0.08</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

The pretest mean for School #1 was 9.07 and the mean posttest score was 9.87. The difference between pre/post test scores was 0.80, indicating a 5% change between testing.
### Table 9 Summary of Spatial Literacy Scores for School #3

<table>
<thead>
<tr>
<th>ID</th>
<th>Cohort</th>
<th>Teacher</th>
<th>School</th>
<th>Grade</th>
<th>Gender</th>
<th>Pre (out of 16)</th>
<th>Post (out of 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>181906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>2</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>281906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>2</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>381906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>581906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>2</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>681906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>1</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>781906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>2</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>881906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>2</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>981906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>1</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>1481906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>9</td>
<td>2</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>1781906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>9</td>
<td>2</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>1881906</td>
<td>1</td>
<td>Teacher - 3</td>
<td>School - 3</td>
<td>12</td>
<td>2</td>
<td>3</td>
<td>11</td>
</tr>
</tbody>
</table>

### Table 10 Summary of overall changes in pre/post scores for School #3

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Diff</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>8.91</td>
<td>2.9</td>
<td>3</td>
<td>13</td>
<td>10</td>
<td>2.8</td>
</tr>
<tr>
<td>Posttest</td>
<td>9.36</td>
<td>2.7</td>
<td>5</td>
<td>13</td>
<td>.45</td>
<td>2.8</td>
</tr>
</tbody>
</table>
The pretest mean for School #3 was 8.91 and the mean posttest score was 9.36. The difference between pre/post test scores was 0.45, indicating a 2.8% change between testing.

School #4

Table 11 Summary of Spatial Literacy Scores for School #4

<table>
<thead>
<tr>
<th>ID</th>
<th>Cohort</th>
<th>Teacher</th>
<th>School</th>
<th>Grade</th>
<th>Gender</th>
<th>Pre (out of 16)</th>
<th>Post (out of 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>1</td>
<td>Teacher - 4</td>
<td>School - 4</td>
<td>12</td>
<td>2</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>211</td>
<td>1</td>
<td>Teacher - 4</td>
<td>School - 4</td>
<td>11</td>
<td>2</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 12 Summary of Overall Changes in Pre-test and Post-Test Scores for School #4

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Diff</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>14</td>
<td>2.83</td>
<td>12</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td>12.5</td>
<td>0.71</td>
<td>12</td>
<td>13</td>
<td>-1.5</td>
<td>-9.4</td>
</tr>
</tbody>
</table>

The pretest mean for School #4 was 14 and the mean posttest score was 12.5. The difference between pre/posttest scores was -1.5, indicating a -9.4% change between testing.
**School #5**

Table 13 Summary of Spatial Literacy Scores for School #5

<table>
<thead>
<tr>
<th>ID</th>
<th>Cohort</th>
<th>Teacher</th>
<th>School</th>
<th>Grade</th>
<th>Gender</th>
<th>Pre (out of 16)</th>
<th>Post (out of 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>10</td>
<td>1</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>4661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>12</td>
<td>1</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>5661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>12</td>
<td>1</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>6661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>10</td>
<td>1</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>7661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>10</td>
<td>2</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>8661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>10</td>
<td>1</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>10661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>12</td>
<td>1</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>11661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>1</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>12661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>2</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>13661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>1</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>14661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>12</td>
<td>2</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>15661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>2</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>17661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>2</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>20661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>1</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>21661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>2</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>23661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>10</td>
<td>1</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>24661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>10</td>
<td>2</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>26661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>2</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>27661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>12</td>
<td>2</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>28661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>1</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>29661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>12</td>
<td>2</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>30661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>2</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>31661102</td>
<td>1</td>
<td>Teacher - 5</td>
<td>School - 5</td>
<td>11</td>
<td>1</td>
<td>12</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 14 Summary of Overall Changes in Pre-Test and Post-Test Scores for School #5

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Diff</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>11.25</td>
<td>2.25</td>
<td>6</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td>10.42</td>
<td>2.50</td>
<td>6</td>
<td>14</td>
<td>-0.83</td>
<td>-5.2</td>
</tr>
</tbody>
</table>
The pretest mean for School #5 was 11.25 and the mean posttest score was 10.42. The difference between pre/posttest scores was -0.83, indicating a -5.2% change between testing.

The graphs below show the changes in spatial literacy assessment scores from pre-test to post-test and the resulting percent change.

Figure 6 Change in Mean for Schools From Pre-test to Post-Test
Spatial literacy skills assessment data was disaggregated by gender to help identify potential benefits associated with the intervention. Only schools that took the pretest and posttest assessment were included in this analysis. SPSS Ver. 13.0 software was used to provide descriptive statistical analysis of the differentiated data. Table 15 below displays the data broken down into gender categories with means for both pretest and post test scores.
The pretest mean for females was 10.48, the posttest mean was 9.61, resulting in a difference of -0.87, or – 5.4% loss. The pretest mean for males was 10.03, the posttest mean was 10.52, resulting in a difference of 0.48, or a 3% increase.

Figure 8 Change in Mean by Gender from Pre-test to Post-test

Grade Level

Table 16 below shows the spatial literacy skills assessment data broken into grade level categories.
### Table 16 Spatial Literacy Skills Assessment Data by Grade Level

<table>
<thead>
<tr>
<th>Assessment</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Diff</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ninth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>2</td>
<td>8.50</td>
<td>3.54</td>
<td>6</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>9.00</td>
<td>5.66</td>
<td>5</td>
<td>13</td>
<td>0.5</td>
<td>3%</td>
</tr>
<tr>
<td>Tenth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>6</td>
<td>12.33</td>
<td>2.16</td>
<td>9</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>11.17</td>
<td>2.48</td>
<td>7</td>
<td>14</td>
<td>-1.1</td>
<td>-7%</td>
</tr>
<tr>
<td>Eleventh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>19</td>
<td>9.84</td>
<td>2.87</td>
<td>3</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>10.16</td>
<td>2.29</td>
<td>6</td>
<td>13</td>
<td>0.4</td>
<td>2%</td>
</tr>
<tr>
<td>Twelfth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>25</td>
<td>10.16</td>
<td>3.02</td>
<td>3</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>9.92</td>
<td>2.66</td>
<td>6</td>
<td>15</td>
<td>-0.3</td>
<td>-2%</td>
</tr>
</tbody>
</table>

**Figure 9 Change in Mean by Grade Level From Pre-test to Post-test**
Students in the ninth grade and eleventh grade appear to have benefited from the associated intervention as evidenced by the positive change from pretest scores to posttest scores. Ninth grade students mean score was 8.5 on their pretests and 9 on their posttest scores, indicating a positive gain in their score of 0.5 or a 3% gain. It is important to note there were only two students in the ninth grade group, allowing for greater variation between pretest and posttest scores. Students in the eleventh grade group had a mean score of 9.8 on their pretest assessment and 10.2 on their posttest assessment, eliciting a positive difference of 0.4 or a 2% change from pretest to posttest. Based on the pretest and posttest scores for the tenth and twelfth grade groups there appear to be no associated benefits from the intervention on students’ spatial literacy scores. The tenth grade group had a mean score of 12.3 on their pretest scores and 11.2 on their posttest scores, giving a difference of -1.1 or a -7% change. While this negative change is the largest of all the grades, it is important to note the high pretest scores obtained by the tenth grade group, in fact this score was the highest of all pretest scores by two points. It is also important to note that even though the posttest score did decrease, it is still the highest of all posttest scores.

Students in the twelfth grade group had a mean score of 10.2 on the pretest assessment and 9.9 on their posttest assessment for a difference of -0.3 or a – 2% change between pretest and posttest scores.

**Proficiency Level**

Schools spatial literacy skills assessment data was disaggregated by proficiency level, in order to determine the amount of growth between pretest and posttest. The scale used designated 0% - 69% as novice and 70% - 100% as proficient. The levels of
proficiency used for this analysis parallel the NAEP proficiency levels, which fall around 70%, depending on the grade level and subject (Rosenberg, 2004). Proficient and advanced levels were merged together for this analysis. Students were categorized based on their level of proficiency for pretest. Table 17 below shows the number of students categorized as novice and proficient for the pretest assessment and the corresponding scores on pretest and posttest assessments.

Table 17 Proficiency Level of Students for Pretest and Posttest Scores

<table>
<thead>
<tr>
<th>Assessment</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Diff</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>33</td>
<td>8.70</td>
<td>2.46</td>
<td>3</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>9.70</td>
<td>2.77</td>
<td>5</td>
<td>15</td>
<td>1.0</td>
<td>6%</td>
</tr>
<tr>
<td>Proficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>19</td>
<td>12.89</td>
<td>1.37</td>
<td>12</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>10.84</td>
<td>2.06</td>
<td>7</td>
<td>14</td>
<td>-2.1</td>
<td>-13%</td>
</tr>
</tbody>
</table>
Students categorized as novice based on pretest scores appear to have benefited from the associated intervention as evidenced by the change in their pretest and posttest scores. Pretest scores for the novice group was 8.7 and the posttest score was 9.7, resulting in a difference of 1.0 or a positive 6% change. Students categorized as proficient do not appear to have benefited from the associated intervention based on the negative change in their mean spatial literacy scores from pretest to posttest. Pretest scores for the proficient group were 12.9 and their posttest scores were 10.8, for a difference of -2.1 or a 13% decrease. While the change from pretest to posttest within the proficient group is large, it is important to note the high mean of their pretest scores (12.9).
Technology Capacity

Student spatial literacy data was disaggregated by school technology capacity in order to analyze the impact it may have on students’ spatial literacy skills. Teachers were asked three questions to rate the amount of technology available to their students in order to assign a high or low technology capacity rating to each teacher. Table 18 below shows the results of the teacher capacity survey.

Table 18 Teacher Technology Capacity Rating

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Student to computer ratio at 1 to 5 or better (1 or 0)</th>
<th>Tech support person (1 or 0)</th>
<th>Number of student computers in classroom (1 or 0)</th>
<th>Total (High or Low)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3 (High)</td>
</tr>
<tr>
<td>Teacher 3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3 (High)</td>
</tr>
<tr>
<td>Teacher 4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3 (High)</td>
</tr>
<tr>
<td>Teacher 5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3 (High)</td>
</tr>
</tbody>
</table>

Because all of the teachers ranked “High” for technology capacity, an analysis was not conducted as the results would have mirrored the analysis conducted for individual schools. Had there been more schools with differing amounts of capacity, the analysis may have produced an interesting outcome.

Quantity of Implementation

Student spatial literacy data was disaggregated by the quantity of implementation as measured by the amount of time the teacher spent during the course of the school year implementing geospatial technologies. Teachers were asked to specify between less than one month, more than one month but less than a year, or across the school year. Table 19 below shows the results of the teacher responses.
The responses fell into two categories, across the school year (high ranking), and
less than one month (low ranking). Students’ spatial literacy pretest and posttest scores
were analyzed based on the two above categories. Table 20 shows the results of the
quantity of implementation analysis.

Table 20 Results of Quantity of Implementation Analysis

<table>
<thead>
<tr>
<th>Assessment</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Diff</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>35</td>
<td>10.51</td>
<td>2.67</td>
<td>3</td>
<td>16</td>
<td>-0.42</td>
<td>-3%</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>10.09</td>
<td>2.57</td>
<td>5</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>17</td>
<td>9.65</td>
<td>3.43</td>
<td>3</td>
<td>16</td>
<td>0.53</td>
<td>3%</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>10.18</td>
<td>2.65</td>
<td>6</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Students in classrooms of teachers that engaged in a high quantity implementation showed an increase from pretest to posttest spatial literacy scores suggesting a benefit from the associated implementation. Students’ scores had a mean of 9.65 on the pretest assessment and 10.18 on posttest assessment, resulting in a gain of 0.5 or a 3% increase in scores. This positive change from pretest to posttest suggests the students in the high quantity of implementation benefitted from the increased exposure to geospatial technologies. Students in classrooms of teachers that engaged in low quantity implementation showed a decrease in mean spatial literacy scores from pretest to posttest. The mean pretest score for those students was 10.51 and the mean posttest score was 10.09, producing a difference of -0.42 or a 3% decrease in scores, thus suggesting the students associated with the low quantity implementation group did not benefit from the associated intervention. While the mean score for the students in the low quantity implementation
group decreased, it is important to note the high mean for this group for the pretest assessment.

Teacher Competency

Student spatial literacy data was differentiated based on teacher competency. Teacher responses from a survey completed during the summer institute were aggregated to produce a teacher competency score. Four survey questions, dealing specifically with teachers’ self-assessment of their expertise in using geospatial technologies, were collected to produce this rating, see Table 21 below.

Table 21 Teacher Competency Categories

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Expertise in using geotechnologies (1,2,3)</th>
<th>Expertise in locating datasets (1,2,3)</th>
<th>Expertise in creating datasets (1,2,3)</th>
<th>Expertise in the use of ArcGIS (1, 2, 3)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher – 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4 (Low)</td>
</tr>
<tr>
<td>Teacher – 3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>7 (Medium)</td>
</tr>
<tr>
<td>Teacher – 4</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>9 (High)</td>
</tr>
<tr>
<td>Teacher – 5</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>9 (High)</td>
</tr>
</tbody>
</table>

Three categories emerged based on the teacher responses; 4 – 6 being low, 7-8 as medium, and 9-12 as high. One teacher fell into the low category, one teacher fell into the medium category, and two teachers fell into the high category. Students’ spatial literacy scores were analyzed based on these categories, see Table 22 below.
## Table 22 Results of Teacher Competency Analysis

<table>
<thead>
<tr>
<th>Teacher Competency</th>
<th>Assessment</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Diff</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Pretest</td>
<td>15</td>
<td>9.07</td>
<td>3.13</td>
<td>3</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td></td>
<td>9.87</td>
<td>2.67</td>
<td>6</td>
<td>15</td>
<td>0.8</td>
<td>5%</td>
</tr>
<tr>
<td>Medium</td>
<td>Pretest</td>
<td>11</td>
<td>8.91</td>
<td>2.91</td>
<td>3</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td></td>
<td>9.36</td>
<td>2.69</td>
<td>5</td>
<td>13</td>
<td>0.5</td>
<td>3%</td>
</tr>
<tr>
<td>High</td>
<td>Pretest</td>
<td>26</td>
<td>11.46</td>
<td>2.35</td>
<td>6</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td></td>
<td>10.58</td>
<td>2.47</td>
<td>6</td>
<td>14</td>
<td>-0.9</td>
<td>-6%</td>
</tr>
</tbody>
</table>

### Figure 12 Change in Mean by Teacher Competency From Pre-test to Post-test
Students in the “Low” and “Medium” categories appear to have benefited from the associated intervention as evidenced by the increase in pretest and posttest mean scores. Students categorized in the “Low” teacher competency group had a mean score of 9.1 on the pretest assessment and 9.9 on the posttest, producing a gain of 0.8, or a 5% increase. Students categorized in the “Medium” teacher competency group had a mean score of 8.9 on the pretest and 9.4 on the posttest, for a gain of 0.5, or a 3% gain. Students in the “High” category do not appear to have benefitted from the associated intervention, based on the decrease in mean scores between the pretest and posttest. Student pretest means were 11.5 and posttest means were 10.6, resulting in a difference of -0.9, or a -6% change.

Summary of Spatial Literacy Skills Assessment

Pre - post assessment data was analyzed to determine the effects of a teacher geospatial technologies professional development project, and the subsequent implementation of a geospatial curriculum model had on student spatial literacy skills. Overall, there appears to be no benefit from the associated treatment as evidenced by the negative change in student spatial literacy scores between pretest and posttest. Post – hoc analyses produced data categories that showed modest changes from pre - test to post – test. Spatial literacy assessment data disaggregated by gender produced a -5.4% change in females and a 3.0% change in males. Data disaggregated by grade level produced a 3.0% change in ninth grade students, a -7.0% change in tenth grade students, a 2.0% change in eleventh grade students, and a -2.0% change in twelfth grade students. Spatial literacy assessment data disaggregated by proficiency level produced a 6.0% change in students that moved from the novice category to the proficient category from pre – test to post –
test. The same analysis produced a -13.0% change in students that moved from proficient on the pre – test to novice on the post – test.

Student spatial literacy assessment scores disaggregated by quantity of teacher implementation produced a -3.0% change in the low implementation group and a 3.0% change in the hig implementation group. Results from the teacher competency analysis produced a 5.0% change in students of teachers reporting low competency, a 3.0% change in students of teachers reposting medium competency, and a -6.0% change in students of teachers reporting high competency.

**Analysis of Students’ Interests in Science and Technology**

A 56 item Likert scale science and technology survey instrument was administered to the treatment and control groups pre-treatment and post-treatment. This survey allowed for student responses to range from disagree strongly (1), disagree (2), no opinion (3), agree (4), and strongly agree (5). The survey was developed by GTEC project staff based on a variety of sources dealing with standards in geosciences, and asks students a series of questions which yielded beliefs about and interest in science as well as in geospatial content and careers. The survey was broken into two sections; the first section focused on interest in science and geotechnologies and contained 20 questions; 10 relating to beliefs about science and 10 relating to beliefs about geotechnologies; the second section focused on careers in science and geospatial technologies; with 36 questions, 18 relating to careers in science and 18 relating to careers in geospatial technologies. The aim of this survey research was to establish positive and negative trends within the dataset. For this reason, Likert scale data was combined into three sections from five. The Likert scale rating of
“Strongly Disagree” and “Disagree” was combined and was represented by “SD – D”; the Likert scale rating of “Neutral” remained the same; and the Likert scale rating of “Agree” and “Strongly Agree” was combined and was represented by “A – SA.”

A total of 257 students responded to the student interest in science and technology survey. Of these, 113 were not included in the statistical analysis for the following reasons:

- Invalid response sets, missing responses
- Did not complete the pre and post instrument

Following the reduction in participants there were 144 individuals left in the sample. The remaining participants represented eight schools. See Table 23 for breakdown of the number of students per school.

Table 23 Summary of Number of Students per School, Grade Levels, and Gender

<table>
<thead>
<tr>
<th>School</th>
<th>Cohort</th>
<th>N</th>
<th>Grade Levels</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4th 5th 6th 7th 8th 9th 10th 11th 12th</td>
<td>Male Female</td>
</tr>
<tr>
<td>School #1</td>
<td>1</td>
<td>11</td>
<td>0 0 0 0 0 0 0 0 5 6</td>
<td>5 6</td>
</tr>
<tr>
<td>School #2</td>
<td>1</td>
<td>12</td>
<td>0 12 0 0 0 0 0 0 0</td>
<td>4 8</td>
</tr>
<tr>
<td>School #3</td>
<td>1</td>
<td>12</td>
<td>0 0 0 0 0 4 0 0 8</td>
<td>9 3</td>
</tr>
<tr>
<td>School #5</td>
<td>1</td>
<td>18</td>
<td>0 0 0 0 0 0 7 6 5</td>
<td>9 9</td>
</tr>
<tr>
<td>School</td>
<td>1</td>
<td>50</td>
<td>0 0 0 50 0 0 0 0 0</td>
<td>30 20</td>
</tr>
</tbody>
</table>
For this research study, there were two cohorts involved. For the first year of the project, cohort one served as the experimental group and cohort two served as the control group. In the second year, cohort two received the treatment, which was similar to the treatment received by cohort 1. For the purposes of this research, only data from the first year was used. Of the schools listed above six were from Cohort 1 and the remaining two were from Cohort 2. Microsoft Excel 2007 and SPSS Ver. 13.0 software were used to provide descriptive statistical analysis of the Student Science Interest survey data. Data tables and graphs are used to display frequencies for the different data sets. A copy of the science and technology interest survey can be found in Appendix I.

<table>
<thead>
<tr>
<th>School #6</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>School #8</td>
<td>1</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>School #11</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>School #12</td>
<td>2</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>17</td>
</tr>
</tbody>
</table>
Table 24 Frequency Distributions of Experimental and Control Group for Beliefs About Science and Geotechnologies

<table>
<thead>
<tr>
<th>Questions about science and geospatial beliefs</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Q1 I think science is exciting.</td>
<td>77%</td>
<td>57%</td>
</tr>
<tr>
<td>Q2 I like using the computer to create maps.</td>
<td>41%</td>
<td>35%</td>
</tr>
<tr>
<td>Q3 Solving science problems is fun.</td>
<td>53%</td>
<td>36%</td>
</tr>
<tr>
<td>Q4 I like to use maps to answer questions about people and places</td>
<td>34%</td>
<td>28%</td>
</tr>
<tr>
<td>Q5 I like science better than I do most other subjects</td>
<td>43%</td>
<td>28%</td>
</tr>
<tr>
<td>Q6 Satellites, GPS devices and remote sensing equipment are cool.</td>
<td>69%</td>
<td>61%</td>
</tr>
<tr>
<td>Q7 I have a real desire to learn science.</td>
<td>48%</td>
<td>44%</td>
</tr>
<tr>
<td>Q8 The use of computer maps will be important to me in my job some day.</td>
<td>38%</td>
<td>30%</td>
</tr>
<tr>
<td>Q9</td>
<td>Science is useful for solving problems in my everyday life.</td>
<td>72%</td>
</tr>
<tr>
<td>Q10</td>
<td>I like to use maps to explore and gather information about new places.</td>
<td>49%</td>
</tr>
<tr>
<td>Q11</td>
<td>Learning science will improve my career chances.</td>
<td>84%</td>
</tr>
<tr>
<td>Q12</td>
<td>I like to think about how to solve environmental problems.</td>
<td>53%</td>
</tr>
<tr>
<td>Q13</td>
<td>I have a good feeling toward science.</td>
<td>65%</td>
</tr>
<tr>
<td>Q14</td>
<td>I like spending lots of time outdoors.</td>
<td>87%</td>
</tr>
<tr>
<td>Q15</td>
<td>I enjoy talking to people about science.</td>
<td>29%</td>
</tr>
<tr>
<td>Q16</td>
<td>I am interested in where things are located in the world.</td>
<td>66%</td>
</tr>
<tr>
<td>Q17</td>
<td>I like writing about science.</td>
<td>14%</td>
</tr>
<tr>
<td>Q18</td>
<td>I often wonder how satellites, computers, and other advanced</td>
<td>76%</td>
</tr>
</tbody>
</table>
Frequency distributions for the experimental group pre/post show an overall decline in the percentage of participants agreeing or strongly agreeing with the survey statements dealing with science and geospatial technology beliefs. Based on the above table, only one item out of twenty showed any increase in student agreement from pre-treatment to post-treatment, nineteen of the twenty items showed a decrease in the percentage of agreement from pre to post. The survey item with the greatest percentage of students in agreement with the statement is question #14 – “I like spending time outdoors.” 87% of students responding in the pretest survey agreed with this statement and 89% agreed on the posttest survey, the only item in the survey to increase from pre to post. Other survey items eliciting high percentages of agreement were question #11, “Learning science will improve my career choices” had an 84% agreement rating pre-treatment and a 72% rating post-treatment. Question #6; “Satellites, GPS devices, and remote sensing equipment are cool” had a 69% agreement rating at the beginning of the project and ended with a 61% of students responding positively to the statement. Question #18, “I often wonder how
satellites, computers, and other advanced technologies work,” elicited 76% agreement prior to the treatment, but dropped to 55% post treatment.

