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Learning transfer of geospatial technologies in secondary science and mathematics core areas

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LEARNING TRANSFER OF GEOSPATIAL TECHNOLOGIES IN SECONDARY SCIENCE AND MATHEMATICS CORE AREAS

An Abstract of a Dissertation

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

Approved:

Dr. Radhi Al-Mabuk, Committee Chair

Dr. Michael Licari, Dean of the Graduate College

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ABSTRACT

The purpose of this study was to investigate the transfer of geospatial technology knowledge and skill presented in a social sciences course context to other core areas of the curriculum. Specifically, this study explored the transfer of geospatial technology knowledge and skill to the STEM-related core areas of science and mathematics among ninth-grade students. Haskell's (2001) research on "levels of transfer" provided the theoretical framework for this study, which sought to demonstrate the experimental group's higher ability to transfer geospatial skills, higher mean assignment scores, higher post-test scores, higher geospatial skill application and deeper levels of transfer application than the control group. The participants of the study consisted of thirty ninth-graders enrolled in U.S. History, Earth Science and Integrated Mathematics 1 courses. The primary investigator of this study had no previous classroom experiences with this group of students. The participants who were enrolled in the school's existing two-section class configuration were assigned to experimental and control groups. The experimental group had ready access to Macintosh MacBook laptop computers, and the control group had ready access to Macintosh iPads. All participants in U.S. History received instruction with and were required to use ArcGIS Explorer Online during a Westward Expansion project. All participants were given the ArcGIS Explorer Online content assessment following the completion of the U.S. History project. Once the project in U.S. History was completed, Earth Science and Integrated Mathematics 1 began units of instruction beginning with a multiple-choice content pre-test created by the classroom teachers. Experimental

participants received instruction with ArcGIS Explorer Online and were required to use ArcGIS Explorer Online with the class project. Control group participants received the same unit of instruction without the use or influence of ArcGIS Explorer Online. At the end of the Earth Science and Integrated Math 1 units, the same multiple-choice test was administered as the content post-test. Following the completion of Earth Science and Integrated Math 1 post-tests, both the experimental and control groups were given geospatial technologies questionnaires. The experimental group's questionnaire asked participants how they used points, the measure tool, and base maps of ArcGIS Explorer Online, while the control group's questionnaire asked participants how they could have used points, the measure tool, and base maps of ArcGIS Explorer Online. The ordinal data gleaned from the questionnaire rubric was analyzed by using the Chi-square statistic.

The results showed no statistically significant difference between the experimental and control groups. However, the modest gain in transfer ability among experimental participants is encouraging. Future research using bigger samples and conducted over longer periods of time in more than one school would contribute greatly to the new and important field of geospatial technology and transfer skills.

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Dr. William Callahan, Committee Member

Dr. Jody Stone, Committee Member

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DEDICATION

To my wife Janet who:

together we raised David and Terry, great sons.

encouraged me to further my education.

enhanced my teaching through various creative activities and ideas.

supported me through cancer.

who is a once in a lifetime spouse that inspires me each day.

for 26 years has exemplified and taught me that through hard work the impossible can be possible.

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CHAPTER 1

INTRODUCTION

Geospatial technologies measures and analyses the earth's surface features to create visualizations of information using global positioning systems, geographical information systems, and remote sensing. Since its inception, geospatial technologies have been logically restricted to well-funded research universities and large government agencies. Yet in recent years geospatial technologies have gained momentum in the day-to-day lives of people everywhere particularly twenty-first century students (Nielsen, Oberle, & Sugumaran, 2011). Given the infusion of geospatial technologies in the daily lives of people globally, geospatial technologies needs to become part of K-12 learning communities as well as our student's everyday educational processes (Coulter, 2007). As a tool for data interpretation and problem solving geospatial technologies has continued to expand its value-added influence in industry as well as in K-12 education.

Bednarz et al. (2007) built on Coulter's (2007) theme as he claimed that spatial thinking, an integral component in the use of geospatial technologies, could be framed by investigating student's knowledge and application of space. In addition to knowledge and application, students need a foundation of geospatial technologies skill before they can stretch their wings and become independent learners with geospatial technologies. Mastering knowledge of the technology, but not knowing how to apply the concepts that go with spatial issues confidently can create students of tools rather than spatial thinkers. A global information economy requires proficient workers of technology and spatial thinking in combination (Mackaness, 2003; Wiske & Beatty, 2009).