Frequency distributions for the control group pre/post show an increase in agreement for nine of the survey items, a decrease in eight of the survey items, and 3 remained the same. The survey item with the greatest percentage of students in agreement with the statement is question #14 – “I like spending time outdoors.” 93% of students responding in the pretest survey agreed with this statement and 96% agreed on the posttest survey. Other survey items with a high percentage of agreement were question #6, “Satellites, GPS devices, and remote sensing equipment are cool” with 71% in agreement pretest and 75% in agreement for the posttest survey. Question #11, “Learning science will improve my career choices” had a 71% agreement pre-treatment and a 79% agreement post-treatment, gaining eight percentage points between survey administrations.

Between the experimental and control groups there were some similarities between pre/post response percentages. For example, question #1, “I think science is exciting”, elicited pretest agreement rating of 77% for the experimental group and a 79% agreement rating for the control group. The post-treatment agreement rating for the experimental group and control group dropped by at least 20% for each group, with the experimental group agreement rating of 57% and the control group agreement rating of 57%. Other survey items with similar results between groups were items #14, “I like spending lots of time outdoors” with agreement ratings over 70% for both groups, pre/post; item #6 “Satellites, GPS devices and remote sensing equipment are cool” and #16 “am interested in where things are located in the world” each had an agreement rating of over 60% for
both groups pre-post; and item #1 “I think science is exciting” had an agreement rating of 70% or higher for both groups pre-post.

Frequency distributions for science and geospatial technology beliefs, for the treatment group, aside from survey item #14 and #15 (low agreement rating to begin with), show an overall decrease from pretest to posttest. Students in this project did not appear to have positively changed their interest in science and geospatial technologies, as measured by the science interest survey. There was not an important difference of 10% within the groups between any of the survey items; therefore a Pearson’s Chi-square was not used.

The graphs below display the breakdown of pre – post data for survey items 1 – 20 for the experimental group and control group.
Figure 13 Pre - Post Experimental Group Frequency Distributions for Questions 1-20
The second part of the science interest survey dealt with biotechnology and geospatial technology careers. For the purposes of this research study, only the items dealing with geospatial technology will be analyzed to determine changes in agreement percentage from pretest to posttest between treatment and control groups.
Table 25 Frequency Distributions of Experimental and Control Group for Geotechnology Careers

<table>
<thead>
<tr>
<th>Questions about geospatial technology careers</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Use maps and databases to plan the best possible uses for our land.</td>
<td>24%</td>
<td>22%</td>
</tr>
<tr>
<td>Design high tech devices like GPS units and Personal Digital Devices.</td>
<td>36%</td>
<td>32%</td>
</tr>
<tr>
<td>Use a GPS device to record the locations of earthquakes and tornados.</td>
<td>35%</td>
<td>28%</td>
</tr>
<tr>
<td>Analyze images of the earth taken from satellites.</td>
<td>34%</td>
<td>25%</td>
</tr>
<tr>
<td>Write computer programs to predict where forest fires might occur.</td>
<td>33%</td>
<td>27%</td>
</tr>
<tr>
<td>Design a satellite that takes super high-definition pictures of the earth.</td>
<td>45%</td>
<td>32%</td>
</tr>
<tr>
<td>Work with city</td>
<td>45%</td>
<td>30%</td>
</tr>
<tr>
<td>Question</td>
<td>Activity Description</td>
<td>Percentage</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Q35</td>
<td>Study weather patterns on computer maps to see if climate change is occurring.</td>
<td>25%</td>
</tr>
<tr>
<td>Q37</td>
<td>Use maps and databases to see where people from different cultures live.</td>
<td>26%</td>
</tr>
<tr>
<td>Q39</td>
<td>Use special cameras to study the surface of the earth in three dimensions.</td>
<td>37%</td>
</tr>
<tr>
<td>Q41</td>
<td>Work on a team to find out the height of hills and mountains.</td>
<td>13%</td>
</tr>
<tr>
<td>Q43</td>
<td>Design computer models to explain how the earth has changed over time.</td>
<td>32%</td>
</tr>
<tr>
<td>Q45</td>
<td>Develop computer software that creates interactive maps.</td>
<td>28%</td>
</tr>
<tr>
<td>Q47</td>
<td>Teach others how to use mapping programs on the computer.</td>
<td>21%</td>
</tr>
<tr>
<td>Question</td>
<td>Description</td>
<td>Pre</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Q49</td>
<td>Design roads, rail systems, and other parts of a city.</td>
<td>37%</td>
</tr>
<tr>
<td>Q51</td>
<td>Use special equipment to collect air samples to see if it is polluted.</td>
<td>22%</td>
</tr>
<tr>
<td>Q53</td>
<td>Study what would happen if dams are removed.</td>
<td>35%</td>
</tr>
<tr>
<td>Q55</td>
<td>Teach people about how to take care of the environment</td>
<td>26%</td>
</tr>
</tbody>
</table>

Frequency distributions for the experimental group pre/post show an overall decline in the percentage of participants agreeing or strongly agreeing with the survey statements dealing with geospatial technology careers. Based on the above table, only two items out of 18 showed any increase in student agreement from pre-treatment to post-treatment, two items stayed the same and fourteen items showed a decrease in the percentage of agreement from pre to post. Overall, there were no items above a 45% agreement rating for all of the questions relating to geospatial careers. The survey item with the greatest percentage of students in agreement with the statement is question #31 – “Design a satellite that takes super high-definition pictures of the earth.” Forty-five percent of students responding in the pretest survey agreed with this statement and 32% agreed on the posttest survey. Other survey items eliciting high percentages of agreement were question #33, “Work with city planners to help businesses decide where to put their buildings.” had a 45% agreement
rating pre-treatment, dropped to a 30% rating post-treatment. Question #37, “Use maps and databases to see where people from different cultures live” and question #53 “Study what would happen if dams are removed” were the only items to show a positive change in agreement rating between pretest and posttest. Two other items remained the same from pretest to posttest; item #41, “Work on a team to find out the height of hills and mountains” had an agreement rating of 14% pre – post and item #51, “Use special equipment to collect air samples to see if it is polluted” had a 22% agreement rating pre – post.

Frequency distributions for the control group pre/post show an increase in agreement for five of the survey items, a decrease in twelve of the survey items, and one item remained the same. Overall, there was one item above a 45% agreement rating for all of the questions relating to geospatial careers. The survey item with the greatest percentage of students in agreement with the statement is question #53 – “Study what would happen if dams are removed.” 46% of students responding in the pretest survey agreed with this statement and 29% agreed on the posttest survey. Other survey items eliciting high percentages of agreement were question #31, “Design a satellite that takes super high-definition pictures of the earth.” had a 43% agreement rating pre-treatment, and dropped to a 32% rating post-treatment. Questions #21, 23, 33, 37, and 41 all showed positive gains in agreement from pre-test to post-test, however, the post-test percent never rose above 40%, indicating a low number of individuals in agreement with the statements.

Some similarities existed between pre/post response percentages between the treatment group and control group. For example, question #31, “Design a satellite that takes super high-definition pictures of the earth,” elicited pretest agreement rating of 45%
for the experimental group and a 43% agreement rating for the control group. The post-treatment agreement rating for the experimental group and control group dropped by at least 10% for each group, with the experimental and control group agreement rating of 32%. Another survey items with similar results between groups were items #41, with agreement ratings under 15% for both groups, pre/post.

Overall, frequency distributions for geospatial technology careers survey items indicates a decrease in interest in these careers from pre-test to post-test. All but two items showed no change or negative change in percentage of individuals in agreement with the item statement. Students in this project do not appear to have positively changed their interest in geospatial technology careers, as measured by the science interest survey. There was not an important difference of 10% within the groups, between any of the survey items; therefore a Pearson’s Chi-square was not used.

The graphs below display the breakdown of pre – post data for survey items 21 – 55, specific to geospatial careers, for the experimental group and control group.
Figure 15 Pre - Post Experimental Group Frequency Distributions for Questions 21 - 55
To aide in the interpretation of the quantitative data an illustrative comparative analysis was conducted between the students from two participating teachers, Teacher – 1, and Teacher – 5. The teachers chosen for this analysis represent two rural high schools in Montana. However, these two teachers implemented their geospatial curriculum module in two distinct ways. The Table 26 below, compares the two teachers within the following categories, technology capacity, quantity of implementation, and teacher competency.
Teachers 1 and 5 have a high technology capacity within their schools. Teacher 1 had the highest level of implementation while teacher 5 had the lowest level of implementation. After assessing the level of implementation between teacher 1 and 5, it was apparent their levels of implementation were significantly different. Teacher 1 developed a geospatial curriculum using the more advanced software package of ArcView and implemented this curriculum across the school year, as evidenced by the high score under “Quantity of Implementation.” The curriculum was based on a local watershed within the schools community and addressed a critical issue, see Appendix K for a sample of the curriculum. Teacher 1 also engaged students in a geospatial competition as part of the implementation process, in which they were given a problem that had to be solved using one or more geospatial tools. Students worked in groups over an extended period of time to solve this complex geospatial problem. Samples of student projects can be found in Appendix L. Involvement in this project also led the teacher 1 students to compete at the national envirothon.

Teacher 5 developed a geospatial curriculum using the entry level geospatial tool, Google Earth. This curriculum was implemented over a much shorter period of time (approximately one week). Teacher 5 had numerous issues with the installation of the
ArcView software within his classroom, thus attributing to the low quantity of implementation and use of Google Earth. The curriculum module was based on a look at Mars, see Appendix M for a sample of the curriculum. Teacher 5 did not participate in the geospatial competition. See Table 27 below for comparison of implementation.

Table 27 Implementation Comparison for Teacher 1 (high implementation) and Teacher 5 (low implementation)

<table>
<thead>
<tr>
<th>Teacher 1</th>
<th>Teacher 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity</strong></td>
<td><strong>Time Allotted</strong></td>
</tr>
<tr>
<td>Teach students to use ArcView GIS through tutorials and problem-based learning experiences</td>
<td>3 weeks</td>
</tr>
<tr>
<td>Implementation of curriculum using ArcView GIS and GPS for analysis of local watershed and accompanying investigation by students</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Development of solutions for geospatial competition by student groups using ArcView GIS</td>
<td>3 weeks</td>
</tr>
<tr>
<td><strong>Total time allotted for geospatial activities</strong></td>
<td>8 weeks</td>
</tr>
</tbody>
</table>

Teacher competency scores in the use of geospatial technologies varied between teachers, with teacher 1 reporting a low level of competency and teacher 5 reporting a high level of competency.
Student Scores on the Spatial Literacy Assessment

Student scores on the spatial literacy assessment for teachers 1 and 5 were disaggregated to determine the changes that occurred between pre-test and post-test. See Table 28 below for student scores.

Table 28 Students' Spatial Literacy Scores for Teacher 1 and 5

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Diff</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher - 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>9.07</td>
<td>3.1</td>
<td>3</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td>9.87</td>
<td>2.7</td>
<td>5</td>
<td>15</td>
<td>0.08</td>
<td>5</td>
</tr>
<tr>
<td>Teacher – 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>11.25</td>
<td>2.25</td>
<td>6</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posttest</td>
<td>10.42</td>
<td>2.50</td>
<td>6</td>
<td>14</td>
<td>-0.83</td>
<td>-5.2</td>
</tr>
</tbody>
</table>

Students’ scores for teacher 1 increased by 5% from pre-test to post-test. Students’ scores for teacher 5 decreased by 5.2% from pre-test to post-test. Students in the classroom of teacher 1 appear to have benefited from the associated high quantity of implementation. See Figure 17 for a graph showing change from pre-test to post-test between teacher groups.
Figure 17 Comparison of Mean Scores on Spatial Literacy Assessment for Teacher 1 and 5 Between Pre-Test and Post-Test

Student Responses to Science and Technology Interest Survey

Students’ responses to the science and technology interest survey for teacher 1 and 5 were disaggregated to determine the differences from pre-test to post-test between teachers. Only data from respondents reporting agree or strongly agree were used for this analysis, in order to assess the positive interests students had toward science and technology. Frequency distributions were used for student responses of the two teachers for pre-test and post-test data and a corresponding percentage was calculated. The two percentages were then used to find the percent difference between the percentage of students agreeing or strongly agreeing to the statement at pre-test and the percentage of students agreeing or strongly agreeing to the statement at post-test. For the purposes of this study, only differences of greater than 10% between the two teachers were used to
assess the impact this curriculum implementation had on students’ interests in science and technology. See Table 29 below. For a listing of difference scores for all questions see Appendix P.

Table 29 Student Interest Survey Questions with Difference Greater Than 10%

<table>
<thead>
<tr>
<th>Question</th>
<th>Teacher 1</th>
<th>Teacher 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>2</td>
<td>73%</td>
<td>36%</td>
</tr>
<tr>
<td>4</td>
<td>18%</td>
<td>18%</td>
</tr>
<tr>
<td>6</td>
<td>73%</td>
<td>64%</td>
</tr>
<tr>
<td>8</td>
<td>27%</td>
<td>45%</td>
</tr>
<tr>
<td>9</td>
<td>64%</td>
<td>64%</td>
</tr>
<tr>
<td>10</td>
<td>45%</td>
<td>18%</td>
</tr>
<tr>
<td>16</td>
<td>100%</td>
<td>73%</td>
</tr>
<tr>
<td>18</td>
<td>82%</td>
<td>36%</td>
</tr>
<tr>
<td>20</td>
<td>45%</td>
<td>36%</td>
</tr>
<tr>
<td>21</td>
<td>27%</td>
<td>27%</td>
</tr>
<tr>
<td>23</td>
<td>45%</td>
<td>36%</td>
</tr>
<tr>
<td>25</td>
<td>55%</td>
<td>18%</td>
</tr>
<tr>
<td>27</td>
<td>55%</td>
<td>9%</td>
</tr>
<tr>
<td>29</td>
<td>55%</td>
<td>36%</td>
</tr>
<tr>
<td>31</td>
<td>55%</td>
<td>36%</td>
</tr>
<tr>
<td>33</td>
<td>45%</td>
<td>9%</td>
</tr>
<tr>
<td>35</td>
<td>45%</td>
<td>45%</td>
</tr>
<tr>
<td>37</td>
<td>45%</td>
<td>45%</td>
</tr>
<tr>
<td>39</td>
<td>55%</td>
<td>36%</td>
</tr>
<tr>
<td>43</td>
<td>55%</td>
<td>36%</td>
</tr>
<tr>
<td>45</td>
<td>45%</td>
<td>0%</td>
</tr>
</tbody>
</table>
As described earlier, the survey was broken into two sections; the first section focused on interest in science and geotechnologies and contained 20 questions; 10 relating to beliefs about science and 10 relating to beliefs about geotechnologies; the second section focused on careers in science and geospatial technologies; with 36 questions, 18 relating to careers in biotechnology and 18 relating to careers in geospatial technologies. For questions 1 – 20 the even numbered questions pertained to beliefs about geospatial technologies while the odd numbered questions pertained to beliefs about science. For questions 21 – 56, the odd numbered questions dealt with geospatial technology careers and the even numbered questions pertained to biotechnology careers. Table 30 shows the differences for each teacher from pre-test to post-test, along with the differences between the two teacher groups.
Table 30 Differences for Teacher 1 and 5 for Questions 1 - 20

<table>
<thead>
<tr>
<th>Beliefs About Science and Geotechnologies</th>
<th>Question</th>
<th>Teacher 1 Differences</th>
<th>Teacher 5 Differences</th>
<th>Between Group Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q2 - I like using the computer to create maps.</td>
<td>-36%</td>
<td>-6%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Q4 - I like to use maps to answer questions about people and places.</td>
<td>0%</td>
<td>17%</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>Q6 - Satellites, GPS devices and remote sensing equipment are cool.</td>
<td>-9%</td>
<td>22%</td>
<td>31%</td>
</tr>
<tr>
<td></td>
<td>Q8 - The use of computer maps will be important to me in my job some day.</td>
<td>18%</td>
<td>-17%</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>Q9 - Science is useful for solving problems in my everyday life.</td>
<td>0%</td>
<td>-17%</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>Q10 - I like to use maps to explore and gather information about new places.</td>
<td>-27%</td>
<td>0%</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>Q16 - I am interested in where things are located in the world.</td>
<td>-27%</td>
<td>11%</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>Q18 - I often wonder how satellites, computers, and other advanced technologies work.</td>
<td>-45%</td>
<td>-6%</td>
<td>39%</td>
</tr>
<tr>
<td></td>
<td>Q20 - I like to close my eyes and visualize objects in three dimensions.</td>
<td>-9%</td>
<td>11%</td>
<td>20%</td>
</tr>
</tbody>
</table>
The results from section one of the science and technology interest survey for the students of teacher 1 and 5 produced differences greater than 10% for nine questions. All survey items that resulted in a 10% or greater difference between groups, except Questions #9, related to beliefs about geospatial technologies. Only one of the items dealing with beliefs about geospatial technologies showed a positive gain for teacher 1 (high quantity of
implementation), Question #8 - The use of computer maps will be important to me in my job someday.” This same item showed a negative change in positive responses for teacher 5 (low quantity of implementation). For the responses relating to geospatial technologies, from the students of teacher 5, five out of nine showed positive gains in student responses between pre-test and post-test. Table 31 shows the differences for each teacher from pre-test to post-test, along with the differences between the two teacher groups.

Table 31 Differences for Teacher 1 and 5 for Questions 21 - 56

<table>
<thead>
<tr>
<th>Question</th>
<th>Teacher 1 Differences</th>
<th>Teacher 5 Differences</th>
<th>Between Group Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q21 - Use maps and databases to plan the best possible uses for our land.</td>
<td>0%</td>
<td>28%</td>
<td>28%</td>
</tr>
<tr>
<td>Q23 - Design high tech devices like GPS units and Personal Digital Devices.</td>
<td>-9%</td>
<td>11%</td>
<td>20%</td>
</tr>
<tr>
<td>Q25 - Use a GPS device to record the locations of earthquakes and tornados.</td>
<td>-36%</td>
<td>33%</td>
<td>69%</td>
</tr>
<tr>
<td>Q27 - Analyze images of the earth taken from satellites.</td>
<td>-45%</td>
<td>28%</td>
<td>73%</td>
</tr>
<tr>
<td>Q29 - Write computer programs to predict where forest fires might occur.</td>
<td>-18%</td>
<td>22%</td>
<td>40%</td>
</tr>
<tr>
<td>Q31 - Design a satellite that takes super high-definition pictures of the earth.</td>
<td>-18%</td>
<td>0%</td>
<td>18%</td>
</tr>
<tr>
<td>Q33 - Work with city planners to help businesses decide where to put their buildings.</td>
<td>-36%</td>
<td>-6%</td>
<td>30%</td>
</tr>
<tr>
<td>Q35 - Study weather patterns on computer maps to see if climate change is occurring.</td>
<td>0%</td>
<td>17%</td>
<td>17%</td>
</tr>
<tr>
<td>Q37 - Use maps and databases to see where people from different cultures live.</td>
<td>0%</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Q39 - Use special cameras to study the surface of the earth in three dimensions.</td>
<td>-18%</td>
<td>11%</td>
<td>29%</td>
</tr>
<tr>
<td>Question</td>
<td>Pre-test %</td>
<td>Post-test %</td>
<td>Increase/Decrease</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>------------</td>
<td>-------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Q43 - Design computer models to explain how the earth has changed over time.</td>
<td>-18%</td>
<td>0%</td>
<td>18%</td>
</tr>
<tr>
<td>Q45 - Develop computer software that creates interactive maps.</td>
<td>-45%</td>
<td>17%</td>
<td>62%</td>
</tr>
<tr>
<td>Q47 - Teach others how to use mapping programs on the computer.</td>
<td>-27%</td>
<td>6%</td>
<td>33%</td>
</tr>
<tr>
<td>Q49 - Design roads, rail systems, and other parts of a city.</td>
<td>-9%</td>
<td>6%</td>
<td>15%</td>
</tr>
<tr>
<td>Q51 - Use special equipment to collect air samples to see if it is polluted.</td>
<td>-9%</td>
<td>28%</td>
<td>37%</td>
</tr>
<tr>
<td>Q53 - Study what would happen if dams are removed.</td>
<td>-27%</td>
<td>11%</td>
<td>38%</td>
</tr>
<tr>
<td>Q56 - Teach people about how to take care of the environment.</td>
<td>-9%</td>
<td>17%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Figure 19 Percent Difference for Student Interest Survey (Questions 21 - 56) from Pre-test to Post-test for Teacher - 1 and Teacher - 2
Students’ responses for section two of the science and technology interest survey produced differences greater than 10% for seventeen questions. All seventeen of the questions were those dealing with beliefs about geospatial technologies. None of the questions dealing with beliefs about biotechnologies showed differences greater than 10% between groups. Only one item dealing with geospatial technology careers did not show an important difference between groups, Question #41 – “Work on a team to find out the height of hills and mountains.” This item showed an increase in positive responses for students from teacher 1 (18%) and teacher 5 (22%). All other responses from students of teacher 1 (high quantity of implementation) showed no differences or negative differences in positive responses between pre-test and post-test responses. All responses, except for question #33, from students of teacher 5 (low quantity of implementation) showed no differences or positive differences between pre-test post-test responses.

**Summary**

The null hypotheses for this study were tested using data collected during the first year of implementation for the GTEC project. This study considered student spatial literacy skills, as measured by the Spatial Literacy Skills Assessment, and students’ interest in science and geospatial technologies, as measured by the student science and technology interest survey. Two null hypotheses were tested for this study.

1. There will be no significant difference found in scores between pre – post treatment group performance on the Spatial Literacy Skills Assessment due to the implementation of a teacher geospatial technologies professional development model.
2. There will be no experimentally important difference found in student science interest scores pre – post between treatment and control groups, as measured by the student science interest survey, due to the implementation of a teacher geospatial technologies professional development model.

Following statistical analysis of the pretest – posttest student data from the Spatial Literacy Skills Assessment, statistical significance was not met, therefore, the researcher failed to reject the null that the implementation of a teacher geospatial technologies professional development model would not produce a significant change in students’ performance on the Spatial Literacy Skills Assessment.

Following analysis of the frequency distributions and median scores of pre-test and post-test Science Interest Surveys, there was no experimentally important difference found that withstood analysis to the point of being considered significant. Therefore, the researcher failed to reject the null that there would be no experimentally important difference found in student science interest scores pre – post between treatment and control groups, as measured by the student science interest survey, due to the implementation of a teacher geospatial technologies professional development model.

Following a comparative analysis conducted between the students of two participating teachers, teacher 1 (high quantity of implementation) and teacher 5 (low quantity of implementation), differences between the two groups were discovered. Spatial literacy scores for teacher 1 increased while spatial literacy scores for teacher 5 decreased. Differences between teacher groups for students’ beliefs about science and technology were also discovered, with students from teacher 1 showing negative changes and students
from teacher 5 showing positive gains in responses. Students’ interests in careers in science and geotechnologies also varied across groups. Teacher 1 students showed no increase in positive responses for the survey items relating to geospatial technologies, while teacher 5 students showed several positive gains in responses.

The following chapter provides conclusions from this research based on the analysis conducted in chapter four. Recommendations for additional research will also be provided that could give more insight into teacher professional development in the area of geospatial technologies.
CHAPTER FIVE

The purpose of this study was to better understand how a teacher geospatial technologies professional development project and the subsequent implementation of a teacher-developed geospatial curriculum would impact student spatial literacy skills and students’ interests in science and technology. This study compared pre-test and post-test data, as measured by a spatial literacy skills test, from an experimental group. In addition, data was collected pre-test and post-test on students’ interest in science and technology, as measured by a science interest survey, for an experimental group and control group.

Findings

The null hypotheses for this study were tested using data collected during the first year of the implementation of the GTEC project. This study considered student spatial literacy skills, as measured by the Spatial Literacy Skills Assessment, and students’ interest in science and geospatial technologies, as measured by the student science interest survey. Two null hypotheses were tested for this study.

1. There will be no significant difference found in scores between pre – post treatment group performance on the Spatial Literacy Skills Assessment due to the implementation of a teacher geospatial technologies professional development model.

2. There will be no experimentally important difference found in student science interest scores pre – post between treatment and control groups, as
measured by the student science interest survey, due to the implementation
of a teacher geospatial technologies professional development model.

Finding 1 – Spatial Literacy

Students’ scores on the spatial literacy skills assessment decreased from a mean
score of 10.23 on the pre-test to 10.12 on the post-test, resulting in a p value = 0.775, which
is in excess of an alpha value $\alpha = 0.5$. When a post-hoc analysis was conducted to further
analyze the data, interesting trends were discovered. Within this post-hoc analysis students
were disaggregated by teacher, gender, grade, proficiency level, and teacher competency.
There were positive changes in spatial literacy scores within some of these groups. For
example, within two schools there was a positive increase in spatial literacy scores from
pre-test to post-test. When the entire sample was disaggregated according to gender, there
was a 3% increase in males’ scores from pre-test to post-test, while the female group
decreased by 5.4%. Grade level groupings elicited positive changes in grades 9 (3%) and
11 (2%) and students that were identified as novice scored 6% better on their post-test
assessment. In regards to quantity and teacher competency, high quantity of
implementation yielded a 3% gain in scores, while a low and medium teacher competency
yielded a 5% and 3% gain, respectively. As more data becomes available to project
directors, these trends may be able to withstand the more rigorous test for statistical
significance.

Finding 2 – Students’ Interests in Science and Technology

Students’ responses on the first section of the science and technology interest
survey, students’ beliefs about science and technology (questions 1 – 20), decreased from
pre-test to post-test for the experimental group, with the exception of questions #14. In all other cases the percentage of participants agreeing or strongly agreeing with the survey statement decreased. As a whole, median scores either remained the same or decreased between the two tests, indicating student positive responses for each of the survey items did not change. Frequency distributions for the control group elicited an increase in positive responses between pre-test and post-test for nine of the survey items, a decrease in positive responses for eight items and three items showed no change.

The second section of the science and technology interest survey dealt with careers in science and geospatial technology (question 21 – 56). For the purposes of this study, only questions dealing with geospatial technology were analyzed. For the experimental group, of the eighteen items analyzed, only two items produced an increase in positive responses from pre-test to post-test, two items stayed the same and fourteen items showed a decrease in the percentage of agreement. For the experimental group there were no items within the geospatial careers section that produced higher than a 45% positive agreement rating. Frequency distributions between pre-test and post-test for the control group show an increase in agreement for five of the survey items, a decrease in twelve of the survey items, and one item remained the same. One item within the control group produced an agreement rating over 45%.

Finding 3 – Comparative Analysis of Students’ Data From Two Participating Teachers

A comparative analysis was conducted between two teachers to determine the effect quantity of implementation had on student spatial literacy scores and students’ interest in science and technology. The two teachers selected for the comparison implemented their
curriculum in two distinct ways. Teacher 1 had the highest level of implementation for all teachers in the project, while teacher 5 had the lowest level of implementation.

Students’ scores on the spatial literacy assessment varied between groups. Teacher 1 (high quantity of implementation) student scores increased by 5% between pre-test and post-test, while teacher 5 (low quantity of implementation) student scores decreased by 5.2%. This increase in students’ scores on the spatial literacy assessment for teacher 1 indicates this group may have benefited from the high quantity of implementation offered by teacher 1.

Students’ responses on the first section of the science and technology interest survey (questions 1-20) produced differences greater than 10% for nine questions. Of the survey items showing a difference of 10% or greater, only one item produced a positive increase in student responses for the teacher 1 group, two items remained the same, and six items decreased between pre-test and post-test. All of the items, aside from question #9 were specific to geospatial technologies. Teacher 5 students’ responses produced four items with positive gains, one item remained the same, and four items decreased between pre-test and post-test.

The second section of the science and technology interest survey (questions 21-56), dealt with students’ interests in careers in science and geospatial technologies. For the purposes of this study, only those questions dealing with geospatial technologies were used. Students’ responses for section two of the survey produced differences greater than 10% for seventeen questions. For teacher 1, there were no items that produced an increase in positive responses between pre-test to post-test, three items showed no change, and
fourteen items produced negative changes. For teacher 5, fourteen items produced positive changes from pre-test to post-test, two items showed no change, and only one item resulted in a negative change.

Based on the results of the comparative analysis between teacher groups on the science and technology interest survey, there appears to be a relationship between the quantity of implementation and students’ positive feelings toward science and technology. For teacher 1 students, results on the survey generally decreased from pre-test to post-test. For teacher 5 students, results on the survey, especially in section two, generally increased from pre-test to post-test.

Observations on the Study

The spatial literacy skills assessment was an instrument produced by the Association of American Geographers (AAG) and was designed for use with pre-service teachers. This instrument, prior to this research project, had not been tested on students in grades 5 – 12. At the onset of this project, project directors decided to use the instrument for all students in the project (grade 5-12), however, based on email conversations with the instrument’s creator and after findings from initial evaluation from the project evaluator, the researcher decided to eliminate the students in grades 5 – 8 from the spatial literacy skills assessment due to concern about the reading level. This reduced the population of students from over 400 to 52. While it is unknown how this reduction changed the outcome of the study, increased numbers in the study could have allowed for different statistical analyses to be performed on the differentiated groups, i.e. gender, grade, teacher, as well as others. The reduction in population also completely eliminated the control group.
for this study. Had a control group remained in place for this study, different statistical analyses could have been conducted to better control for pre-treatment conditions and also help explain the drop in spatial literacy scores from pre-test to post-test. As the GTEC project continues and more students are involved in the assessment, more data will become available which may prove helpful in determining the overall impact this professional development model can have on students’ spatial literacy skills and interests in science and technology.

The science and technology interest survey, produced by project directors, was designed to measure students’ interest in science and technology and determine whether or not the geospatial technologies curriculum model changed those interests. When working with surveys, it is difficult to move away from ordinal level data, which in turn makes it difficult to analyze. It was the intent of the researcher to treat ordinal data as rank order data (no equal intervals between scores) and therefore, not subject given data to inferential statistics significance tests. Therefore, frequency scores and medians were all that was reported for the science interest survey, making it more difficult to assess change. It is also important to note the experimental group and control group was unbalanced in number and makeup. The experimental group consisted of 116 participants and the control group was made up of 28. There was also an unequal grade range between the groups; the experimental group consisted of grades 5 – 12 and the control group was made up of entirely of students in grade 7.

Two teacher groups were used for a comparative analysis between students that received high quantities of implementation and students that received low quantities of
implementation. While aggregated results of the spatial literacy assessment and the science and technology interest survey produced negative results for the experimental group, differences emerged between the high and low quantity implementation groups. As the GTEC project continues, it may become important to reassess the tools used to measure the implementation of geospatial technologies into classroom instruction.

Conclusions

Based on the statistical analysis of the student spatial literacy skills assessment, the frequency distributions from the results of the interests in science and technology survey, and the teacher comparative analysis, the GTEC project results do not provide a clear consensus. While the spatial literacy skills decreased for the experimental group from pre-test to post-test and the students’ interests in science and technology decreased as well, the comparative analysis between the high quantity implementation teacher and the low quantity implementation teacher did produce a considerable difference in spatial literacy scores and students’ responses to the science and technology interest survey. Students from the high quantity implementation group had a 5% increase in spatial literacy scores from pre-test to post-test, while students from the low quantity implementation group had a 5.2% decrease on scores. This increase for the high quantity implementation group may likely be attributed to the amount of exposure they received to geospatial technologies throughout the year. The decrease for the low quantity implementation group could be attributed to the minimal exposure to geospatial technologies these students received.

Additionally, the frequency distributions for the high quantity implementation group generally decreased from pre-test to post-test within section one and two of the
survey. The overall decrease in students’ positive responses could be attributed to a point-of-saturation effect, resulting from too-much-all-at-once integration within their classroom. Conversely, students in the low implementation group generally stayed the same or increased in positive responses between pre-test and post-test, suggesting they were still excited about using geospatial technologies. Because the implementation was short (only one week), the students in this group did not reach a point-of-saturation and therefore still had positive attitudes toward geospatial technologies.

**Recommendations for Further Research**

From this research project three areas for future research arose. First, a need exists for a series of instruments that can be used to measure how the use of geospatial technologies impacts students’ spatial literacy skills and interests in science and technology. GIS can “stimulate students' intellectual development and enable learners to create, revise, and reconstruct what they know to create new frameworks of knowledge” (Burns, 2006). With the above statement comes the task of measuring the impact these technologies can have on student learning.

There remains little data to support how geospatial technologies influence students’ spatial literacy skills and interests in science and technology. New instruments that effectively measure the impact these new technologies have on student learning need to be developed that can address the complex nature of school environments including but not limited to differences in; age, gender, content areas, as well as other factors. Instruments that measure specific skills within the geospatial domain should be created in order to
measure the relationships between individual students’ skill sets and their corresponding ability to think spatially.

Follow-up student interviews could be conducted in order to gain a more intimate view into individual student interests in geospatial technologies and overcome some of the limitations of current instruments. These interviews could be conducted at different points within the implementation process to help determine if and when a point-of-saturation is reached. A look at how the affective domain relates to student performance may also shed light on future research into geospatial technologies. Additionally, as supported by the research conducted by Waddoups, (2004), ongoing formative evaluations of technology integration projects are necessary for continued improvement.

Secondly, lessons learned from the GTEC project suggest the need for additional research into teacher geospatial technologies professional development to help build effective models that can help teachers gain the skills, confidence, and understanding necessary to implement these technologies into classroom instruction. New teacher geospatial professional development models should be flexible, and must consider, teacher skill levels, content area, and grade levels taught, along with other factors. In order for teachers to feel comfortable implementing geospatial technologies into classroom instruction, they must first feel comfortable navigating the software themselves. Christensen (2002) explored the extent to which targeted teacher training promotes classroom technology use and fosters positive student attitudes toward technology. The author concluded that training teachers to use technology strongly influences their attitudes about its use in the classroom and has direct effect on students’ computer enjoyment.
The GTEC project findings, consistent with Trautmann and MaKinster (2008) and McClurg and Buss (2007), confirmed the crucial aspects of teacher geospatial technologies professional development as an intensive summer training, ongoing technological and curricular support throughout the school year with shorter face-to-face workshops throughout the school year, the promotion of a supportive learning community, assistance in development and implementation of individual curricular plans, and program flexibility to meet teacher interests and needs.

Given the results of the comparative analysis between the two groups, it is apparent that teachers play a significant role in bringing geospatial technologies into classrooms. As evidenced by the increase in spatial literacy skills for the high quantity implementation group, teachers that commit adequate time to geospatial technologies do see favorable results on student performance assessments aimed at measuring spatial skills. These findings combined with the research conducted by Audet and Paris (1997), that found teachers believe that GIS is a valuable educational tool because it enhances problem solving, enables spatial data analysis, supports interdisciplinary connections, and is enjoyable to students, makes for a strong case for the continuation of this line of research in order to find the most effective way to bring geospatial technologies into classrooms.

Finally, the findings of this research study indicate that a level of saturation may have been experienced by the student group that received the high quantity of implementation. These findings are consistent with the research done by Waxman and Haung (1996), who found significant differences between classrooms where technology was used slightly, resulting in higher affiliation, parent involvement, and motivation; than
those classrooms where technology was used moderately, resulting in significantly lower scores on the same measures. These findings suggest the quantity of implementation plays an important role in successful technology integration. This outcome suggests that geospatial skills are best learned over time, where beginning skills are taught first, with ample time for students to practice their newly acquired skills before moving on to more complex skills. This approach could in turn produce a more spatially competent workforce, thus filling the critical need for science, technology, engineering, and math (STEM) positions.

Further, the National Research Council, 2006, suggests there is a need for spatial thinking standards along with an articulated curriculum that encompass grades K-12. Spatial literacy should not be taught all at once or within the scope of one year. Rather, students should be taught to think spatially across content domains and across grade levels. Geospatial technologies can provide both low- and high-tech solutions for practicing and performing spatial thinking. Researchers at James Madison University are currently working on the development of a GIS skills sequence matrix designed to identify when certain skills should be taught as well as determining the level of cognitive ability associated with each skill. This type of analysis will need to continue and should not be limited to the more sophisticated geospatial applications, but also focus on those application that are easier to use, thus allowing for the integration of geospatial technologies at lower grade levels and across content domains.

The study of the utilization of geospatial technologies in schools is still in its early stages. More research needs to be conducted that will provide researchers information and
educators strategies to implement these new and emerging technologies into classroom practice. From research studies, come new strategies and educational materials that will help shape the way we teach to our future generations of students. Enabling our students to make decisions about the world in which they live is a critical part of our educational system, for it is these students today that will become the decision makers of tomorrow.
REFERENCES


http://www.spiegel.de/international/spiegel/0,1518,429525,00.html


http://www.esri.com/news/arcnews/fall06articles/the-fourth-r.html


Kolvoord, R., & Keranen, K. (n.d.). *Spatial thinking with ArcExplorer--Java edition for education: Applications for grades 4-6*.


APPENDIX A

GTEC TEACHER CONTRACT ACTIVITIES OUTLINE
GTEC Teacher Contract Activities Outline

2006

September  Electronically submit geospatial module to GTEC at:
            lisa.blank@mso.umt.edu and lisa@spatialsci.com by September 1
            Distribute GTEC student permission letter; administer student Technology
            & Science Interest/Career pre-test online via Spatial Sci website

October  Attend synchronous chat: Tuesday, October 10th, 2006; 4:30-6:30

November Implement GIS Curriculum module or communicate to GTEC staff when
       module will be implemented

December Arrange and participate in Site Visit (Teacher Interview & GTEC
       Components Survey; Student Focus Group)

2007

January  Attend synchronous chat: Tuesday, January 16th, 4:30-6:30
       GIS Competition details outlined

February Participate in pilot GIS Competition

March  Attend synchronous chat: Tuesday, March 6th, 4:30-6:30
       Pilot GIS Competition Awards announced
April  
GTEC teachers submit representative GIS student work samples generated from GIS curriculum module.

May  
Attend synchronous chat: Tuesday, May 8th, 2007; 4:30-6:30

GTEC students complete Technology & Science Interest/Career post-test online.

GTEC teachers complete Geospatial Literacy post-test online.

GTEC teachers submit GIS curriculum module with revisions made after piloting.
APPENDIX B

GTEC TEACHER PROGRAM APPLICATION
Science Goes Spatial: Geotechnology in the Classroom (GTEC) Program

Application

All applications must be postmarked by March 30th. Announcements for all GTEC fellows will be made by April 10th, 2006. Please submit all application materials to:

The GTEC Program
c/o Lisa M. Blank
School of Education
Department of Curriculum & Instruction
University of Montana
32 Campus Drive
Missoula, Montana 59812

Contact Information

Name: ___________________________      School: ___________________________
Home Address: _____________________      School Address: _____________________
                                              ________________________________
Home Phone: ________________________        School Phone: ______________________
Email: _______________________________       Grade(s) & Subject(s) Areas Taught_____
                                              ________________________________
Principal: _____________________________

Checklist of Application Materials:

☐ Teacher Information Form
☐ Letter of Support from building principal

I am available full time for the mandatory summer workshop held at The University of Montana ~ Missoula from June 19-23, 2006 or June 18-22, 2007.

Yes _____ No _______
Teacher Information Form:

1. Please list geospatial workshops, courses, or programs you have participated in during the past five years:

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

2. Please list the spatial data sets you have used with your students (e.g., NRIS vegetation cover).

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

3. Are there spatial data sets you would like to use with students but for reasons of access or projection you have not? Please describe these.

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
4. What are the biggest limitations for you regarding the infusion of GIS into your science teaching?

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

5. Please provide a 1-3 page outline of how you use GIS in your teaching including types of software/hardware used by students, time of year, duration of the unit/lesson(s), and science concepts you develop.

6. Please attach one example of a GIS lesson you have used with students and a student work sample generated using GIS.
APPENDIX C

ARCLESSIONS TEMPLATE
The ESRI ArcLessons Web site ([www.esri.com/arclessons](http://www.esri.com/arclessons)) has, over a series of years, become a rich repository of ready-made, downloadable classroom activities and modules. Since the site’s contents are from many sources and authors, lesson styles and structures vary. This is not a problem as there is no single instructional design for all classroom settings. However, ESRI Education Program staff members have received requests from prospective ArcLessons authors for suggested guidelines on how to structure a lesson document for the site. Likewise, the popularity of the ESRI Press workbook, *Mapping Our World: GIS Lessons for Educators* (MOWGLE) has spawned calls for more ArcLessons packages to mimic the composition found there ([www.esri.com/mappingourworld](http://www.esri.com/mappingourworld)). The result is the creation of the attached ArcLessons Template.

Designed for your use in creating GIS lessons using ESRI technology, the ArcLessons Template framework on the following pages is drawn directly from that found in MOWGLE. For persons unfamiliar with MOWGLE, the template does not necessarily provide an ample picture of what might populate the various lesson components. To better visualize how a finished lesson might look, review and download the sample MOWGLE lesson,


You also will note that the template carries an ESRI copyright on the bottom of each page.

ArcLessons Template, Copyright © 2005 ESRI. All rights reserved.