Learning demonstrations and appropriate information presentations present opportunities of growth for students. Merrill (2002) has cited four instructional phases, which include: (a) prior practice, (b) skill demonstration, (c) application and (d) skill integration of real-world activities (p. 44). From these experiences students are able to schematically form their own understandings of curricula (Merrill, 2006). Further, Merrill's (2002) instructional phases leading to problem solving cement growth and learning in students. Application of tools as Coulter (2007) claimed combined with Mackaness' (2003) foundation of learning theory and Merrill's (2006) thoughts on schematic formation of learning may well set up students to become efficient and effective geospatial technology users as well as competent 21^{st} Century citizens.

Exploring how students think and what they can do with their knowledge beyond the walls of the school is central to the aims of education (Lobato, 2006). For students to apply learning elsewhere students must see a similarity between the learning context and application context. Learning transfer is driven by connections between learning contexts (Haskell, 2001). However, seldom-successful identification of context connections from previous learning hinders student's ability to transfer (Haskell, 2001).

Contextually understanding today's digital native students and their thinking is pivotal to successful instruction for transfer. In the case of geospatial technologies transfer, knowledge is visible in all practical examples of its use, which drives arguments for its continued inclusion in curricula. The purpose of this study is to investigate the relationship between interdisciplinary transfer of geospatial technology skills from a social sciences context to student achievement in the STEM-related core courses of Earth Science and Integrated Mathematics among ninth grade students.

Statement of the Problem

The inclusion of geospatial technologies in the curricula and educational experiences aimed at K-12 students are lagging compared to societal demands. Early in the 21st Century Kerski (2003) found that 2% of United States high schools used geographic information systems (GIS) in their instruction. At that time the reasons for the lack of GIS use were unclear. In 2009 a follow up study by Baker, Palmer and Kerski demonstrated that teachers needed collegial support in their schools to foster a technology rich learning environment for K-12 students.

The National Research Council (2006) poses an optimistic view of geospatial technologies inclusion in K-12 education.

> Workforce demands are changing; those demands can be met only if the K-12 education system produces graduates with the requisite skills and knowledge, with a commitment to lifelong learning, and with flexibility to adapt to change. Central to changing workforce needs are knowledge workers for the rapidly growing IT sector. Central to the IT sector and many other sectors is spatial thinking. (p. 113)

Along with the National Research Council's (2006) view, the United States Department of Labor Statistics (2006) included predictions for the growth of geospatial technologies by the year 2014. Information-growth along with computer systems design was projected to top 40 percent, more than three times faster than the average of all occupations (Hecker, 2005, p. 72). Additionally, Hecker (2005) noted the Network and Computer Systems Administrators field growing at a rate of 38.4%. These growth rate predictions coupled with an estimated 600% market increase, from five billion to 30 billion, over the years 2002 to 2005 gave an optimistic outlook for jobs in the field of geospatial technologies. Currently growing faster than the average for all occupations, geospatial technologies related fields are predicted to grow at a rate of 19% from the years 2008 to 2018 (United States Department of Labor, 2010). In relation to K-12 education the question of geospatial technologies inclusion is fostered by the amalgamation of two events, the increased development of Information Technology (IT) and the global awareness of geographical circumstances (Mackaness, 1994).

The combination of an escalating use of geospatial technologies in society and the encouragement of the United States Department of Labor signal a call for geospatial technologies in the K-12 schools of America. However, the enacted geospatial technologies infused curriculum in schools is lagging significantly in comparison to the use of geospatial technologies in society. Among the reasons impeding school use include a lack of funding for hardware and software, little pre-service and in-service training for teachers and school cultures that don't encourage classroom innovation. As the integration of technology in schools hovers around 3% the availability of technology to schools and what the schools employ in the curriculum are drastically diverse (Kerski, 2003). A 2008 survey found that 8% of 1000 instructors, students and IT staff employed technology with the curriculum fully (Moeller & Reitzes, 2011). Interestingly, 43% of students surveyed felt they were not prepared to use technology in higher education or occupational employment.