This statement refers to the template document and its design, not lesson content you might insert into it. This material, your creative work, belongs to you (unless you have transferred this copyright to another party, such as via a contract for curriculum writing services). This is why the template document carries a second copyright line

Lesson Name, Copyright © 200X Your Name.
As you create your activity, you will want to claim it as your own copyrightable work. In addition to your name, you also should include your contact information somewhere in the lesson document. This will be helpful to users of your material who may wish to explore with you the possibility of localizing or translating your work for use in other classroom or country settings, as well as applaud your efforts.

Lastly, to provide greater clarity on the legal use of the ESRI ArcLessons Template document, we offer the following:

*ESRI grants you (the educator/curriculum designer) the nonexclusive, royalty-free license and permission to use the ArcLessons Template in the creation of your lesson(s) and thereafter copy, reproduce, and redistribute your lesson plan(s) formatted in the ArcLessons template to other educators for the purpose of GIS classroom instruction.*

If you have questions, regarding this template, or would like to discuss lesson and module ideas with ESRI Education Program staff members, please write us at k12-lib@esri.com. Thank you.
Module Name (if applicable)

[Main Lesson Title]

[Subtitle]

Lesson Overview

[Type your lesson overview text here; it should be at least one paragraph that summarizes the general idea of the lesson. It will be around four or five sentences long.]

Estimated Time

[List the time in the number of 45 minute class periods. (i.e.: Two or three 45 minute class periods).]

Materials

Student handouts to be copied:
- GIS Investigation sheet (p. X – XX)
- Student Answer sheet (p. XX – XX)
- Assessment (p. XX – XX)
[Any other materials (map, reference book, etc.)]
[Any other materials (map, reference book, etc.)]
## National Standards of Your Choice

<table>
<thead>
<tr>
<th>Standard</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Type the standard here (don’t forget the standard number)</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
<tr>
<td>4 Type the next standard here</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
<tr>
<td>7 Type the next standard here</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
</tbody>
</table>

## National Geography Standards

<table>
<thead>
<tr>
<th>Geography Standard</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Type the standard here (don’t forget the standard number)</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
<tr>
<td>4 Type the next standard here</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
<tr>
<td>7 Type the next standard here</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
</tbody>
</table>

## National Technology Foundation Standards

<table>
<thead>
<tr>
<th>Technology Standard</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Type the standard here (don’t forget the standard number)</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
<tr>
<td>4 Type the next standard here</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
<tr>
<td>7 Type the next standard here</td>
<td>Type definition of this standard for MS</td>
<td>Type definition of this standard for HS</td>
</tr>
</tbody>
</table>
Objectives

The student is able to:

[List an objective]
[List another objective]
[List another objective]

GIS Skills & Tools

[GIS skill (may include a graphic of the button or tool used)]
[GIS skill (may include a graphic of the button or tool used)]
[GIS skill (may include a graphic of the button or tool used)]
[GIS skill (may include a graphic of the button or tool used)]
[GIS skill (may include a graphic of the button or tool used)]

Insert geographic inquiry graphic

For more on geographic inquiry and these steps, see whitepaper titled “Geographic Inquiry: Thinking Geographically.”

Teacher Notes

[Type the lesson introductory activity here. This is a pre-activity that allows the students to get their baseline understanding of the lesson topic out. The activity can be done in the classroom with no technology. It could be an interactive discussion, individual brainstorm that leads to small group and then whole group discussions, or other similar activity. See MOWGLE for examples.]

Before completing this lesson with students, we recommend that you complete it as well. Doing so will allow you to modify the activity to accommodate the specific needs of your students.

[First paragraph provides a bridge to the GIS lab activity. It also states if the students are to work individually or in teams. For sample text see MOWGLE.]

[Second paragraph describes what handout the students will be using and what they can expect as they work through the investigation. It will highlight the key components of each part of the lesson.]
The investigation sheets include questions to help students focus on key concepts. Some questions will have specific answers: others require creative thought.

Things to look for while the students are working on this activity:

- Are the students using a variety of tools?
- Are the students answering the questions as they work through the procedure?
- Are the students beginning to ask their own questions of the data they are observing
  
  [Insert any other “look for” items here]

[Short paragraph that allows the students to compare their findings from the investigation to the original thoughts from the introductory activity. This also provides a bridge to the assessment piece.]

**Conclusion**

**Assessment**

*Middle School: Highlights skills appropriate to grades 5 through 8*

[Provides a summary of the assessment for middle school and notes for the teacher on how to introduce the assessment, set up small groups (if applicable), etc. Also provides expectation as to what the students will produce as part of the assessment.]

*High School: Highlights skills appropriate to grades 9 through 12*

[Provides a summary of the assessment for high school and notes for the teacher on how to introduce the assessment, set up small groups (if applicable), etc. Also provides expectation as to what the students will produce as part of the assessment.]

**Extensions**

[Bulleted list of extension activity ideas. These could include links where the student can conduct additional research, independent project ideas, or just something cool that you wish you could have added into the lesson if you could make it as long as you want!]

[Another extension idea]
[Another extension idea]
[Another extension idea]
[Another extension idea]

**Web Links**

[Bulleted list of Internet links that could provide additional resources and lesson ideas]

[Another web link]
[Another web link]
[Another web link]
[Another web link]

Bibliography

[List all resources for creating the lesson (including references used for data) here. Bibliography must be in APA format per ESRI Press guidelines. Don’t forget to include metadata for each data file in the project. Use ArcCatalog to help you create the metadata file.]
[Main Lesson Title]

A GIS investigation

Answer all questions on the student answer sheet handout

[Insert lesson step-by-step instructions, lessons questions, and screenshot graphics in this section.]
Name ________________________________  Date ______________________

Student Answer Sheet

Lesson Title
[Main Lesson Title]

Middle School Assessment

[Type the text of the assessment here. It should be a problem based assessment project that allows students to demonstrate the knowledge of the history standards identified for the lesson. It will use the same or similar project and data from the GIS Investigation. The assessment should be able to be evaluated with its associated standards-based rubric. See page xix in MOWGLE for a definition of rubric-based assessment.]
## Assessment Rubric

**Middle School**

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>EXEMPLARY</th>
<th>MASTERY</th>
<th>INTRODUCTORY</th>
<th>DOES NOT MEET REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student understands [insert text here]</td>
<td>[The student has gone above and beyond a particular standard. He or she has a strong understanding of the concept and has the ability to mentor other students.]</td>
<td>[This is the target level for all students. Performance at this level shows that they have a good understanding of the concept illustrated in the standard.]</td>
<td>[The student has limited understanding of the standard. Or, the product he or she produced shows little evidence of meeting the standard.]</td>
<td>[The student does not show any foundational knowledge of the standard and the products they produce show no evidence of their understanding.]</td>
</tr>
<tr>
<td>The student understands [insert text here]</td>
<td>[The student has gone above and beyond a particular standard. He or she has a strong understanding of the concept and has the ability to mentor other students.]</td>
<td>[This is the target level for all students. Performance at this level shows that they have a good understanding of the concept illustrated in the standard.]</td>
<td>[The student has limited understanding of the standard. Or, the product he or she produced shows little evidence of meeting the standard.]</td>
<td>[The student does not show any foundational knowledge of the standard and the products they produce show no evidence of their understanding.]</td>
</tr>
<tr>
<td>The student understands [insert text here]</td>
<td>[The student has gone above and beyond a particular standard. He or she has a strong understanding of the concept and has the ability to mentor other students.]</td>
<td>[This is the target level for all students. Performance at this level shows that they have a good understanding of the concept illustrated in the standard.]</td>
<td>[The student has limited understanding of the standard. Or, the product he or she produced shows little evidence of meeting the standard.]</td>
<td>[The student does not show any foundational knowledge of the standard and the products they produce show no evidence of their understanding.]</td>
</tr>
</tbody>
</table>
This is a four-point rubric based on the National Standards for [enter subject here]. The “Mastery” level meets the target objectives for grades 5-8.
[Main Lesson Title]

High School Assessment

[Type the text of the assessment here. It should be a problem based assessment project that allows students to demonstrate the knowledge of the history standards identified for the lesson. It will use the same or similar project and data from the GIS Investigation. The assessment should be able to be evaluated with its associated standards-based rubric. See page xix in MOWGLE for a definition of rubric-based assessment.]
**Assessment Rubric High School**

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>EXEMPLARY</th>
<th>MASTERY</th>
<th>INTRODUCTORY</th>
<th>DOES NOT MEET REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The student understands [insert text here]</strong></td>
<td>[The student has gone above and beyond a particular standard. He or she has a strong understanding of the concept and has the ability to mentor other students.]</td>
<td>[This is the target level for all students. Performance at this level shows that they have a good understanding of the concept illustrated in the standard.]</td>
<td>[The student has limited understanding of the standard. Or, the product he or she produced shows little evidence of meeting the standard.]</td>
<td>[The student does not show any foundational knowledge of the standard and the products they produce show no evidence of their understanding.]</td>
</tr>
<tr>
<td><strong>The student understands [insert text here]</strong></td>
<td>[The student has gone above and beyond a particular standard. He or she has a strong understanding of the concept and has the ability to mentor other students.]</td>
<td>[This is the target level for all students. Performance at this level shows that they have a good understanding of the concept illustrated in the standard.]</td>
<td>[The student has limited understanding of the standard. Or, the product he or she produced shows little evidence of meeting the standard.]</td>
<td>[The student does not show any foundational knowledge of the standard and the products they produce show no evidence of their understanding.]</td>
</tr>
<tr>
<td><strong>The student understands [insert text here]</strong></td>
<td>[The student has gone above and beyond a particular standard. He or she has a strong understanding of the concept and has the ability to mentor other students.]</td>
<td>[This is the target level for all students. Performance at this level shows that they have a good understanding of the concept illustrated in the standard.]</td>
<td>[The student has limited understanding of the standard. Or, the product he or she produced shows little evidence of meeting the standard.]</td>
<td>[The student does not show any foundational knowledge of the standard and the products they produce show no evidence of their understanding.]</td>
</tr>
</tbody>
</table>

This is a four-point rubric based on the National Standards for [enter subject here]. The “Mastery” level meets the target objectives for grades 9-12.
APPENDIX D

GTEC SUMMER INSTITUTE SCHEDULE
GTEC Summer Institute Agenda

• Monday
  • Introduction of participants and short group activity to get everyone acquainted.
  • Geospatial technologies activity to revisit skills and learn new ones
  • Application of geospatial technologies to authentic problem
    o Introduce scenario participants must use geospatial technologies to solve
    o Groups present solutions to remainder of class
  • Presentation by geospatial technologies professional

• Tuesday
  • Geospatial technologies skills session
    o Introduce new skills to participants
  • Introduce new problem students must solve using geospatial technologies
    o Students work in teams to solve problems
  • Teachers work in groups to talk about their curriculum and how they might use it to
    engage students in real-world problems
    o Groups present to rest of class
  • Project leaders share samples of how other teachers are using geospatial
    technologies in their classrooms
  • Assignment for Wednesday was for each teacher to have five ideas for projects
    they may be able to do in their own classroom

• Wednesday
  • Geospatial technologies professional explains how they use it to solve problems
- Project leaders demonstrate how to mine data from Internet and other sources
- Teachers share ideas regarding their projects and others offer suggestions to improve ideas
- Geospatial technologies skills session where teachers were introduced to new skills and how they might be applied to a classroom setting.
- Teachers were given time to develop ideas for classroom module
- Teachers share idea for module with the rest of the class and others offer suggestions

- Thursday

- Teachers spent the morning working on module, writing curriculum and mining data for project.
  - Project leaders offered individualized help to participants as they develop their modules
- Geospatial technologies skills session
  - Project leaders, based on teacher needs presented last round of skills to teachers in order to help them with project design

- Teacher work session

- Friday

- Teachers spent the morning preparing module ideas and received last minute advice and training from project directors
- Presentation of project and plan of action to remainder of class
APPENDIX E

GTEC INTERACTIVE WEBSITE
The mission of SpatialSci is to provide educators with a sustained environment for the integration of geo-technologies into classroom instruction. From relevant spatial data sets to GIS-based curriculum, SpatialSci is a one stop shop for teachers committed to implementing geo-technologies into K-12 classroom instruction.
The overall goal of GTEC is to contribute to a national model that improves the teaching and learning of science in grades 5-12 using geotechnologies. The emergence of geotechnologies (satellite imagery and Geographic Information Systems) has revolutionized how scientists interpret and use data. Because of its great analytical power, Geographic Information Systems (GIS) is currently used as a research and planning tool in many applications of science such as agriculture (e.g., for precision planting and application of pesticides and fertilizer); environmental planning and research (e.g., to conduct environmental impact assessments and groundwater contamination modeling); forestry (e.g., to model wildlife and plan harvests); and petroleum and mining exploration (e.g., to identify potential locations of oil and mineral deposits).

Indeed, GIS is used daily in so many aspects of human activity that many predict it will one day be a required basic skill set just as word processing is today (Allbrandy, 2003). If you have ever pulled a travel map off the internet, you have used GIS. If you watched last night’s weather report, you viewed a geographic information system. GIS simply combines layers of information about a place, such as cloud cover and temperature, to better understand that place.

Geotechnologies are everywhere in society now, yet only approximately 5% of GIS users are educators and students (ESRI, 2005). Schools lag behind in introducing students to geotechnologies because of a lack of training, support, and access to spatial data sets appropriate for 5-12 grade audiences.

This teacher training program models effective use of emerging geospatial technology, builds leadership teams within and across school districts, and shares the possibilities of geotechnology through the establishment of a statewide geotechnology competition. Further, the project delineates key indicators that make the program sustainable and transferable to other sites across the country.

GTEC has the potential to generate long-term and widespread innovations in science education. To this end, GTEC has assembled a collaborative partnership between The University of Montana School of Education, Salish Kootenai College, The Montana Association of Geographic Information Professionals, The GIS Intermountain Association, and a geographically/culturally representative group of Montana school districts.
Renewable Energy Atlas of the West - 80-page, full-color presentation of the renewable energy resources in the West, including newly released high-resolution wind maps of the Pacific Northwest. The atlas features wind, solar, geothermal and biomass power:
http://www.epa.gov/energy/atlas.html


National Renewable Energy Laboratory - nation's primary laboratory for renewable energy and energy efficiency research and development: http://www.nrel.gov/

Montana Wind Energy Atlas - comprehensive analysis of wind energy data available as of 1997. Data collected by a variety of public and private organizations at 166 wind monitoring sites around Montana, and are available at site and county levels:


National Center for Appropriate Technology - serves economically disadvantaged people by providing information and access to appropriate technologies that can help improve their lives:
http://www.ncat.org/

Rocky Mountain Institute - nMInds!-profit think and do think! that works with individuals and organizations of any size, imagination to help them use energy and resources efficiently while being ever-better stewards of the environment: http://www.rmi.org/

H2education and the Alternative Energy Learning Site - the Alternative Energy Learning Site, located in Billings, Montana, provides educational opportunities to the public about renewable energy technologies. The site includes a 10 kilowatt wind turbine, a 2 kilowatt solar photovoltaic array, a proton exchange membrane fuel cell and a backup backup unit. H2education provides educational resources on hydrogen technology:

Geospatial data and tools:

National Renewable Energy Laboratory's Dynamic Maps, GIS Data and Analysis Tools Website - provides dynamically-generated maps of renewable energy resources (solar, wind, biomass, and hydrogen) that determine which technologies are viable solutions in national and international regions. The site also provides access to an FTP site where you can download data and Geospatial Tools: http://www.nrel.gov/gis/

National Climatic Data Center - NCCDC is the world's largest active archive of weather data. NCCDC produces numerous climate publications and responds to data requests from all over the world. Available data sets include land- and satellite-based upper air and marine weather and climate at various spatial and temporal resolutions:
http://www.ncdc.noaa.gov/oa/ncdc.html

http://www.energyst.gov/kindfinder/energy_BOLD/energy_BOLD_windmaps.asp

Wind Energy Resource Atlas of the United States - includes regional wind speed summaries and a great selection of graphical maps showing seasonal and annual wind resources at state and regional levels (see ‘List of Maps’ link toward the bottom of the document):
http://ned.net/docs/publicatals

National Renewable Energy Laboratory's United States Atlas of Renewable Resources - Vere climatic and geospatial interactive maps of solar, wind, geothermal and biomass resources in the U.S.:
http://www.epa.gov/energy/atlas.html

Reports and documents available for download:


Spatial Data Sets

- **Glaciers of Glacier National Park**
  - This data set contains spatial information on the glaciers of Glacier National Park. Within this data set there are four different shapefiles of glaciers found within the park. The data on some of the glaciers dates back as far back as 1850. There is also a general glacier data set with all of the current glaciers of the park, along with a park boundary.
  - If you are looking for imagery to serve as a backdrop for this data you can access the 2005 aerial photography for this area (tile numbers, 1504, 1605, and 1035. Be sure to download the "j2k" files (spatial reference data) to accompany the imagery. Click here to go to get aerial photos of Montana.

- **Montana Climate Trends**
  - This data set includes average temperature and precipitation for several Montana sites. Each site has averages for 1950 and 2000. We have also included a trend with projected averages for temperature and precipitation for the year 2050.

- **Montana Forest Fires**
  - This data set includes perimeters of all fires to strike Montana during 2003.

  - This spatial data set contains historical information on forest fires in Region 1 of the forest service (Montana and Montana) from 1980 to 2005. There are several different data sets within this folder: a shapefile with all the years and several other shapefiles with the fire data for 1980-2001, however, this data does not appear to be as accurate as the previously mentioned file. The two primary data sets are accompanied with metadata to help make sense of the data.

- **Montana Climate Vegetation**
  - This data set includes climate vegetation information for Montana. The shapefile is broken into seven categories as represented by the color in the attribute table. To determine what each vegetation code represents, open the climate_veg_final file and scroll down to the title and attribute information table.

- **Montana Ecoregions**
  - This polygon shapefile shows Montana ecoregions - areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. To determine what each ecoregion code represents, open the scorep_2002html file and scroll down to the title and attribute information table.

For further information and sources for climate related spatial data please visit the UNHS and DATA sections of the SpatialSci website.

Chat Narrative 12-12-2005
Click here to download chat session.

Chat Narrative 1-23-2007
Click here to download chat session.
APPENDIX F

HELP DESK LOG
### Help Desk Activity Sheet

<table>
<thead>
<tr>
<th>INITIALIZED</th>
<th>TEACHER</th>
<th>REQUEST</th>
<th>ACTION</th>
<th>HOURS</th>
<th>COMPLETED</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/13/06</td>
<td>All teachers</td>
<td>Update email</td>
<td></td>
<td>0.25</td>
<td>9/13/06</td>
</tr>
<tr>
<td>9/13/06</td>
<td>Teacher - 1</td>
<td>Stream order and watershed analysis</td>
<td>Sent email requesting data files</td>
<td>0.25</td>
<td>9/13/06</td>
</tr>
<tr>
<td>9/13/06</td>
<td>Teacher - 7</td>
<td>Information on joining tables and citing data sources</td>
<td>Email reply with information</td>
<td>1</td>
<td>9/13/06</td>
</tr>
<tr>
<td>9/14/06</td>
<td>Teacher - 6</td>
<td>Projection help; digital data on ocean bathymetry</td>
<td>Provide projection information</td>
<td>1</td>
<td>9/14/06</td>
</tr>
<tr>
<td>9/14/06</td>
<td>Teacher - 5</td>
<td>Copy of Bob Rumney's agriculture data</td>
<td>Sent data via email</td>
<td>1</td>
<td>9/14/06</td>
</tr>
<tr>
<td>9/14/06</td>
<td>Teacher - 6</td>
<td>Set up site visit when lesson is taught</td>
<td>Email request for more information</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>9/19/06</td>
<td>Teacher - 8</td>
<td>Information on GTEC credits</td>
<td>Sent info via email</td>
<td>0.25</td>
<td>9/19/06</td>
</tr>
<tr>
<td>9/20/06</td>
<td>Teacher - 1</td>
<td>Delineating and measuring watersheds</td>
<td>Requested more info via email</td>
<td>0.25</td>
<td>9/20/06</td>
</tr>
<tr>
<td>9/20/06</td>
<td>Teacher - 6</td>
<td>Creating new shapefiles</td>
<td>Phone reply with information</td>
<td>0.5</td>
<td>9/20/06</td>
</tr>
<tr>
<td>9/26/06</td>
<td>Teacher - 1</td>
<td>Delineating and measuring watersheds</td>
<td>Sent steps for delineating and measuring watersheds</td>
<td>2</td>
<td>9/26/06</td>
</tr>
<tr>
<td>10/2/06</td>
<td>Teacher - 8</td>
<td>Continental Divide data layer</td>
<td>Created and posted data layer on the SpatialSci website</td>
<td>1</td>
<td>10/2/06</td>
</tr>
<tr>
<td>Date</td>
<td>Employee</td>
<td>Task Description</td>
<td>Notes</td>
<td>Time</td>
<td>Date</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>10/12/06</td>
<td>Teacher - 4</td>
<td>Projecting SID files</td>
<td>Dean forwarded my reply to his student, Charley May</td>
<td>0.25</td>
<td>10/12/06</td>
</tr>
<tr>
<td>10/17/06</td>
<td>Teacher - 6</td>
<td>Buffering and selecting volcanoes; request for graphics from summer workshop presentation</td>
<td>Sent email detailing processing steps; also files from summer workshop</td>
<td>2.5</td>
<td>10/17/06</td>
</tr>
<tr>
<td>10/17/06</td>
<td>Teacher - 4</td>
<td>Projecting SID files</td>
<td>Sent email requesting data files</td>
<td>0.25</td>
<td>10/17/06</td>
</tr>
<tr>
<td>7/25/2007</td>
<td>Teacher - 6</td>
<td>Yellowstone hotspots data request</td>
<td>Provided links to data sets</td>
<td>2</td>
<td>7/26/2007</td>
</tr>
<tr>
<td>8/2/2007</td>
<td>Teacher - 10</td>
<td>Help on selection tools and exporting</td>
<td>Provided steps to accomplish tasks</td>
<td>1</td>
<td>8/2/2007</td>
</tr>
<tr>
<td>8/2/2007</td>
<td>All teachers</td>
<td></td>
<td>Created and emailed GPS Drawing Tutorial at teachers' request</td>
<td>10</td>
<td>8/2/2007</td>
</tr>
<tr>
<td>8/9/2007</td>
<td>Teacher outside of Project</td>
<td>Help with ArcView install</td>
<td>Provided installation information</td>
<td>1</td>
<td>8/9/2007</td>
</tr>
<tr>
<td>8/9/2007</td>
<td>Teacher - 10</td>
<td>Help with 3D Analyst Extension; question about Hutto's bird data</td>
<td>Provided help with 3D Analyst and further information on Hutto data</td>
<td>2</td>
<td>8/9/2007</td>
</tr>
<tr>
<td>Date</td>
<td>Teacher</td>
<td>Request Description</td>
<td>Action Description</td>
<td>Time</td>
<td>Date</td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>9/6/2006</td>
<td>Teacher - 10</td>
<td>Help with ArcCatalog and fixing data source errors in ArcView</td>
<td>Sent steps for repairing data sources and managing spatial data files in ArcCatalog</td>
<td>2</td>
<td>9/7/2007</td>
</tr>
<tr>
<td>9/7/2007</td>
<td>Teacher - 10</td>
<td>Additional help with ArcCatalog</td>
<td>Sent steps for managing spatial data files in ArcCatalog</td>
<td>2</td>
<td>9/7/2007</td>
</tr>
<tr>
<td>12/18/2007</td>
<td>Teacher - 10</td>
<td>Help managing spatial data files; help with clipping image files; help with file transfer to UM's FTP site</td>
<td>Provided information via email and telephone to address all questions</td>
<td>2</td>
<td>12/18/2007</td>
</tr>
</tbody>
</table>
APPENDIX G