Curriculum reform involving geospatial technologies at the K-12 levels may well fundamentally change students' spatial thinking and problem solving skills, both central to the Iowa Core Curriculum's 21st Century essential skills and concepts. This sort of reform could challenge the current position of schools in society. To investigate the transfer of geospatial technologies knowledge application from the core area of social sciences to other core areas of science and mathematics among ninth grade students could yield interesting results. Seeing the curriculum enacted through many disciplines can build strength in student's cognitive competencies (Sinton & Lund, 2007). Key to transfer and application of thinking from one subject to another in today's educational context could be central to the advancement of 21st Century citizens.

Significance of the Study

The application of geospatial technologies in the curriculum of schools in America has been reported by Kerski (2003) to be less than 2%. This number could be an indicator of the disconnection between the tools schools are using with students and requisite skills fostered in technology rich societies. Currently, the evolving environment that surrounds technology requires that students prepare themselves for jobs, technologies and problems yet to be discovered (Fisch & McLeod, 2007). With the continual emphasis in education on Science, Technology, Engineering, and Mathematics (STEM) content courses for the advancement of student capability and preparation, integrating geospatial technologies in the core areas of social studies, science, and mathematics could be a way to boost well-documented student math and science scores. Student achievement fairing better on the global stage would benefit educational systems in Iowa and the nation. Additionally, students that are innovative, adept at acquiring and applying new knowledge, and proficient in problem solving will meet 21st Century goals as outlined by the Iowa Department of Education (2011).

Central to the application of geospatial technologies in schools is the ability of students to transfer knowledge and skills to other contexts. The transfer of skills and creation of new knowledge is dependent on the learner identifying connections and similarities between the original learning context and the novel situation (Haskell, 2001). This mixed methods study was designed to investigate the use of Haskell's (2001) levels of transfer applied to geospatial technologies in ninth grade STEM courses. In support, Coulter (2007) asserted that geospatial technologies should become part of a student's everyday tools for learning and Mackaness (2003) along with Wiske and Beatty (2009) claimed that a global economy requires technology proficiencies in combination with spatial thinking. In addition, this investigation is an extension of a study by Nielsen et al. (2011) in which they found that by acquiring geospatial technologies skills in isolation secondary students increased their understanding of geospatial technologies in real-world applications (p. 65).

Today's students can be characterized as Digital Natives who fundamentally process information differently from students in previous generations (Prensky, 2001). Many times the K-12 schools today are based on what Collins and Halverson (2009) call "just-in-case learning" pedagogy, schooling that is based on central knowledge (p. 3). This study attempted to move past Collins and Halverson's (2009) "just-in-case" model description to their "just-in-time," hands on, model of pedagogy by pairing technologically proficient teachers with geospatial technologies in their two-section courses.

Geospatial technology in the curriculum of schools today could cultivate a culture of innovation demanded by social institutions and communities in Iowa, the United States and the world. Through the investigation of geospatial technology skill transfer this study will demonstrate that high school students can transfer learning from one subject area to another, breaking down the institutional silos typically found in American high schools.

Purpose of the Study

The purpose of this study is to investigate the transfer of geospatial technologies knowledge and skill presented in a social sciences course context to other core areas of the curriculum. Specifically this study explores the transfer of geospatial technologies knowledge and skill to the STEM-related core areas of science and mathematics among ninth grade students. Haskell's (2001) research on "levels and kinds of transfer" provides the theoretical framework for this study.

1. What level of transfer did subjects demonstrate as they completed assignments and/or projects with the use of geospatial technologies in the context of an Earth science course?
2. What level of transfer did subjects demonstrate as they completed assignments and/or projects with the use of geospatial technologies in the context of an Integrated Mathematics course?

3. How does geospatial technologies infused instruction of the curriculum impact student achievement compared to non-geospatial technologies infused instruction?

Assumptions

It is assumed that the content and instruction in the Earth Science and Integrated Mathematics courses are typical for the teachers involved in this study. It is also assumed that identical course content will be delivered to each study group with the exception of geospatial technology inclusion for the treatment group. Pre and post-tests are assumed to be measuring the content of each unit. Additionally it is assumed that the instructors and students involved in this study are adept at computer use as well as website manipulation. It is also assumed that the teachers' and students' use of geospatial technologies will be a new endeavor for each.

Definition of Terms

The following terms used in this research are defined according to their use:

Spatial Thinking

Bednarz, Acheson, and Bednarz (2006) stated, "Spatial thinking is the knowledge, skills, and habits of mind to use spatial concepts, maps, and graphs and processes of reasoning in order to organize and solve problems" (p. 398).

Geospatial Technologies

Geospatial Technology is "an information technology field of practice that acquires, manages, interprets, integrates, displays, analyzes, or otherwise uses data focusing on the graphic, temporal, and spatial context" (National Research Council, 2006). geospatial technologies includes three distinct branches, which are Geographic Information Systems (GIS), Global Positioning Systems (GPS), and Remote Sensing (RS). Each geospatial branch has unique applications for varied spatial contexts and can function independently or in concert with each other to reveal more in-depth spatial relationships. The ultimate use of geospatial technologies revolves around problem solving within contexts of spatial orientation. The demand for persons with geospatial skills has continued its rapid growth in the twenty first century (U.S. Department of Labor, 2006, p. 22).

Remote Sensing (RS)

Acquiring data about the Earth or phenomena of the Earth without coming in contact with the Earth.

Geographic Information Systems (GIS)

"A geographic information systems (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically references information" (GIS.com, 2011).

Global Positioning System (GPS)

"GPS is a space-based service that provides position, navigation, and timing information to users anywhere on Earth, at any time of day or night, in any weather" (Aerospace, 2012).

Google Earth

Dubois, Truillet and Bach (2007) define Google Earth as, "A free application that supports navigation, bookmarks and search onto satellite pictures of the Earth.

Pictures, presented from a bird-eye view perpendicular to the surface of the globe, are mapped on a sphere representing the Earth" (p. 32).

Transfer of Learning

"Transfer refers to how previous learning influences current and future learning, and how past or current learning is applied or adapted to similar or novel situations" (Haskell, 2001, p. 23).

Intercontextuality

"When two or more contexts become linked with one another" (Engle, 2006, p. 456)

Situated Learning

"Situated learning emphasizes the idea that much of what is learned is specific to the situation in which it is learned" (Anderson, Reder & Simon, 1996, p. 5)

CHAPTER 2

SUMMARY OF THE LITERATURE

The purpose of this study is to investigate the transfer of skills and creation of geospatial technologies knowledge from social sciences to the other, STEM related, core areas of science and mathematics among ninth grade students. Specifically this study seeks to describe student application and transfer of acquired geospatial technologies skills and knowledge to the curricula demands of core area courses of science and mathematics.

Industry Growth

Currently growing faster than the average for all occupations, geospatial technologies have been cited by the U.S. Department of Labor's Occupational Outlook Handbook (2006, 2010) as a high growth industry. Geospatial technologies related fields are predicted to grow at a rate of 19% from the years 2008 to 2018 (United States Department of Labor, 2010). The events of September 11, 2001 fueled a conscience effort in the public and private sectors to gather information for improved decision-making (U.S. Department of Labor, 2005). Foreshadowing this growth rate, on October 6, 2005 and January 27, 2006 the United States Department of Labor (2006) in conjunction with Geospatial Information and Technology Associations, and the Association of American Geographers convened The President's High Growth Job Training Initiative to examine Targeted High Growth Industries. Among these industries were geospatial technologies. The overall program objectives affirmed that educational institutions play an important role in the development of a workforce that can meet the industry demand for various geospatial tasks. A goal of the President's Initiative is to pilot a connection of geospatial technologies tools and applications with labor needs through education, economic development, and employment opportunities (United States Department of Labor, 2006). This goal supports an acknowledgement that technology is part of the world culture and the need for people to understand its use and application (Mackaness, 1994).

Intent of Geospatial Technologies

The intent of geospatial technologies is to find the connections between data and location-creating maps that provide a basis for contextual problem solving. A visualization of data can frame a context from which learning and analysis will increase student engagement (Baker &White, 2003). Furthering students' educational engagement and experience with geospatial technologies will benefit education and ultimately student achievement. The National Research Council (2006) in support of geospatial technologies inclusion in K-12 education posits the demand for workers is shifting and requires educational institutions to provide instruction that is focused on new requisite skills such as critical thinking and data driven decision making. Workers as life-long learners with requisite IT skill levels prior to employment are necessary to address the perceived needs that American employers seek.