SAMPLE CHAT LOG
Sample Chat Log

〈lisa〉 For david and carl, hank is the individual who developed the spatial sci
website 12/12/2006 15:24:02
〈carl〉 looking forward to break! 12/12/2006 15:24:20
〈Randy-Eval〉 i'll be in and out - hope that is ok 12/12/2006 15:24:37
〈lisa〉 of course randy 12/12/2006 15:25:06
〈David〉 I am doing fine but still having computer problems - glad I can chat
12/12/2006 15:25:17
* Tim joins My room 12/12/2006 15:25:23
〈lisa〉 hi tim! 12/12/2006 15:25:32
〈Tim〉 Hello all 12/12/2006 15:25:32
〈jeff〉 Hello folks 12/12/2006 15:26:14
〈rachel〉 12/12/2006 15:26:17
〈Dean〉 Hey Lisa and jeff 12/12/2006 15:26:22
〈jeff〉 Hello Dean 12/12/2006 15:26:33
〈carl〉 hi jeff did you make it to griz game? 12/12/2006 15:26:40
〈Dean〉 Hey Rachel... didn't see you there 12/12/2006 15:26:57
〈jeff〉 Yep, I was there. Not quite good enough this time. 12/12/2006 15:27:08
〈lisa〉 i'm trying out this color 12/12/2006 15:27:10
〈rachel〉 Pink is the new black 12/12/2006 15:27:24
〈Randy-Eval〉 dean - you must have made it home safe on saturday! 12/12/2006
15:27:32
〈lisa〉 i think it's too hard to read 12/12/2006 15:27:48
〈Dean〉 Hey Randy... Yeah a little freezing rain. 12/12/2006 15:28:13
〈Randy-Eval〉 just rain for me going over the hill 12/12/2006 15:28:26
〈Tim〉 Mike just got blocked at the school so has to drive home 12/12/2006
15:28:31
〈Dean〉 That's good 12/12/2006 15:28:46
〈Randy-Eval〉 12/12/2006 15:28:57
〈jeff〉 The firewall blocked him? 12/12/2006 15:29:05
〈carl〉 dean-did you get much fire work this summer? 12/12/2006 15:29:05
〈Tim〉 Yes 12/12/2006 15:29:09
〈lisa〉 thanks tim, that's too bad 12/12/2006 15:29:30
〈Dean〉 Carl--Yeah I played in Nevada and Southern Cal 12/12/2006 15:29:35
〈hank〉 That's strange.. it's just port 80 traffic 12/12/2006 15:29:36
〈Tim〉 Kids could view porn this week, but Mike is shut out of professional
development! 12/12/2006 15:29:53
LISA: LOL 12/12/2006 15:30:01
DEAN: nice 12/12/2006 15:30:05
CARL: I did get 25 days in throughout the state 12/12/2006 15:30:33
DEAN: cool ... 12/12/2006 15:30:49
LISA: while we wait for everyone to join us, can those of us who are here talk about how you have or plan to spend your 500 classroom grant? 12/12/2006 15:31:33
TIM: Mike and I have bought a textbook and might go to the ESRI conference in San Diego 12/12/2006 15:31:54
DAVID: I am undecided how I will spend the $500. 12/12/2006 15:31:54
LISA: thanks tim, dean what software did you decide to buy? 12/12/2006 15:32:08
CARL: I have spent most of mine already- I purchased the ARCGIS book and tutorial and bought 4 GPS units 12/12/2006 15:32:18
LISA: do you have any ideas, david about how you might want to spend your money? 12/12/2006 15:32:39
DAVID: None yet 12/12/2006 15:32:45
LISA: which arcgis book, carl, was it the tutorial 12/12/2006 15:32:58
DEAN: I am looking at purchasing the Pharoes GPS for the Ipaq hx2750 that will run through the compact card as opposed to the bluetooth that sucks.. 12/12/2006 15:33:19
CARL: it was the workbook that goes with ARCVIEW 9. 12/12/2006 15:34:15
LISA: have any of you held a teacher inservice -tim did you and mike have one this fall? 12/12/2006 15:34:21
LISA: thanks carl 12/12/2006 15:34:35
DEAN: Lisa--ESRI came through for me with the software.. 12/12/2006 15:34:36
LISA: thanks dean 12/12/2006 15:34:56
TIM: We did not. We have been discussing having one. We also might do something with the school board 12/12/2006 15:35:08
LISA: really??? that's great dean 12/12/2006 15:35:29
DEAN: yep 12/12/2006 15:35:36
RANDY-EVAL: dean "knows" people... 12/12/2006 15:35:36
LISA: the school board is a great idea - i think mike dropped off GTEC newsletters for them 12/12/2006 15:35:44
JEFF: Dean, I have a bluetooth GPS that works great. It may be the specific brand you purchased 12/12/2006 15:35:46
CARL: I brought our tech coordinator in and have gone through the basic program with him. He also came in when jeff did his on site visit 12/12/2006 15:35:47
DEAN: lol 12/12/2006 15:35:46
DAVID: I have not yet held a teacher insevice but would like to get together with a teacher in Savage that is using GIS 12/12/2006 15:36:13
* lisa quit (timeout) 12/12/2006 15:36:20
<Dean> I will call you on Thursday jeff and pick your brain.. 12/12/2006 15:36:31 <David> So Lisa does not like us any more?? 12/12/2006 15:36:49
<Dean> She was sent to Timeout 12/12/2006 15:37:06
<jeff> Dean sounds good, you may want to wait until next week, after finals 2/12/2006 15:37:04
<lisa> no lisa was trying a new function that obviously doesn't work 12/12/2006 15:37:08
<David> These bad girl! 12/12/2006 15:37:20
<lisa> very funny david 12/12/2006 15:37:24
<carl> I guess she will have to get a refocus card! 12/12/2006 15:37:32
<Dean> Jeff--ok 12/12/2006 15:37:58
<jeff> Carl, did you get to check out the camtasia? 12/12/2006 15:38:14
<lisa> you are all very funny 12/12/2006 15:39:17
<lisa> jeff, do you want to tell everyone about the camtasi? 12/12/2006 15:39:28
<carl> Yes, I got to look it over but I'm waiting until next week to run it through with my class. Scott(old student) will be back on break and i'm going to have him assist. 12/12/2006 15:39:33
<lisa> that is camtasia i mean 12/12/2006 15:40:43
* jennifer joins My room 12/12/2006 15:40:52
<lisa> welcome jennifer! 12/12/2006 15:41:07
<lisa> we've just been talking about how everyone has been spending their 500 classroom grant 12/12/2006 15:41:11
<jeff> Hello Jennifer 12/12/2006 15:41:21
<lisa> have you spent yours yet or do you have any plans? 12/12/2006 15:41:24
<jennifer> hi, I'm having computer issues so if I go away, I'll just restart and come back in 12/12/2006 15:41:56
<lisa> no worries, i got kicked out already for bad behavior 12/12/2006 15:41:57
<jennifer> no, not yet, I'd like to buy GPS's 12/12/2006 15:42:12
<jennifer> lol 12/12/2006 15:42:14
<lisa> how many, do you have specific kinds? 12/12/2006 15:42:24
<jennifer> what, we have to behave here? 12/12/2006 15:43:10
<jennifer> I have taught Garmin XL's forever. I was all ready to purchase a couple and found out that they're obsolete 12/12/2006 15:43:30
<jennifer> the golden triangle has a classroom set that I'm trying to talk them out of 12/12/2006 15:43:49
<David> Jennifer you might try ebay 12/12/2006 15:43:53
<jennifer>sofar, I've convinced them to make my classroom their home site 12/12/2006 15:44:09
<jennifer> then people will check them out from me. 12/12/2006 15:44:15
Lisa: that's great news Jennifer 12/12/2006 15:44:20
Carl: I purchased four just like the ones we had at the class-they were cheap from walmart and they sent the usb hookup also. 12/12/2006 15:44:24
Jennifer: so, I'm good..... anyone want my $500??? 12/12/2006 15:44:45
Dean: lol 12/12/2006 15:44:45
Rachel: DIBS!! 12/12/2006 15:45:47
Jeff: Jennifer all you have to do is convince Jere and they are yours 12/12/2006 15:46:57

Lisa: hey everyone, one of the other items we wanted to start our conversation with was how your GIS teaching units are going 12/12/2006 15:47:13
Lisa: tim i know yours is done, how about everyone else? 12/12/2006 15:47:17
Jennifer: seriously, I'm trying to convince her that GTC needs to be on the cutting edge and showing up with those old Garmins is like pulling up to the country club in a VW van 12/12/2006 15:48:02
Lisa: what kinds of support do you still find you are needing to complete your projects? 12/12/2006 15:48:51
Lisa: we also wanted to know how you have found the help desk ... 12/12/2006 15:49:01
David: I have not yet started. Computer problems! Windows gets very mad when you run low on hard drive space. Ended up deleting all of the GIS programs and data. Thought I had the data parked on a different drive but!!#*! Looks like I am getting the computer problems under control so will start working again. 12/12/2006 15:49:06
Carl: I started with the basics and my kids really liked it... we are working on the camtasia project with Jeff and are looking forward to the snow project. I'm not sure if my kids are ready for geodatabasing yet. 12/12/2006 15:49:17

* Mariann joins My room 12/12/2006 15:49:41
Lisa: mariann - great to see you! 12/12/2006 15:49:56
Mariann: Hi, I had some difficulty signing in. I had to run home. Our firewall must be configured to not allow chats 12/12/2006 15:50:09
Jennifer: I've run into a couple roadblocks that are typical of working with Jr. High kids. I 12/12/2006 15:50:10
Lisa: we have been catching up with each other, talking about plans for how to use the 500 classroom grant - have you spent yours yet 12/12/2006 15:50:24
Lisa: Mike had to run home to Mariann so it seems you are not alone 12/12/2006 15:50:53
Carl: we are also doing a tech night for the public in March... the admin wants to run a tech levy so my students will be presenting projects. 12/12/2006 15:50:56
Mariann: I bought a palm handheld and some memory. I am getting ready to buy ArcPad for it 12/12/2006
15:51:03
{lisa} carl, the tech night sounds great 12/12/2006 15:51:14
{lisa} what will you showcase? 12/12/2006 15:51:34
{lisa} david, that sounds very frustrating but glad to hear it seems to be working out?? 12/12/2006 15:52:00
{jeff} Mariann, remember ArcPad will only run on Windows CE and not the Palm software 12/12/2006 15:52:10
{Mariann} I have been going insane trying to get my student lesson done however. Between all out war to get access to computers (English teachers seem to think they have priority) and having the network down, I have only had 1.5 days on the computer since October 12/12/2006 15:52:18
{carl} I would like to do something with the local snowpack data sets and let the kids run with ARC mapping. 12/12/2006 15:52:57
{Mariann} AAAARRRRRGGGGHHHHH. I guess the science club will buy the Palm and I will be purchasing a Windows CE handheld 12/12/2006 15:53:04
{lisa} that's a great idea, carl, when we get to talking about the GIS competition you will see that the focus is the montana snowpack so these two may work well together 12/12/2006 15:53:09
* Bill joins My room 12/12/2006 15:53:24
* Dean quit (timeout) 12/12/2006 15:53:36
{jeff} Let me know if you need some advice on what to purchase 12/12/2006 15:53:38
{Mariann} Is there any sort of non-mountain snowpack data 12/12/2006 15:53:47
{lisa} welcome bill! bill is from cohort two. i asked them to join us for the part of the chat where we share camtasia and the gis competition 12/12/2006 15:53:53
{Mariann} Jeff-- I need advice 12/12/2006 15:54:03
{Bill} Yo 12/12/2006 15:54:11
{jeff} Hello Bill 12/12/2006 15:54:18
{lisa} snotel sites are located all across montana but we are running a specific check for your area now mariann 12/12/2006 15:54:17
{Mariann} Hi Bill-- Missed you at MEA 12/12/2006 15:54:32
{Bill} Nice to see some names I recognize (specially at my age) 12/12/2006 15:54:34
{lisa} no, they are not any near you mariann 12/12/2006 15:54:52
* Dean quit (timeout) 12/12/2006 15:54:56
{Mariann} We don't usually have a "level" The snow falls here and lands in ND. 12/12/2006 15:55:06
{Dean} Lisa--We finally appear to have some City and State specific data on lung abnormalities coming from the ATSDR, and the EPA throughout the nation. I am not sure what other attributes will be attached to it, but we are confident we are making forward progress with the bureaucracy. 12/12/2006 15:55:15
We have had snowcover since October, however, with no end in sight 12/12/2006 15:55:35

There are many fewer SNOTEL sites in eastern Montana compared with western Montana - but national weather service stations often report snow depth or snow water equivalence. 12/12/2006 15:55:46

There may be a snowtell site on the south side of the Fred Robinson bridge. Seems like I may have seen one. 12/12/2006 15:55:54

Took too long to find out how to spell bureaucracy... 12/12/2006 15:56:15

great news dean, i'm lol at the moment again 12/12/2006 15:56:16

can my students find good enough data to determine if ski areas are seeing any trends? 12/12/2006 15:56:14

Great, Dean, We have the county data for cancer from 1995 to 2004. It includes specific kinds of cancer (including lung) if that would help you 12/12/2006 15:56:45

The 2 closest SNOTEL sites to Opheim are Havre and Sidney - not ideal. 12/12/2006 15:56:55

We love data 12/12/2006 15:57:17

i think so, carl, rachel has the snotel site up right now so we'll see if we can find any right now 12/12/2006 15:57:19

Have any of the rest of you found that version 9 requires a bit more processing power than you have? 12/12/2006 15:57:26

carl - there was a story in the paper recently about a ski hill building a new lift and they are hedging their bets by building all new ones lots higher on the mountain 12/12/2006 15:57:29

lookout pass has one 12/12/2006 15:57:48

We haven't updated the computers in about 5 years--all the money has been going to SmartBoards. 12/12/2006 15:57:56

switzerland has wrapped a glacier near one of their ski resorts in a reflective material to stave off melting 12/12/2006 15:58:06

sorry to hear that mariann 12/12/2006 15:58:12

one of my students is interested possibly for the competition 12/12/2006 15:58:41

hey everyone since we are talking about the gis competition let's go to that for the moment - seize the day if you will 12/12/2006 15:58:45

Try this for data near opheim 12/12/2006 15:58:53

I visited Glacier right after our June get-together. The glaciers are definitely receding 12/12/2006 15:59:36

here's where i'd like you to go, DONT close this chat, minimize it and go
back to the spatial sci site, click on programs, gtec, and then take a look at the GIS competition guidelines see what you think 12/12/2006 15:59:39

 RANDY, was that a local story? 12/12/2006 16:00:47

* Dean quit (timeout) 12/12/2006 16:01:15

 MARIANN: I am not seeing GIS competition under gtec. There are only the links for the two surveys the students took. 12/12/2006 16:01:23

 DEAN: . 12/12/2006 16:01:35

 LISA: mariann - click on GTEC link to get to new page 12/12/2006 16:01:38

 JENNIFER: I just got the newsletter, looks great! 12/12/2006 16:01:37

 RANDY-EVAL: it was carl - can't remember if it was a WA ski area; i'll try to find out 12/12/2006 16:02:25

 MARIANN: Mibad 12/12/2006 16:03:12

 DAVID: Geospatial Competition tab 12/12/2006 16:03:39

 LISA: it's confusing mariann - we'll take off the survey tabs tonight so it's not so confusing 12/12/2006 16:03:47

 TIM: Seems pretty high level, but will see if we can give it a go 12/12/2006 16:03:49

 LISA: we'll put them in a separate box 12/12/2006 16:03:57

 CARL: It looks very straightforward. I think I can even do it. 12/12/2006 16:04:07

 LISA: you will find two items to explore: the gis competition and the entry form 12/12/2006 16:04:43

 LISA: we'd like to know if you think it makes sense, if you see any problems, changes you would like to see, do the dates work for everyone? 12/12/2006 16:05:05

 LISA: thanks tim, any parts seem doable? 12/12/2006 16:05:23

 LISA: glad you like it jennifer 12/12/2006 16:05:35

 * Suz joins My room 12/12/2006 16:05:38

 CARL: One question, once they have saved the map is there any special way to send it.. attachment or something else? 12/12/2006 16:06:22

 JENNIFER: Dean wins 12/12/2006 16:06:23

 LISA: welcome suz 12/12/2006 16:06:53

 SUZ: Thanks! 12/12/2006 16:07:25

 MARIANN: The competition looks good. Would it be possible for me to work on how the snowpack at the headwaters is affecting the level of Fort Peck Lake? 12/12/2006 16:07:29