Application of geospatial technologies skills through relevant and rigorous curriculum may allow students the opportunity to engage their relative levels of spatial thinking skills and develop spatial skills using technological tools of all types. Lindsey and Berger's (2009) description of authentic experiences supports the idea that relevance is key to learner's success in the classroom (p. 120). The cumulative effect of multiple experiences with geospatial technologies tools may well enhance the spatial thinking processes for students thus better equipping students for geospatial technologies applications in the future. Sinton and Lund (2007) in their book, *Understanding Place: GIS and Mapping Across the Curriculum*, support the claim that spatial thinking comes before all other geospatial skills. Individuals subconsciously use spatial thinking when driving a car, riding a bike, playing video games, reading a map, organizing space, and participating in many other daily activities.

National Survey

In a national survey of 1,520 high school teachers who owned Geographic Information Systems (GIS) software, Kerski (2003) reported several hurdles to overcome with the introduction of geospatial technologies tools in schools. Lack of geospatial technologies lesson planning time, training support and perceptions of software difficulties all contributed to barriers that needed to be overcome. Eliminating these barriers may allow geospatial technologies to gain momentum and excitement with teachers generating the interest among students and the community at large.

Another theme appearing in the literature is the application of geospatial technologies that must have a real-life component for students. Real-world application of learning with GIS can create an environment where students view their engagement as having purpose (Kerski, 2003). Lindsey and Berger (2009), Merrill (2009), and Slavery (2009) support Kerski's (2003) point in their views of authenticity and experience. Beatty (2009) adds a brain-based view that theorizes connections between the brain's biological systems and environment of learning will improve scholarship for students, which in turn will improve education. Students who are subjected to authenticity, connected to previous experience, will be engaged learners.

There are barriers that exist to using geospatial technologies in schools. A national survey revealed that GIS has not made significant advancements in terms of the number of secondary schools using it. There were over a half million ArcView users worldwide but less than 1,500 users were in the database of U.S. educators (Kerski, 2003). Couple that with Kerski's other finding that only 20% of teachers using GIS do so in more than one lesson indicates there are other issues, barriers to use, with GIS. Why are so few teachers using geospatial technologies in their classrooms? The literature indicates three basic barriers to geospatial technology use in classrooms: (a) Pre-service teacher training and teacher in-service training, (b) lack of software and data, (c) the systematic barriers to encouraging innovation in education.

Kerski (2003) pointed to the lack of pre-service training as a significant barrier in the use of geospatial technologies in the classroom. This only leaves teachers with an in-service opportunity to learn the necessary skills to competently instruct with and about geospatial technologies. Given this response and the lack of nation-wide state mandated requirements of geospatial technologies in the schools, it seems reasonable that only 20% of all teachers using GIS in their classroom use it with more than one lesson. The context of an environment with an emphasis on student assessment success pressures teachers to stay within the curricular norm. However, when teachers were asked to what extent they planned to use the technology the next year, 71% stated they would increase their use of the software. In a follow up to Kerski's (2003) study Baker et al. (2009) found that teachers used GIS as a catalyst for multi-disciplinary instructional approaches. GIS has effectively become a tool for instruction and learning in multiple settings, which was a change from the previous findings. Barriers such as technology access, cost of software and complexity have been replaced by length of class periods, time for fieldwork and routine pressures on educators in the later survey. Furthering students' experience with geospatial technologies will benefit education and ultimately student achievement.

In sum, teachers liked the technology and felt strongly that the application and potential for meaningful learning was a positive addition to their classrooms. geospatial technologies can be an effective tool to support student growth, learning and change in classroom contexts (Environmental Systems Research Institute, 1995). Effective use of geospatial technologies in the classroom could raise the level of meaningful learning and instruction for students and teachers alike.

Geospatial Technologies Instruction

A constructivist approach to teaching with geospatial technologies is supported by Johansson (2003) as he believes a constructivist approach will allow the teacher to move from being the sole source of information to that of a guide. Doering and Veletsianos (2007) studied student use of real-time data in conjuction with Google Earth to follow researchers in the arctic. They found students were more enthusiastic and engaged learners through this use of geospatial technologies embedded into the curriculum of the classroom.

Another view by Kerski (2003) suggested that in order for GIS to be institutionalized in the school, teams of teachers from the same school should be trained at the same time. This organization of cohort groups could give teachers a sense of camaraderie when instructing with this new technology as well as a common knowledge base. They would be able to share their experiences with each other and in effect become each other's trainers in the use of geospatial technologies. Both of these approaches could be welcomed in many schools.