 JEFF: Hello Sindie I mean Suzie 12/12/2006 16:07:35

 * Dean quit (timeout) 12/12/2006 16:07:34

 LISA: of course marian! 12/12/2006 16:08:33

 SUZ: Hello to you George.. I mean Jeff. 12/12/2006 16:08:34
Mariann: The local snow data that you put up from the weather service is far from accurate. I haven’t seen bare ground since November and right now there is no less than 2 inches of snow on the level here. 12/12/2006 16:09:44
Lisa: we are still working on all the accompanying data sets - these will be shared in a future chat session but if you have specific data you would like to see on the spatial sci site let us know 12/12/2006 16:10:02
Dean: Excellent competition guidelines. 12/12/2006 16:10:10
Lisa: if you look at the gis competition resources you will see a list of resources and a powerpoint that rachel put together 12/12/2006 16:10:13
Lisa: thanks dean 12/12/2006 16:10:44
Carl: what about relationship of snow data to fire duration and intensity? 12/12/2006 16:10:45
* Dean quit (timeout) 12/12/2006 16:10:47
Rachel: For snow data I would stay away from short-term weather station data and look for vetted, longer-term data sets (e.g. NRCS, NCDC). We can help with that. 12/12/2006 16:10:59
Dean: Crazy Timeouts 12/12/2006 16:11:19
Jennifer: do we have data on El Nino years? and does that have anything to do with the bigger global warming picture? 12/12/2006 16:11:36
Lisa: yes, carl, that is definitely one of the data areas we have outlined to collect data for 12/12/2006 16:11:39
Tim: For middle schoolers it might be advantageous for them not to have put together data sets 12/12/2006 16:11:42
* Dean quit (timeout) 12/12/2006 16:11:47
Rachel: All of your ideas for the competition is great - part of the challenge is in incorporating valid data sets and posing (and addressing) interesting questions - so please feel free to run with those. 12/12/2006 16:12:01
Lisa: i completely agree tim - these are still in development 12/12/2006 16:12:09
Rachel: I mean ideas ARE great 12/12/2006 16:12:10
Lisa: which data sets would you most likely use? 12/12/2006 16:12:28
Mariann: Rachel, what sort of data might be available for the mountains near Lewistown? I am thinking that it would be good to relate the climatic changes to the snowpack on those mountains and then relate that to the level of Fort Peck--normalized for release 12/12/2006 16:12:44
Lisa: as we were typing rachel suggested it might help if you submitted 5 copies of your cd's to help with judging would this be a problem for anyone?? 12/12/2006 16:12:47
* Dean quit (timeout) 12/12/2006 16:13:40
Mariann: Not a problem if I can get my kids near a computer before January. I will be glad when term paper deadlines are past. 12/12/2006 16:14:34
Am I correct in that you want the student's work burned on CD's?  
12/12/2006 16:14:58
right carl 12/12/2006 16:15:03
One thing to remember in general is that by definition climate change refers to trends observed over a period of 10 or more years. So, in relating changes in snowpack to climatic changes one would want to integrate data over that period of time. Using shorter-term (i.e. weather) data is possible and interesting, but the questions should be framed in terms of weather variability rather than climate change.  
12/12/2006 16:15:16
* David quit (timeout) 12/12/2006 16:15:18
Mariann, I can talk to Ted Hawn at NRCS to ask him about the data for the mountains near Lewistown. I am from Lewistown and work with Ted on the watershed council.  
12/12/2006 16:15:28
rather than climate change.  
12/12/2006 16:15:43
Jennifer--There is data on the El-Nino years. Actually right up to 2005.  
12/12/2006 16:15:46
Thank you,  
12/12/2006 16:16:04
* Dean quit (timeout) 12/12/2006 16:16:19
Stupid Timeout  
12/12/2006 16:16:28
Ideally each CD would contain folders, and in each folder should be the entire project submission for each student - maps, written components, etc.  
12/12/2006 16:16:28
I would also like to find archived aerial photos of those mountains over as many years as possible.  
12/12/2006 16:16:29
Is there data on river flow rates (yellowstone and missouri)  
12/12/2006 16:16:50
dean you are giving us a bad case of the giggles  
12/12/2006 16:17:13
NOAA should have river flow data. You might have to join it to a map, however.  
12/12/2006 16:17:20
David, USGS river flow is available via the web  
12/12/2006 16:17:38
Mariann - see the USGS and Rocky Mountain Repeat Photography projects (on our web site under Links)  
12/12/2006 16:17:43
sorry...  
12/12/2006 16:18:04
FWP might also have that info. Remember that you will have missing data for most of the winter months in lower-flowing steams due to ice  
12/12/2006 16:18:04
david, as well, if you look in GIS competition resources you will see a pdf file from usepa that talks about the effects of stream flow  
12/12/2006 16:18:16
this might be help with directing, developing student ideas  
12/12/2006 16:18:41
* Dean quit (timeout) 12/12/2006 16:19:10
〈David〉 Can we get a copy of this chat when we are all finished? 12/12/2006 16:19:28
〈Mariann〉 Dean, I can sympathize. with our network problems, it took almost 5 minutes to load one map. 12/12/2006 16:19:38
〈carl〉 I would like that also. 12/12/2006 16:19:41
* Dean quit (timeout) 12/12/2006 16:19:55
〈lisa〉 yes, david, we can put it into a pdf file and put it under GTEC competition resources how about that 12/12/2006 16:20:01
* Suz quit (timeout) 12/12/2006 16:20:10
〈Mariann〉 That would be great. 12/12/2006 16:20:19
〈David〉 Thanks that will work 12/12/2006 16:20:25
〈carl〉 sounds great. 12/12/2006 16:20:54 <
〈Dean〉 I am at the firehall on a regular phone line...Really slow...might have something to do with all of the timeouts.. 12/12/2006 16:21:03
〈lisa〉 no wonder 12/12/2006 16:21:02
〈jennifer〉 if I wanted to do a project relating to farming, how would one peel away all the other variables that effect agriculture 12/12/2006 16:21:16
〈Suz〉 Mariann, were you saying thank you to me? Does that mean you want me to talk to look into the weather variability and snowpack data for the mountains around Lewistown? 12/12/2006 16:22:14
〈rachel〉 Jennifer - you want to isolate weather alone? In terms of agricultural productivity we run models and archive satellite data in my lab that relate to ag production. 12/12/2006 16:22:20
* Dean quit (timeout) 12/12/2006 16:22:26
〈Suz〉 oops, I got an extra word in there. I meant do you want me to look into, not talk to look into. Sorry. 12/12/2006 16:22:59
〈Mariann〉 Suz-- I was saying that would be great to get a copy of the chat. I will try to find the data myself first and yell for help if I run into difficulty. 12/12/2006 16:23:52
〈Mariann〉 Thank you so much for the offer, though. Sometimes I find that if I make the kids do their own looking, it makes them better students. It is frustrating, but they do love it when they can find it before I can. 12/12/2006 16:24:01
* Dean quit (timeout) 12/12/2006 16:24:21
〈Dean〉 Discovery Learning 12/12/2006 16:24:31
〈carl〉 would it be possible for jeff to maybe set up a camtasia example on some snow data for the students to look at? 12/12/2006 16:24:42
〈Mariann〉 Rachel, Do you have any data on fish production? 12/12/2006 16:24:47 〈jennifer〉 good idea carl 12/12/2006 16:24:49
〈lisa〉 hey everyone jeff is putting up a pdf file entitled questions scientists ask about climate change that I think might help direct your thoughts here
Mariann> I can contact FWP for data on Fort Peck 12/12/2006 16:25:21
Lisa> i put it together earlier but wasn't sure if you wanted this much direction it will be at the bottome of competition resources in about one minute 12/12/2006 16:25:45 Lisa> can you all take a look at it to see how it helps how you might guide a discussion with students? 12/12/2006 16:26:19
* Dean quit (timeout) 12/12/2006 16:27:26
Carl> is that pdf file in competition resources? 12/12/2006 16:27:40
Lisa> what i did was take a usepa document that forecast climate change in montana and put it in the form of questions and predictions that scientists are currently working on 12/12/2006 16:27:57
Lisa> yes it is 12/12/2006 16:28:04
* Dean quit (timeout) 12/12/2006 16:28:21
* Mariann quit (timeout) 12/12/2006 16:28:34
Tim> Looks good 12/12/2006 16:28:50
Lisa> so should i incorporate this more into the competition guidelines tim? 12/12/2006 16:29:05
Lisa> rather than as a resource? 12/12/2006 16:30:03
Jeff> Under the competition resources link you will notice I placed a link the chat narrative. Once the chat is over I will convert it to a pdf and place it on the page 12/12/2006 16:30:08
Tim> It seems, (without talking to Mike first), at the seventh grade level they would then need specific data sets that relate to a question 12/12/2006 16:30:33
Lisa> right, that was what i was thinking too, so for each question or prediction on that sheet we would have a related data set 12/12/2006 16:30:38
Lisa> is this what you are thinking too? 12/12/2006 16:30:54
Dean> Lisa, Rachel, Jeff--Tony Ward was using a program called TrakPro to apparently create Trends. Do you know if works around Linear or Exponential? It created a beautiful graph. 12/12/2006 16:30:58
* Dean quit (timeout) 12/12/2006 16:31:30
Tim> Yes 12/12/2006 16:31:39
Mariann> I would probably have to use my 7th and 8th grade class to do the competition because they are working on Earth Science this year. You know how superintendents get when you go off curriculum for a project. i would agree that having some specific data sets at that age would be helpful 12/12/2006 16:31:56
Dean> He used to graph the particulate matter in the air on their pm2.5 research. 12/12/2006 16:32:15
* Dean quit (timeout) 12/12/2006 16:32:13
Lisa> So, from those questions and predictions - which ones are of most interest
for your curriculum, . . 12/12/2006 16:32:39
"carl" my kids are new to mapping even though they are juniors and seniors.. I think having data sets would be beneficial. 12/12/2006 16:32:46
"Tim" I will have to defer that to Mike 12/12/2006 16:33:39
"disa" data sets have always been the plan so you can all be sure to have those by january - just wanted to see which ones were of most interest to all of you so thanks for all the great feedback 12/12/2006 16:33:52
* Dean quit (timeout) 12/12/2006 16:34:04
"carl" I think data pertaining to fire, aquifer levels, skiing, those things that directly effect the students. 12/12/2006 16:34:20
"disa" david, how about for physics, what do you think? 12/12/2006 16:34:43
"David" I like physics. 12/12/2006 16:34:59
* Dean quit (timeout) 12/12/2006 16:35:05
"David" But the data sets noted should be ok 12/12/2006 16:35:19
"disa" 12/12/2006 16:35:26
"Mariann" I would love to have my (one) physics student work on this project. I just need to think of a tie in 12/12/2006 16:35:42
"rachel" David, can you put the GIS in physics? All the letters are already there except for the G. 12/12/2006 16:35:56
* Dean quit (timeout) 12/12/2006 16:36:12
"David" I think it is spelled gPHYSICS. 12/12/2006 16:36:15
"Mariann" Great physIcS 12/12/2006 16:36:37
"rachel" physgics 12/12/2006 16:37:30
"disa" how about dates for the contest - does february as a start and then march 10th as end data look ok? notice the award includes travel to donnelly, idaho - a great ski resort for those that ski 12/12/2006 16:37:36
* Randy-Eval quit (timeout) 12/12/2006 16:38:08
"Tim" sounds good 12/12/2006 16:38:13
"David" The snow pack problem has geophysics, hydophysics, flow physics and other areas I can not spell. 12/12/2006 16:38:16
"Mariann" That is actually a great time frame. Basketball will be over and it will be too cold for track meets 12/12/2006 16:38:30
"carl" looks OK 12/12/2006 16:38:45
"disa" ok, great, we'll keep the time frame then 12/12/2006 16:38:54
"disa" any other questions, concerns, thoughts? 12/12/2006 16:39:21
"rachel" David, how about something on snow water equivalence (SWE) with changes in temperature? 12/12/2006 16:39:54
"David" that sounds interesting is there data? 12/12/2006 16:40:05
"Mariann" What about sublimation rates due to temperature increase? 12/12/2006 16:40:31
Rachael: David, I think so, at SNOTEL sites. Follow that link that was posted before. 12/12/2006 16:40:36
Bill: 12/12/2006 16:40:39
* Dean quit (timeout) 12/12/2006 16:40:54
Lisa: hey everyone, another place we wanted you to check out on the website is a camtasia video Jeff put together 12/12/2006 16:41:01
Lisa: we would like to make a series of these based on your needs 12/12/2006 16:41:35
Lisa: you can find the camtasia video on the spatial sci front page under featured projects 12/12/2006 16:41:47
Lisa: take a look at it - minimize chat again- and see what you think 12/12/2006 16:42:06
Rachael: Everyone, I think this link will provide great food for thought: http://nris.mt.gov/nrcs/snowater.html 12/12/2006 16:42:23
Lisa: Jeff made a specific one for carl and we would love to be able to do the same for others 12/12/2006 16:42:40
Carl: Thanks, Jeff for all of your help on the project. 12/12/2006 16:42:49
* Mariann quit (timeout) 12/12/2006 16:43:05
Lisa: but to know what it is Jeff made one as a demo so you can see the possibilities 12/12/2006 16:43:14
Tim: where is it located, the video vignette does not work 12/12/2006 16:43:36
Lisa: are you on the front page of spatial sci 12/12/2006 16:43:41
Lisa: in the featured programs? 12/12/2006 16:43:45
* Dean quit (timeout) 12/12/2006 16:43:50
Lisa: it's not under video vignettes 12/12/2006 16:44:43
Lisa: if you try and click on spatial sci virtual tour 12/12/2006 16:44:44
Tim: found it, is big 12/12/2006 16:44:47
Lisa: does this help? 12/12/2006 16:44:49
Lisa: it is big 12/12/2006 16:45:05
David: At http://www.spatialsci.com/index.php on the right hand side is the featured project button then click on the image 12/12/2006 16:45:15
* Mariann joins My room 12/12/2006 16:45:21
Lisa: thanks david 12/12/2006 16:45:27
Dean: It would take me 2 days to download it...I will check it out back at school... 12/12/2006 16:45:57
Mariann: I just had a full-on cat-static crash. did I miss anything? 12/12/2006 16:46:01
Jeff: The file is set to stream once it gets to 10 % 12/12/2006 16:46:32
Tim: Jeff's voice is echoing across my house. Practice Jeff 12/12/2006 16:46:34
David: Or dribble for Dean 12/12/2006 16:46:46
Dean: No kidding 12/12/2006 16:46:53
Mariann: I will join Dean in checking it out on DSL. My home connection will barely support loading pictures. 12/12/2006 16:47:23
Rachel: Um...um...ummmmmmm 12/12/2006 16:47:37
Jeff: Hey, it was the best I could do with the compression I used 12/12/2006 16:48:03
Lisa: OK, thanks for trying all. When we finish the synchronous chat know that this option will remain if any of several of you would like to meet online 12/12/2006 16:48:26
Mariann: Thanks 12/12/2006 16:48:35
Lisa: one other highlight to mention is that Rachel put together an amazing powerpoint on climate change 12/12/2006 16:48:52
Lisa: it is way too big to view now but it is set up to be used in your classroom 12/12/2006 16:49:07
Lisa: you can find it under competition resources 12/12/2006 16:49:12
Dean: cool 12/12/2006 16:49:28
Mariann: I will show it to the class using the smartboard 12/12/2006 16:49:31
Carl: I also already have the Brokaw program recorded. 12/12/2006 16:49:52
* Dean quit (timeout) 12/12/2006 16:49:56
Lisa: excellent Carl have you seen inconvenient truth? I'm trying to get free copies for all of us but have not worked that out yet 12/12/2006 16:50:20
Lisa: Mariann, that would be a great idea to use the smart board 12/12/2006 16:50:35
Carl: I have not but would really like to get my hands on a copy! 12/12/2006 16:50:42
Lisa: i'll keep trying 12/12/2006 16:50:44
* Dean quit (timeout) 12/12/2006 16:50:55
* Paul joins My room 12/12/2006 16:51:03
Lisa: paul, welcome!!! 12/12/2006 16:51:19
* David quit (timeout) 12/12/2006 16:51:43
David: I think I am still here! 12/12/2006 16:51:48
* Tim quit (timeout) 12/12/2006 16:52:06
Dean quit (timeout) 12/12/2006 16:52:21
David: But when I stopped the tour I got the message 12/12/2006 16:52:41
* Tim quit (timeout) 12/12/2006 16:53:08
* Tim joins My room 12/12/2006 16:53:48
Dean quit (timeout) 12/12/2006 16:54:35
Lisa: have you seen it Tim - it has a political message so I wonder about your parents a bit given past events 12/12/2006 16:55:19
* Dean quit (timeout) 12/12/2006 16:55:30
* Tim quit (timeout) 12/12/2006 16:55:38
i have not checked mariann - good idea 12/12/2006 16:56:29
* Dean quit (timeout) 12/12/2006 16:57:07
hey everyone, out main goal for the synchronous chat was to reconnect, give you a look at a few new resources, and to get your feedback on the gis competition. We sure do appreciate all your time and effort on this. Are there other questions or concerns that any of you might have? 12/12/2006 16:57:10
There is a free education guide to Inconvenient Truth on this website: http://www.climatecrisis.net/ -that's the official movie website. 12/12/2006 16:57:55
* Bill quit 12/12/2006 16:58:11
Thanks Rachel... 12/12/2006 16:58:43
Hey guys, sorry to be so out of touch... my dial-up and Hardin's wires didn't want to let me join you. 12/12/2006 16:59:11
if not, thanks for joining us. we don't need to stay online unless you have other thoughts. remember that you can always join your colleagues via the synchronous chat as this option will always be on the site now and you have the passwords. you would just need to let others know when you would like to meet 12/12/2006 16:59:25
I just need to get more aggressive when it comes to computer time. that should be interesting since I am already considered somewhat--hmmm -- less than demure 12/12/2006 16:59:27
Paul, minimum requirements for 9.2 are: 2000 or XP, 512 of RAM and 1 GHz processor 12/12/2006 16:59:35
what did you think of the synchronous chat 12/12/2006 16:59:39
* Dean quit (timeout) 12/12/2006 16:59:41
Love it 12/12/2006 16:59:57
if you have a parting thought on it that would be great to know if we can/should continue to use it 12/12/2006 16:59:58
Dean, I have a question, in a notebook computer, is there any great advantage to get a Turion 64X2 over a Centrino solo? 12/12/2006 17:00:09
thanks mariann 12/12/2006 17:00:10
I liked it except for the "Dean quit (timeout)" all the time...lol 12/12/2006 17:00:13
works well if you have good internet access. 12/12/2006 17:00:22
It is actually fun, now I know why my kids like it! 12/12/2006 17:00:31
* Dean quit (timeout) 12/12/2006 17:00:39
Lisa, you can't be wrapping up yet, I just got here! 12/12/2006 17:00:42
Lisa: I don't know Dean, your timeouts provided excellent humor - maybe we should make it a regular event? 12/12/2006 17:00:52

* Mariann quit (timeout) 12/12/2006 17:00:55

Lisa: you can just pop in and out 12/12/2006 17:01:13

Lisa: 12/12/2006 17:01:33

Rachel: 12/12/2006 17:01:39

* Carl quit (timeout) 12/12/2006 17:01:42

Suz: Will the newbies for next summer get to meet the oldies from last summer sometime? 12/12/2006 17:01:50

* Dean quit (timeout) 12/12/2006 17:02:48

Lisa: good question Suz - we're not sure right now b/c we didn't put it into the original grant 12/12/2006 17:02:54

Lisa: it would be nice thought 12/12/2006 17:03:45

Dean: Paul...I have had alot of luck with the Centrino....I do have a dual 64 but it seems to lag a bit when rendering in ArcScene 12/12/2006 17:04:07

Paul: Jeff, any ideas as to when in January you will want to trek to Hardin? 12/12/2006 17:04:43

Dean: No kidding Lisa...the transcription is going to look pretty funny. 12/12/2006 17:05:09

Jeff: Paul, sometime in the first couple weeks 12/12/2006 17:05:52

Jeff: of January that is.. Does one week work better than the other? 12/12/2006 17:06:03

Paul: Dean, thanks. It looks as though I will be trying both. I purchased a dual 64 personally and ordered the same for school, but they purchased the solo centrino instead. Right now I'm just happy to get the machine as I started placing orders in August. 12/12/2006 17:06:28

* Dean quit (timeout) 12/12/2006 17:07:50

Paul: Jeff, there is no difference as far as I can tell...my social-director comes up with the 20th and 21st as dates she wants to be in Bozeman. 12/12/2006 17:08:25

* Dean quit (timeout) 12/12/2006 17:08:46

Jeff: OK, let me look at my calendar and get back to you. 12/12/2006 17:08:50

Lisa: Thanks all for joining us. You can keep chatting as long as you like. The passwords won’t change so chat away today or in future days. Season's best, lisa 12/12/2006 17:08:54

Rachel: Don't forget to show the global warming powerpoint, and please let me know if you have any questions. I'd love to get your feedback as well on how to improve it. Thanks! 12/12/2006 17:09:28

Dean: I can't wait to look at it 12/12/2006 17:09:29

Paul: Rachel where is the global warming powerpoint? 12/12/2006 17:09:42
David: Thanks all - I am signing off 12/12/2006 17:10:03
* Dean quit (timeout) 12/12/2006 17:10:12
* David quit (timeout) 12/12/2006 17:10:33
Dean: Yep, me too.....Training is beginnning....Good kinda seeing you all again... 12/12/2006 17:10:44
Paul: Rachel, I found it. 12/12/2006 17:10:56
rachel: The global warming powerpoint is on the GTEC website, under Geospatial Competition...I was getting there! 12/12/2006 17:11:20
Paul: So are you guys all done chatting? 12/12/2006 17:11:32
Suz: Nice chatting, I am signing off too 12/12/2006 17:11:33
* Dean quit (timeout) 12/12/2006 17:11:38
Tim: I am out - bye 12/12/2006 17:12:01
* Tim quit (timeout) 12/12/2006 17:12:03
* Suz quit (timeout) 12/12/2006 17:12:05
Paul: Thanks for your patience, can we try this again? 12/12/2006 17:12:30
Jennifer: i think it works well 12/12/2006 17:12:37
Lisa: thanks all, i'm sorry paul the next one is january 23rd at 4:30 12/12/2006 17:12:38
Jennifer: and I don't have to miss school 12/12/2006 17:12:43
Lisa: thanks for all your feedback 12/12/2006 17:12:52
Jennifer: see ya the 20th 12/12/2006 17:13:01
Lisa: see yaQ 12/12/2006 17:13:19
Paul: I'll sign off and hope to hear from you guys soon. Paul 12/12/2006 17:13:19
rachel: Jen, I tried to message you a bunch of times but it never went through - let's "talk" via email about ideas for your students. 12/12/2006 17:13:24
* Jennifer quit (timeout) 12/12/2006 17:13:39
* Paul quit (timeout) 12/12/2006 17:14:15
Paul: Stupid question, is there a log off button or just close the window? 12/12/2006 17:14:22
* rachel quit (timeout)
APPENDIX H

SPATIAL LITERACY SKILLS ASSESSMENT
Spatial Skills Test

A
Questionnaire

1. Gender:  □ Male / □ Female

2. Are you geography major?  □ Yes / □ No

3. Have you ever taken a cartography or Geographic Information System (GIS) or map (or aerial photo) reading course?  □ Yes / □ No
DIRECTIONS: Answer question on the basis of the street map below.

1. If you are located at point 1 and travel north one block, then turn west and travel three blocks, and then turn south and travel two blocks, you will be closest to point.

   (A) 2
   (B) 3
   (C) 4
   (D) 5
   (E) 6

2. If you are located at point 1 and travel west one block, then turn left and travel three, then turn west and travel one block, and then turn right and travel four blocks, you will be closest to point.

   (A) 2
   (B) 3
   (C) 4
   (D) 5
   (E) 6
3. If you draw a graph showing change of Texas annual precipitation between A and B, the graph will be .

(A)  (B)  (C)  (D)  (E)
DIRECTIONS: Find the best location for a flood management facility based on the following conditions. First, a possible site for a flood management facility should be within 60 feet of an existing electric line. Second, a possible site for a flood management facility should be located less than 220 feet. And last, a possible site for a flood management facility should be located in State Park or Public Land.

4. Mark √ on the best site (A–E) for the flood management facility on the map above.
5. Imagine that you are standing at location X and looking in the direction of A and B. Among 5 slope profiles (A–E), which profile most closely represents what you would see?

(A)  (B)  (C)  (D)  (E)
DIRECTIONS: Your job is to find maps that have spatial correlations. For example, map (B) and map (D) have positive correlation (similar patterns).

Example
Find a map (A–F) having a strong positive correlation with the map on the left. (Choose closest one).
DIRECTIONS: The following two maps show (A) Acres of corn production and (B) Value of hogs and pigs as percent of total market value of agricultural products sold.

7. If you draw a graph showing the relationship between map (A) and (B), the graph will be [option].

(A)  (B)  (C)  (D)
8. If you look at the area below in the direction of arrow, which terrain view (A~E) most closely represents what you would see?
DIRECTIONS: Solve the following questions based on the example below. Please mark (✓) an answer.

**Example**

9. ( ) A and B  
( ) A or B  
( ) A xor B  
( ) A not B  
( ) B not A

10. A or B

Question #9 and #10 are adapted from Albert and Gollege (1999)
Solve question 11 and 12 based on the following diagram.

11. (not B) and D

12. A and B and C
DIRECTIONS: Real world objects can be represented explicitly by point, line (arc), and area (polygon). Based on the examples below, classify the followings spatial data.

Example

13. Locations of weather stations in Washington County
   (A) Lines
   (B) Area
   (C) Points and Lines
   (D) Points and Area

14. Mississippi River channels and their basins
   (A) Lines
   (B) Area
   (C) Points and Lines
   (D) Lines and Area

15. Shuttle bus route of the Lincoln Elementary School
   (A) Points
   (B) Area
   (C) Points and Lines
   (D) Points and Area

16. Places that can be reached by Franklin County fire engines in 5 minutes or less
   (A) Points
   (B) Lines
   (C) Area
   (D) Points and Lines
Spatial Skills Test

B
Questionnaire

1. Gender:  □ Male / □ Female

2. Are you geography major?  □ Yes / □ No

3. Have you ever taken a cartography or Geographic Information System (GIS) or map (or aerial photo) reading course?   □ Yes / □ No
DIRECTIONS: Answer question on the basis of the street map below.

1. If you are located at point 1 and travel south two blocks, then turn west and travel three blocks, and then turn north and travel one block, you will be closest to point.

   (A) 2  
   (B) 3  
   (C) 4  
   (D) 5  
   (E) 6  

2. If you are located at point 1 and travel west one block, then turn left and travel three, then turn west and travel two blocks, and then turn right and travel two blocks, you will be closest to point.

   (A) 2  
   (B) 3  
   (C) 4  
   (D) 5  
   (E) 6  

© 2005 Association of American Geographers
Direction: The map below shows annual precipitation of Texas.

3. If you draw a graph showing change of Texas annual precipitation between A and B, the graph will be _______.

   ![Map of Texas with precipitation data]

   ![Graph options: A, B, C, D, E]
DIRECTIONS: Find the best location for a flood management facility based on the following conditions. First, a possible site for a flood management facility should be within 60 feet of an existing electric line. Second, a possible site for a flood management facility should be located less than 220 feet. And last, a possible site for a flood management facility should be located in State Park or Public Land.

![Land use](image1.png)
![Elevation (feet)](image2.png)
![60 feet from electronic line](image3.png)
![Potential facility location](image4.png)

4. Mark ✓ on the best site (A–E) for the flood management facility on the map above.
Imagine that you are standing at location X and looking in the direction of A and B. Among 5 slope profiles (A–E), which profile most closely represents what you would see?
DIRECTIONS: Your job is to find maps that have spatial correlations. For example, map (B) and map (D) have positive correlation (similar patterns).

Example
Find a map (A–F) having a strong positive correlation with the map on the left. (Choose closest one).
DIRECTIONS: The following two maps show (A) Acres of corn production and (B) Value of hogs and pigs as percent of total market value of agricultural products sold.

7. If you draw a graph showing the relationship between map (A) and (B), the graph will be ________.
8. If you look at the area below in the direction of arrow, which terrain view (A~E) most closely represents what you would see?
DIRECTIONS: Solve the following questions based on the example below. Please mark (✓) an answer.

Example

9. (✓) A and B
   (✓) A or B
   (✓) A xor B
   (✓) A not B
   (✓) B not A

10. A or B

Question #9 and #10 are adapted from Albert and Gollege (1999)
Solve question 11 and 12 based on the following diagram.

11. (not B) and D

12. A and B and C
DIRECTIONS: Real world objects can be represented explicitly by point, line (arc), and area (polygon). Based on the examples below, classify the following spatial data.

**Example**

13. Locations of weather stations in Washington County
   
   (A) Lines
   (B) Area
   (C) Points and Lines
   (D) Points and Area

14. Mississippi River channels and their basins
   
   (A) Lines
   (B) Area
   (C) Points and Lines
   (D) Lines and Area

15. Shuttle bus route of the Lincoln Elementary School
   
   (A) Points
   (B) Area
   (C) Points and Lines
   (D) Points and Area

16. Places that can be reached by Franklin County fire engines in 5 minutes or less
   
   (A) Points
   (B) Lines
   (C) Area
   (D) Points and Lines
APPENDIX I

SCIENCE AND TECHNOLOGY INTEREST SURVEY
The purpose of this survey is to see what you think about science and technology and what you might do for a career. Your responses on this survey are very important so please take your time and give honest answers.

You don’t have to participate in the survey if you don’t want to. You can choose to answer all, some, or none of the questions. Your teacher will not see your answers but only how the whole class on average answered the questions. We hope that you will answer every question. Your grade in this class will not be affected by this survey.

Be sure to scroll all of the way down the page to see all of the questions. When you are finished click on the Submit Survey button at the bottom of the page. When you see the “Thank You” page you can close your browser. This survey will probably take about 20 minutes. If you have questions about the survey please ask your teacher.

A. Background Information

ID. Please enter the secret Identification Number given to you by your teacher.

ID Number

What is the name of your school?
School Name

What is the last name of the teacher who asked you to take this survey?

Teacher Name

What is the name of the course that you are in now?

Course Name

What grade are you currently in?

☐ 4th
☐ 5th
☐ 6th
☐ 7th
☐ 8th
☐ 9th
☐ 10th
☐ 11th
☐ 12th

What is your age?

Age

Are you a boy or a girl?

☐ Girl
☐ Boy

What is your race?

☐ African American
☐ Asian
Hispanic  
Native American  
Pacific Islander  
White  
Other  
Do not wish to answer

How many years of science do you think you will have taken in high school by the time you graduate?

☐ 1 year  
☐ 2 years  
☐ 3 years  
☐ 4 years

Subject. If you go to college some day what subject do you think you would like to study? (Subjects are things like biology, math, English, foreign language, physics, medicine, architecture, and so on)

Subject

B. What do you think about science and technology?

I think science is exciting.

☐ Disagree Strongly  
☐ Disagree  
☐ No Opinion
I like using the computer to create maps.

I like to use maps to answer questions about people and places.

I like science better than I do most other subjects.
Satellites, GPS devices and remote sensing equipment are cool.

I have a real desire to learn science.

The use of computer maps will be important to me in my job some day.

Science is useful for solving problems in my everyday life.
Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

I like to use maps to explore and gather information about new places.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Learning science will improve my career chances.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

I like to think about how to solve environmental problems.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

I have a good feeling toward science.
Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

I like spending lots of time outdoors.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

I enjoy talking to people about science.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

I am interested in where things are located in the world.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

I like writing about science.
I often wonder how satellites, computers, and other advanced technologies work.

I like to read books, magazines and Web sites about science.

I like to close my eyes and visualize objects in three dimensions.
C. Would you like to do any of these activities in your job someday?

Use maps and databases to plan the best possible uses for our land.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Create new drugs to treat diseases.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Design high tech devices like GPS units and Personal Digital Devices.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Discover cures for diseases like cancer.
Use a GPS device to record the locations of earthquakes and tornados.

Develop methods to detect bio-warfare agents such as anthrax.

Analyze images of the earth taken from satellites.
Agree
Agree Strongly

Design a way to check for food poisons.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Write computer programs to predict where forest fires might occur.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Alter DNA to change the characteristics of plants and animals.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Design a satellite that takes super high-definition pictures of the earth.
Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Devise new ways to use bacteria and other microorganisms.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Work with city planners to help businesses decide where to put their buildings.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Use computers to study the genetic code of living things.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly
Study weather patterns on computer maps to see if climate change is occurring.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Invent substances used to make new products.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Use maps and databases to see where people from different cultures live.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Experiment with new ways to improve foods.

- Disagree Strongly
- Disagree
- No Opinion
Agree
Agree Strongly

Use special cameras to study the surface of the earth in three dimensions.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Use clues from crime scenes to solve murder mysteries.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Work on a team to find out the height of hills and mountains.

Disagree Strongly
Disagree
No Opinion
Agree
Agree Strongly

Perform genetic tests to trace the evolution of plants and animals.
- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Design computer models to explain how the earth has changed over time.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Work with test tubes, pipettes, beakers & other equipment in a laboratory.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly

Develop computer software that creates interactive maps.

- Disagree Strongly
- Disagree
- No Opinion
- Agree
- Agree Strongly
Prepare biological materials for use in research.

☐ Disagree Strongly
☐ Disagree
☐ No Opinion
☐ Agree
☐ Agree Strongly

Teach others how to use mapping programs on the computer.

☐ Disagree Strongly
☐ Disagree
☐ No Opinion
☐ Agree
☐ Agree Strongly

Design and perform biotech experiments in a laboratory.

☐ Disagree Strongly
☐ Disagree
☐ No Opinion
☐ Agree
☐ Agree Strongly

Design roads, rail systems, and other parts of a city.

☐ Disagree Strongly
☐ Disagree
☐ No Opinion
☐ Agree
☐ Agree Strongly
Maintain and troubleshoot equipment used in making products.

☐ Disagree Strongly
☐ Disagree
☐ No Opinion
☐ Agree
☐ Agree Strongly

Use special equipment to collect air samples to see if it is polluted.

☐ Disagree Strongly
☐ Disagree
☐ No Opinion
☐ Agree
☐ Agree Strongly

Collect and analyze water samples to see how healthy streams and lakes are.

☐ Disagree Strongly
☐ Disagree
☐ No Opinion
☐ Agree
☐ Agree Strongly

Study what would happen if dams are removed.

☐ Disagree Strongly
☐ Disagree
☐ No Opinion
Examine pollen under a microscope to see what causes allergies.

Present reports about pollution to those who make decisions about the environment.

Teach people about how to take care of the environment.
APPENDIX J

GEOSPATIAL TECHNOLOGIES COMPETENCIES INDEX
Geospatial Technologies Competencies Index

Q.expertInstr  How would you rate your level of expertise in using geotechnologies in your instruction?

Choice

1. Novice - I can do it but only with a lot of outside assistance and my use is still pretty unsophisticated

2. Advanced Beginner - I have more experience and comfort with it than when I was a beginner, but I still need some help to do it well

3. Competent - If given the time, access to resources, and a detailed plan I can do a pretty good job integrating geotechnologies into my instruction

4. Proficient - I have had lots of experience and success in integrating geotechnologies, but I still feel that I have a lot to learn

5. Expert - I almost don't have to think about it; I recognize potential applications in my instruction and know instinctively how to go about it; People see me as "the" expert

Q.comfortData  How would you rate your level of expertise in locating datasets for use in your instruction?

Choice

1. Novice - If someone gets me to the Web site and gives me step by step instructions I can usually download something useful.

2. Advanced Beginner - If someone gets me to the Web site I can usually download something useful.

3. Competent - I have a list of my favorite sites and can usually find and download something useful.

4. Proficient - After thinking about my instructional goals I know exactly what datasets I need and can find and download what I'm looking for on the Web.

5. Expert - I'm not only proficient at locating datasets but I can adapt them to meet my needs; People see me as "the" expert.
Q.comfortMaking  How would you rate your level of expertise in creating datasets for use in instruction?

Choice

1. Novice - With a lot of assistance I think I could create a really simple dataset.
2. Advanced Beginner - I think I could create a simple dataset with minimal help
3. Competent - Given time, access to resources, and step by step instructions I could create a useful dataset for use in instruction.
4. Proficient - I can find and use data from several different sources and of different types and merge them into a fairly complex dataset.
5. Expert - I have created at least one dataset that is now available on the Web; People see me as "the" expert.

Q.arcview  How would you rate your level of expertise in the use of ArcGIS?

Choice

1. Novice
2. Advanced Beginner
3. Competent
4. Proficient
5. Expert
APPENDIX K

TEACHER 1 SAMPLE CURRICULUM
Introductory GIS

[Climate and stream flow]

Lesson Overview

This lesson will introduce students to basic GIS using the GIS workbook for Arcview 9 and the Montana climate module. Students will then use data from local sources to compare and determine whether or not those measurements are consistent with the climate module.

Estimated Time

Approximately 10-45 minute periods would be needed for this activity.

Materials

- GIS tutorial for Arcview 9
- Student handouts to be copied:
- Geodatabase design and construction-climate module
- Map of Clarkfork watershed
- Student answer sheet
- Rubric for assessment
### National Standards of Your Choice

<table>
<thead>
<tr>
<th>Standard</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science as inquiry</td>
<td>Type definition of this standard for MS</td>
<td>Students gather, analyze, and interpret geodatabases</td>
</tr>
<tr>
<td>Science in personal and social perspectives</td>
<td>Type definition of this standard for MS</td>
<td>Students examine environmental changes occurring in their state and make predictions about future temperature fluctuations in the earth system.</td>
</tr>
<tr>
<td>Practice Spatial Thinking in an Informed Way</td>
<td>Type definition of this standard for MS</td>
<td>Students create GIS-generated surface maps using geodatabases developed by practicing scientists to describe and predict long-term climate trends</td>
</tr>
</tbody>
</table>

### National Geography Standards

<table>
<thead>
<tr>
<th>Geography Standard</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to Use Maps and Other Geographic Representations, Tools, and Technologies to Acquire, Process, and Report Information From</td>
<td>Type definition of this standard for MS</td>
<td>Use Arcview to analyze data for Montana</td>
</tr>
</tbody>
</table>
### a Spatial Perspective

<table>
<thead>
<tr>
<th>How to Use Mental Maps to Organize Information About People, Places, and Environments in a Spatial Context</th>
<th>Type definition of this standard for MS</th>
<th>Use the technology to receive information from many sources to analyze.</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to Analyze the Spatial Organization of People, Places, and Environments on Earth’s Surface</td>
<td>Type definition of this standard for MS</td>
<td>Look at data from climate models, statewide and local to determine what trends are occurring in climate.</td>
</tr>
</tbody>
</table>

### National Technology Foundation Standards

<table>
<thead>
<tr>
<th>Technology Standard</th>
<th>Middle School</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students are proficient in the use of technology</td>
<td>Type definition of this standard for MS</td>
<td>Students use technology to locate, evaluate, and collect information from a variety of sources.</td>
</tr>
<tr>
<td>Students practice responsible use of technology systems, information, and software.</td>
<td>Type definition of this standard for MS</td>
<td>Students use technology tools to enhance learning, increase productivity, and promote creativity</td>
</tr>
<tr>
<td>Students evaluate and select new information resources and technological</td>
<td>Type definition of this standard for MS</td>
<td>Students use a variety of media and formats to communicate information and ideas</td>
</tr>
<tr>
<td>Innovations based on the appropriateness to specific tasks.</td>
<td>Effectively to multiple audiences.</td>
<td></td>
</tr>
</tbody>
</table>

**Objectives**

The student is able to:

- [Determine a quantifiable objective]
- [Access a geodatabase to gain information]
- [Draw meaningful conclusions based upon the information]
- [Opening Arcmap and getting a new template]
- [Searching databases and finding information to use]
- [Converting the data to the correct format]]
- [Pulling the data into the Arcmap program]
- [Using extensions to convert the program if needed]

**GIS Skills & Tools**

1. **Systematically locate and gather geographic information from a variety of primary and secondary sources, as exemplified by being able to**
   - Gather data in the field by multiple procedures - observing, identifying, naming, describing, organizing, sketching,
interviewing, recording, measuring

- Gather data in the classroom and library from maps, photographs, videos, and other media (e.g., CD-ROM), charts, aerial photographs, and other non-book sources, and then use the data to identify, name, describe, organize, sketch, measure, and evaluate items of geographic interest
- Gather data by spatial sampling in both secondary sources and the field (e.g., place a transparent grid of squares on maps to count whether two characteristics - such as corn production and hogs - that are hypothesized to be spatially related do coexist within the grid cells)
- Use quantitative measures (e.g., means, medians, and modes) to describe data (e.g., collect data on social and economic indicators for different nations of the world, conduct simple statistical analysis, and group nations as above or below the average)

2. **Systematically assess the value and use of geographic information, as exemplified by being able to**
   - Contrast the validity and utility of migration data gathered from the field (e.g., a survey) and from secondary sources (e.g., the Census)

Teacher Notes

Lesson Introduction

[The students in environmental science often wonder why getting our stream data is so important. The class will look at some Lynch creek data that previous classes had generated. They will find out how difficult it is to draw conclusions based upon raw numbers. They will then look at a correlation developed by Arcview to see how powerful the program can be. An introductory tutorial will be used to help students practice the Arcview program.]

Student Activity

*Before completing this lesson with students, we recommend that you complete it as well. Doing so will allow you to modify the activity to accommodate the specific needs of your students.*
[The students will work in teams produced by the water monitoring activity on Lynch Creek. They will take the data measured and try to determine the validity of the data. They will then look at the teacher generated map to see if a correlation could be drawn.]

[In lesson one students will learn basic Arcview from the GIS tutorial on Arcview 9. Students will then analyze data accumulated from water monitoring and applied to the STORET database. They will then use the Arcview program to analyze the data obtained from Clarkfork study in Plains. In lesson two students will build the geodatabase of temperature and precipitation using climate data for Montana from the archive from the Center for the Study of Carbon Dioxide and Global Change. In lessons three and four students will use the database to build layers from the model and analyze the trends that are occurring. In lesson five the students will add layers specifically from the Clarkfork river and analyze to see if the trends from the river correlate with the module.]

The investigation sheets include questions to help students focus on key concepts. Some questions will have specific answers: others require creative thought.

Things to look for while the students are working on this activity:

- Are the students using a variety of tools?
- Are the students answering the questions as they work through the procedure?
- Are the students beginning to ask their own questions of the data they are observing
- [Are the students engaged in the analysis or spending more time trying to use the program?]

Conclusion

[The ultimate goal of the activity is to help students realize that data is important and to determine if the local measurements agree with the climate module. Last but not least what trends are they seeing? Is global warming occurring?]

Assessment

*High School: Highlights skills appropriate to grades 9 through 12*

The assessment will be obtained through the use of a rubric that observes how well
the student uses the technology. The rubric will be introduced to the students prior to
the activity and each student will work with a partner on the computers designated
for Arcview training. Each group will be expected to find usable data for building
maps, use Arcview to build the maps, use the climate module to build a geodatabase
and use local data and information to use Arcview to draw correlations about that
local data. If they are comfortable with the program they can begin to build
databases with the local data.

- GIS tutorial-workbook for Arcview 9

Web Links
- http://spatialsci.com
- http://nris.mt.gov/
- The Teachers’ Guide to High Quality Educational Materials on Climate Change
- International Research Institute for Climate Prediction http://iri.columbia.edu/
- Intergovernmental Panel on Climate Change http://www.ipcc.ch/
- United States Environmental Protection Agency Global Warming Site
  http://www.epa.gov/globalwarming/kids/ and
  http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html
- United States Geological Survey/Global Change Research
  http://geochange.er.usgs.gov/
- National Snow and Ice Data Center http://www.nside.colorado.edu/
- National Oceanic and Atmospheric Administration http://www.noaa.gov/
- NASA’S Global Hydrology and Climate Center
  http://www.ghcc.msfc.nasa.gov/
- Center for Ocean-Atmosphere Predication Studies http://www.coaps.fsu.edu/
- NASA’S Visible Earth/Atmosphere
- PEW Center on Global Climate Change http://www.pewclimate.org/
• Union of Concerned Scientists: http://www.climatehotmap.org/index.html

Bibliography


Wilpen L. Gorr and Kristen S. Kurland, GIS Tutorial (ESRI press, Redlands, California) 2005


APPENDIX L

SAMPLES OF STUDENT PROJECTS
Sample – Student Group #1

The map that our group has created represents what we predict will happen in Montana in 2050. Temperatures are rising due to global climate change and we can see these changes already occurring from 1950 to 2000. Respectively this affects how we are having longer, drier summers, leading to harsher fire seasons.

The data that our map consists of are temperature averages, precipitation values and forest fire square acreage. When making our map we used the hyper-linking tool to add pictures to various sites on the map to give the viewers actual photo images to look at. We also used the attributes tables and the layer properties, especially the symbology tab, used to show the 1950, 2000, and 2050 projected temperatures. Within the symbology tab we used several different tools. We were able to color coordinate the projected temperatures and years, as well as graduate the shapes which showed the difference in temperature around Montana.

From this we can predict that the future for Montana will be hotter and drier than we have seen in the past. Fire seasons will be longer and harsher due to the increased temperatures and less precipitation. The question now is what can we do to ensure the safety of our communities. Environmentally we will have to be so much more careful than we are today. Logging and forest operations will have to be more heavily watched. Local community members will have to take charge and recognize the changes in the environment, using BMP’s on personal property as well as public. Farmers can watch how much they irrigate and when they do it. Watching the water levels will be very
important when in a time of drought.
Bibliography

Fire History Region 1 (1985-2005)
www.spatialsci.com

MT Climate Trends
www.spatialsci.com

MT Annual Precipitation
www.spatialsci.com
Outline of climate changes affecting your community

We live in an agricultural community so the dryness and the shifting weather makes it hard on our local farmers/ranchers to thrive uniformly. The level of humidity isn’t that important as long as it stays at a reasonable level. Say for crop farmers, they have means of irrigation for their crops, while there may be health problems for ranchers that have cattle. We’re dumping too much CO2 into the atmosphere by the use of cars and other machines that are ran by fossil fuels.

Community Solutions

There are several things we can do to improve the condition of our atmosphere. We could all use florescent sources of light. We could use different sources of solar energy for things like heat, lighting, and powering appliances. We could incorporate the use of different, more environment friendly fuels, and carpool rides to work and other places.

Description on how spatial data helped

The spatial data allowed us to create a map on ‘Arcmap’. The map helped us visually tell what the climate is like in montana, and what it might be like in 2050. Arcmap is a program that allowes you to plot data on a map, which allows you to see the changes, and the current conditions. The solutions are simple, but will not be easy. People will need to use less fossil fuels.
Sample – Student Group #3

**SpatialSci Map Project**

What we show on these maps is that global warming is having an affect on what we feel temperature-wise over a period of years, and how this affects our weather. The smallest circles contained in the two outer-circles represent the temperature or precipitation in 1950, respectively. The middle circle represents the temperature or precipitation in 2000. From the given information, we are able to estimate the changes we will see in the year 2050.

**Research Findings and Map-related Criteria**

Overall, we see most of the places get warmer and lose precipitation, but there are a few exceptions to this rule.

For the temperature map: The green circles (green being the coolest temperature) tend to be more in the middle (showing the coolest temperatures in 1950). The orange or red circles tend to be on the outer and middle circles (showing the temperature increasing as time passes). This shows a positive correlation between time passing and temperature increasing. It also shows the heat levels from eastern Montana creeping into western Montana. We predict that the central areas of eastern Montana will begin to look like western Montana by the year 2050. This affects our community, as we are in western Montana.
For the precipitation map: Blue shows the most precipitation, red in the middle, and the dry orange-yellow shows the most arid areas. For most circles, the coloration goes red, then yellow as time passes. In conjunction with the temperature map, it shows temperature increasing as time passes, and precipitation decreasing. This is good evidence for global warming, and our theory about eastern Montana (mentioned above).

Possible Solutions

Everyone can lessen the consequences that global warming has on our earth, but it will take many years before we are able to halt it completely. We can speed this process by changing our light bulbs to halogen, and making sure to turn off the lights when we aren’t in a room. This will decrease the amount of carbon dioxide released into our atmosphere. Small things like this have a great impact. Instead of running your own gas guzzling car, you could try carpooling, biking, or walking. If more people did this, it would greatly improve the condition of our environment. Another thing on the rise is the use of biofuels. Within a decade, biofuel use should increase by as much as twenty percent. This will help with the car problem, and the overall environment.
Temperature Trends
1950-2050

Precipitation Trends
1950-2050
Bibliography


MT_state.zip
89.57 KB

Climate.zip
11.97 KB
Sample – Student Group #4

Montana Precipitation and Climate, and How it Determines the Fire Season

Our map shows that Montana’s increasing temperature and the decreasing precipitation will cause the fire rate to increase dangerously. The information shown on our map will tell you that over the years Montana have increased in fires as global warming have increased temperature and decreased annual precipitation. In the areas where the temperature has stayed the same or decreased, the precipitation did not change very much. These are the areas where little to no fires have occurred. In the areas where temperature has increase in general, there is less precipitation, which increases the fire danger. The larger fires occurred where little to no precipitation was present. However, there were some fires that did occur in highly precipitated areas. These fires had little or no effect on the environment because the area was generally moist and the fire could not spread.

If we as Montanans could stop polluting the air by using fossil fuels and pesticides and such that contribute to Global Warming than we could help restore our atmosphere then we would be able to keep fire danger down to a minimum.
Montana Precipitation and Climate, and How it Determines the Fire Season

Bibliography

www.spatialsci.com

Climate trends

Fire 2000

MT_annual_precip

MT_fires_2003

ab41
GIS Project Conclusions

The impacts of global warming are becoming more prominent each decade. Since 1950, some serious signs of global warming have become evident. Locally, we have seen dryer summers, milder winters, more intense fire seasons, and less snow pack. If this trend continues at the current rate it will cause major repercussions in the future.

The diminishing snow pack could hit hard on the winter recreation industry in Montana. Several towns in Montana rely on the ski industry to bring business into the town. If ski hills don’t get enough snow, the towns in the surrounding area may lose business, thus unemployment rates will go up. As the weather warms the snow line will rise. If the ski resorts are not at a higher elevations this could devastate the skiing industry.

Our map gave us a visual of the precipitation levels that we should expect in the future. We can now predict what may happen to our local ski industry. Our map could be used when deciding where to establish future ski resorts, because you can consider projected precipitation patterns.

We need to take the initiative to clean up our environment and lessen our impacts on Earth. By making tougher restrictions on carbon dioxide and other green house gasses, we can try to slow of even reverse the effects global warming.

Our community will be affected in a different way. Less snow pack means less runoff in the spring for growing crops. If our soils are dry the farmers in the area will not be able to grow a large quantity or quality of crops without irrigation.

What will happen when there is no snow pack?
**Geospatial tools that we used to build our map:

Hyperlinking
add data
changed attributes
Layer properties(symbology tools, graduated colors)

**Sources we used to build our map:

Spatialsci data, demography, Physical science, Precip, precip points,

http://www.wintermt.com/dhski.htm

MARCH SNOW LEVEL AT SNOWBOWL
2005 vs. 2055
Lolo Peak
Lookout Pass Ski Area
Whitefish
Blacktail Mountain
APPENDIX M

TEACHER 5 SAMPLE CURRICULUM
Using GIS to Solving Physics problems

Summer 2006 GIS – Science Goes Spatial

Purpose:

To enable students to develop skills in using GIS (geographical information systems) using physics concepts.

Objectives/standards

Use Google Earth, Topographical maps and GPS unit to get latitude, longitude and elevation and then use Helmert’s equation to determine “g” at your house.

Use Google Moon to apply the concept of scale to solve distance problems.

Use Google Mars to apply physics concepts to solve kinematics problems.

Use Google Earth to apply the concept of density in finding the mass of material removed from the Barringer Meteorite crater from the meteorite impact.

Materials needed:

Access to internet for Google Earth, Google Moon and Google Mars, the appropriate topographical maps and a GPS unit

Procedure/Method:

RECORD all observations.

Part A: Using Topographical maps, Google Earth and a GPS to find g

1. Launch Google Earth (down loaded from http://earth.google.com)

2. Navigate to your house and record your latitude, longitude and elevation.

3. Navigate to the University you plan on attending and record latitude, longitude and elevation.
4. Use Helmert’s equation to determine “g” at your house. Use as the latitude and \( H \) the elevation in meters then the acceleration of gravity in SI units is

\[
g = 9.80616 - 0.025928 \cos(2\theta) + 0.000069 \cos^2(\theta) - \left(3.086 \times 10^{-4}\right)H
\]

or

\[
g (\text{m/s}^2) = 9.780356 \times (1 + 0.0052885 \sin^2 \theta - 0.0000059 \sin^2 2\theta) - 0.003086 \times H
\]

From CRC Handbook of Chemistry and Physics Student Edition

5. Using the Topo for your area find your house location and your school location then determine the latitude, longitude and elevation for each.

6a. Turn on the GPS unit outside and determine the latitude, longitude and elevation for the school.

For a Garmin GPS-12 press the red light-bulb until the receiver turns on. After a self test, the position page should appear. If it does not, scroll to the position page using the PAGE button.

6b. Record the latitude, longitude and altitude information

6c. To turn off the Garmin GPS-12 unit, press and hold the light-bulb button for 3 seconds.

7. Using Google Earth look at many of the available layers and explore NASA Blue-marble

**Part B: Using Google Moon and determining scale**

With Google Moon, [http://moon.google.com/](http://moon.google.com/), find the distance between the Apollo 15 landing site and the Apollo 17 landing site. There is no scale given so you will needed to determine the name of the largest crater in the image on Google Moon and then use that and the Lunar Designations and Positions map to determine a scale on the Google Moon images. Then make appropriate measurements to estimate the volume of matter kicked
out of the crater and suggest a way to determine the size of meteor that made the crater. Record and show your work.

**Part C: Using Google Mars**

1. With Google Mars, [http://www.google.com/mars/](http://www.google.com/mars/), look at the main features and determine the name of the largest volume, then determine the volume of this volcano in the image.

2. Standing at the top of the volcano you shoot a paintball with muzzle velocity of 90 m/s toward the horizon. Noting that on Mars there is little or no air resistance, where will the paintball splatter?

**Part D: Using Google Earth estimate mass of “dirt” removed from Barringer Crater**

1. Launch Google Earth and locate the Barringer Crater in Arizona. Then determine the approximate geometric shape of the crater.

2. Determine the approximate diameter and depth of the crater. Record both your measurement and the method used to make the measurements.

3. Using the above information calculate the volume of material removed from the crater hitting the Arizona plains.

4. Using the internet determine the most likely material the plains of Arizona are made out of and using the density of that material, determine the mass of the material blown out of the crater by the meteorite.
APPENDIX N

SCIENCE AND TECHNOLOGY INTEREST SURVEY SCORES FOR TEACHER 1 AND TEACHER 5
<table>
<thead>
<tr>
<th>Question</th>
<th>Teacher 1</th>
<th></th>
<th></th>
<th></th>
<th>Teacher 2</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>Percent</td>
<td>Dif</td>
<td>Percent</td>
<td>Percent</td>
<td>Diff</td>
<td>Diff</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>1</td>
<td>61%</td>
<td>56%</td>
<td>-6%</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>73%</td>
<td>36%</td>
<td>-36%</td>
<td>2</td>
<td>28%</td>
<td>22%</td>
<td>-6%</td>
<td>-36%</td>
</tr>
<tr>
<td>3</td>
<td>64%</td>
<td>55%</td>
<td>-9%</td>
<td>3</td>
<td>56%</td>
<td>44%</td>
<td>-11%</td>
<td>-9%</td>
</tr>
<tr>
<td>4</td>
<td>18%</td>
<td>18%</td>
<td>0%</td>
<td>4</td>
<td>22%</td>
<td>39%</td>
<td>17%</td>
<td>0%</td>
</tr>
<tr>
<td>5</td>
<td>64%</td>
<td>55%</td>
<td>-9%</td>
<td>5</td>
<td>50%</td>
<td>33%</td>
<td>-17%</td>
<td>-9%</td>
</tr>
<tr>
<td>6</td>
<td>73%</td>
<td>64%</td>
<td>-9%</td>
<td>6</td>
<td>44%</td>
<td>67%</td>
<td>22%</td>
<td>-9%</td>
</tr>
<tr>
<td>7</td>
<td>64%</td>
<td>64%</td>
<td>0%</td>
<td>7</td>
<td>50%</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>8</td>
<td>27%</td>
<td>45%</td>
<td>-18%</td>
<td>8</td>
<td>61%</td>
<td>44%</td>
<td>-17%</td>
<td>-18%</td>
</tr>
<tr>
<td>9</td>
<td>64%</td>
<td>64%</td>
<td>0%</td>
<td>9</td>
<td>72%</td>
<td>56%</td>
<td>-17%</td>
<td>0%</td>
</tr>
<tr>
<td>10</td>
<td>45%</td>
<td>18%</td>
<td>-27%</td>
<td>10</td>
<td>28%</td>
<td>28%</td>
<td>0%</td>
<td>-27%</td>
</tr>
<tr>
<td>11</td>
<td>82%</td>
<td>64%</td>
<td>-18%</td>
<td>11</td>
<td>89%</td>
<td>72%</td>
<td>-17%</td>
<td>-18%</td>
</tr>
<tr>
<td>12</td>
<td>73%</td>
<td>45%</td>
<td>-27%</td>
<td>12</td>
<td>50%</td>
<td>17%</td>
<td>-33%</td>
<td>-27%</td>
</tr>
<tr>
<td>13</td>
<td>91%</td>
<td>82%</td>
<td>-9%</td>
<td>13</td>
<td>61%</td>
<td>56%</td>
<td>-6%</td>
<td>-9%</td>
</tr>
<tr>
<td>14</td>
<td>91%</td>
<td>82%</td>
<td>-9%</td>
<td>14</td>
<td>78%</td>
<td>78%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>15</td>
<td>55%</td>
<td>45%</td>
<td>-9%</td>
<td>15</td>
<td>11%</td>
<td>11%</td>
<td>0%</td>
<td>-9%</td>
</tr>
<tr>
<td>16</td>
<td>100%</td>
<td>73%</td>
<td>-27%</td>
<td>16</td>
<td>44%</td>
<td>56%</td>
<td>11%</td>
<td>-27%</td>
</tr>
<tr>
<td>17</td>
<td>18%</td>
<td>27%</td>
<td>-9%</td>
<td>17</td>
<td>6%</td>
<td>6%</td>
<td>0%</td>
<td>9%</td>
</tr>
<tr>
<td>18</td>
<td>82%</td>
<td>36%</td>
<td>-45%</td>
<td>18</td>
<td>78%</td>
<td>72%</td>
<td>-6%</td>
<td>-45%</td>
</tr>
<tr>
<td>19</td>
<td>45%</td>
<td>27%</td>
<td>-18%</td>
<td>19</td>
<td>22%</td>
<td>11%</td>
<td>-11%</td>
<td>-18%</td>
</tr>
<tr>
<td>20</td>
<td>45%</td>
<td>36%</td>
<td>-9%</td>
<td>20</td>
<td>22%</td>
<td>33%</td>
<td>11%</td>
<td>-9%</td>
</tr>
<tr>
<td>21</td>
<td>27%</td>
<td>27%</td>
<td>0%</td>
<td>21</td>
<td>11%</td>
<td>39%</td>
<td>28%</td>
<td>0%</td>
</tr>
<tr>
<td>22</td>
<td>27%</td>
<td>18%</td>
<td>-9%</td>
<td>22</td>
<td>61%</td>
<td>56%</td>
<td>-6%</td>
<td>-9%</td>
</tr>
<tr>
<td>23</td>
<td>45%</td>
<td>36%</td>
<td>-9%</td>
<td>23</td>
<td>28%</td>
<td>39%</td>
<td>11%</td>
<td>-9%</td>
</tr>
<tr>
<td>24</td>
<td>36%</td>
<td>36%</td>
<td>0%</td>
<td>24</td>
<td>61%</td>
<td>50%</td>
<td>-11%</td>
<td>0%</td>
</tr>
<tr>
<td>25</td>
<td>55%</td>
<td>18%</td>
<td>-36%</td>
<td>25</td>
<td>17%</td>
<td>50%</td>
<td>33%</td>
<td>-36%</td>
</tr>
<tr>
<td>26</td>
<td>45%</td>
<td>27%</td>
<td>-18%</td>
<td>26</td>
<td>39%</td>
<td>33%</td>
<td>-6%</td>
<td>-18%</td>
</tr>
<tr>
<td>27</td>
<td>55%</td>
<td>9%</td>
<td>-45%</td>
<td>27</td>
<td>11%</td>
<td>39%</td>
<td>28%</td>
<td>-45%</td>
</tr>
<tr>
<td>28</td>
<td>27%</td>
<td>36%</td>
<td>-9%</td>
<td>28</td>
<td>22%</td>
<td>22%</td>
<td>0%</td>
<td>9%</td>
</tr>
<tr>
<td>29</td>
<td>55%</td>
<td>36%</td>
<td>-18%</td>
<td>29</td>
<td>11%</td>
<td>33%</td>
<td>22%</td>
<td>-18%</td>
</tr>
<tr>
<td>30</td>
<td>73%</td>
<td>45%</td>
<td>-27%</td>
<td>30</td>
<td>39%</td>
<td>39%</td>
<td>0%</td>
<td>-27%</td>
</tr>
<tr>
<td>31</td>
<td>55%</td>
<td>36%</td>
<td>-18%</td>
<td>31</td>
<td>33%</td>
<td>33%</td>
<td>0%</td>
<td>-18%</td>
</tr>
<tr>
<td>32</td>
<td>36%</td>
<td>55%</td>
<td>18%</td>
<td>32</td>
<td>28%</td>
<td>28%</td>
<td>0%</td>
<td>18%</td>
</tr>
<tr>
<td>33</td>
<td>45%</td>
<td>9%</td>
<td>-36%</td>
<td>33</td>
<td>50%</td>
<td>44%</td>
<td>-6%</td>
<td>-36%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>34</td>
<td>36%</td>
<td>27%</td>
<td>-9%</td>
<td>34</td>
<td>17%</td>
<td>28%</td>
<td>11%</td>
<td>-9%</td>
</tr>
<tr>
<td>35</td>
<td>45%</td>
<td>45%</td>
<td>0%</td>
<td>35</td>
<td>6%</td>
<td>22%</td>
<td>17%</td>
<td>0%</td>
</tr>
<tr>
<td>36</td>
<td>55%</td>
<td>27%</td>
<td>-27%</td>
<td>36</td>
<td>50%</td>
<td>56%</td>
<td>6%</td>
<td>-27%</td>
</tr>
<tr>
<td>37</td>
<td>45%</td>
<td>45%</td>
<td>0%</td>
<td>37</td>
<td>6%</td>
<td>39%</td>
<td>33%</td>
<td>0%</td>
</tr>
<tr>
<td>38</td>
<td>55%</td>
<td>27%</td>
<td>-27%</td>
<td>38</td>
<td>39%</td>
<td>44%</td>
<td>6%</td>
<td>-27%</td>
</tr>
<tr>
<td>39</td>
<td>55%</td>
<td>36%</td>
<td>-18%</td>
<td>39</td>
<td>33%</td>
<td>44%</td>
<td>11%</td>
<td>-18%</td>
</tr>
<tr>
<td>40</td>
<td>73%</td>
<td>64%</td>
<td>-9%</td>
<td>40</td>
<td>67%</td>
<td>67%</td>
<td>0%</td>
<td>-9%</td>
</tr>
<tr>
<td>41</td>
<td>9%</td>
<td>27%</td>
<td>18%</td>
<td>41</td>
<td>0%</td>
<td>22%</td>
<td>22%</td>
<td>18%</td>
</tr>
<tr>
<td>42</td>
<td>27%</td>
<td>36%</td>
<td>-9%</td>
<td>42</td>
<td>17%</td>
<td>28%</td>
<td>11%</td>
<td>9%</td>
</tr>
<tr>
<td>43</td>
<td>55%</td>
<td>36%</td>
<td>-18%</td>
<td>43</td>
<td>22%</td>
<td>22%</td>
<td>0%</td>
<td>-18%</td>
</tr>
<tr>
<td>44</td>
<td>18%</td>
<td>36%</td>
<td>18%</td>
<td>44</td>
<td>28%</td>
<td>50%</td>
<td>22%</td>
<td>18%</td>
</tr>
<tr>
<td>45</td>
<td>45%</td>
<td>0%</td>
<td>-45%</td>
<td>45</td>
<td>17%</td>
<td>33%</td>
<td>17%</td>
<td>-45%</td>
</tr>
<tr>
<td>46</td>
<td>36%</td>
<td>27%</td>
<td>-9%</td>
<td>46</td>
<td>17%</td>
<td>22%</td>
<td>6%</td>
<td>-9%</td>
</tr>
<tr>
<td>47</td>
<td>27%</td>
<td>0%</td>
<td>-27%</td>
<td>47</td>
<td>17%</td>
<td>22%</td>
<td>6%</td>
<td>-27%</td>
</tr>
<tr>
<td>48</td>
<td>55%</td>
<td>45%</td>
<td>-9%</td>
<td>48</td>
<td>17%</td>
<td>17%</td>
<td>0%</td>
<td>-9%</td>
</tr>
<tr>
<td>49</td>
<td>27%</td>
<td>18%</td>
<td>-9%</td>
<td>49</td>
<td>44%</td>
<td>50%</td>
<td>6%</td>
<td>-9%</td>
</tr>
<tr>
<td>50</td>
<td>27%</td>
<td>18%</td>
<td>-9%</td>
<td>50</td>
<td>17%</td>
<td>28%</td>
<td>11%</td>
<td>-9%</td>
</tr>
<tr>
<td>51</td>
<td>18%</td>
<td>9%</td>
<td>-9%</td>
<td>51</td>
<td>0%</td>
<td>28%</td>
<td>28%</td>
<td>-9%</td>
</tr>
<tr>
<td>52</td>
<td>55%</td>
<td>45%</td>
<td>-9%</td>
<td>52</td>
<td>17%</td>
<td>28%</td>
<td>11%</td>
<td>-9%</td>
</tr>
<tr>
<td>53</td>
<td>55%</td>
<td>27%</td>
<td>-27%</td>
<td>53</td>
<td>33%</td>
<td>44%</td>
<td>11%</td>
<td>-27%</td>
</tr>
<tr>
<td>54</td>
<td>18%</td>
<td>18%</td>
<td>0%</td>
<td>54</td>
<td>28%</td>
<td>28%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>55</td>
<td>45%</td>
<td>36%</td>
<td>-9%</td>
<td>55</td>
<td>0%</td>
<td>17%</td>
<td>17%</td>
<td>-9%</td>
</tr>
<tr>
<td>56</td>
<td>91%</td>
<td>73%</td>
<td>-18%</td>
<td>56</td>
<td>17%</td>
<td>28%</td>
<td>11%</td>
<td>-18%</td>
</tr>
</tbody>
</table>