Barriers

Many schools experience barriers to the infusion of geospatial technologies into their curricula. First, there is a monetary commitment the school district will have to assume in order for this type of technology to flourish. Grant opportunities and other private funding can overcome the monetary barriers. Essentially, those committed to using GIS in their classrooms must be active players in the search for funding. Secondly, support from the information technicians will need to be in place. In Kerski's (2003) survey teachers deemed training support as a major constraint on using GIS in their classrooms. According to teacher responses to the Kerski's (2003) survey questions, a technological support structure must be in place. The third barrier to geospatial technologies inclusion in K-12 classrooms is situated in the school climate and the level of acceptance of educational innovation (Bednarz & Audet, 1999). As an example of a systematic barrier to successful geospatial technologies implementation, Meyer, Butterick, Olkin and Zack (1999) found that issues of bureaucracy stifled the purchase of needed geospatial technologies application software in a GIS case study. Systemic barriers to the infusion of geospatial technologies in schools have long been an issue to overcome.

Johansson (2003) referenced Bednarz and Audet (1999) and their claim that the impediments to the successful infusion of geospatial technologies in K-12 classrooms include a lack of software and data as the first restraint. The second was the lack of teacher training and curriculum materials, and the third were the systematic barriers to encouraging innovation in education (p. 3). Teacher's need support in all of these areas to move spatial thinking and geospatial learning forward in education. According to Johansson (2003) addressing these barriers is a must to facilitate the inclusion of geospatial technologies in schools. In spite of the barriers, one school has attempted to facilitate the inclusion of geospatial technologies in their school, reporting their results in the form of a pilot study using a case study format. The following case study frames the experience of fourteen secondary students learning about and with geospatial technologies.

Applications in Geospatial Technologies

Instruments

Applications in Geospatial Technologies is a high school student problem solving and spatial thinking course offered by a K-12 school in Midwestern United States. Nielsen et al. (2011) used a Likert survey and blog entry data from 14 participants to report on this unique course investigating positive changes in student understanding of spatial thinking, geospatial technologies, and ability to apply both to view the world in which they live. The course offered opportunities for students to use tools to problem solve community concerns and provided a platform to identify prerequisite skills students needed to close the knowledge gap between high school geospatial introductions and college level geospatial courses.

Methodology

The participants of the Likert survey were the students of the Application in Geospatial Technologies classes in the spring and fall of 2008. Fourteen high school students participated in the survey from an available student population of 19 between the two classes. The Likert survey included 10 questions that were arranged from global Geospatial Technology awareness to specific school and life application of Geospatial Technologies to solve problems (see Table 1). Each item included response choices of 1-Strongly Disagree, 2-Disagree, 3-Indifferent, 4-Agree, and 5-Strongly Agree. Favorable responses were considered to be 4-Agree and 5-Strongly Agree. Unfavorable responses were considered to be 2-Disagree and 1-Strongly Disagree. The coding of each of the response selections was important for further analysis. Additionally students were asked open-ended questions that focused on their assessment of the course (Nielsen et al., 2011).

Table 1
Applications in Geospatial Technology Survey Questions

Questions	SD	D	ID	A	SA
1. This class incresed my understanding of spatial thinking as it applies to life spaces in the world we live	0	0	0	3	11
Percent of total student responses	0.0	0.0	0.0	21.4	78.6
2. This class increased my understanding of spatial thinking as it applies to scientific understanding or visualizing the arrangement of the natural world.	0	1	2	4	7
Percent of total student responses	0.0	7.1	14.3	28.6	50.0
3. This class increased my understanding of spatial thinking as it applies to the relationship among objects that have a spatial distribution or character.	0	1	3	3	7
Percent of total student responses	0.0	7.1	21.4	21.4	50.0
4. This class increased my understanding of how GIS (Geographic Information Systems) might be used to solve a problem.	0	0	1	1	5
Percent of total student responses	0.0	0.0	14.3	14.3	71.4
5.This class increased my understanding of how GPS (Global Positioning Systems) might be used ot solve a problem.	0	0	0	3	11
Percent of total student responses	0.0	0.0	0.0	21.4	78.6
6. This class increased my understanding of how RS (Remote Sensing) might be used to solve a problem.	1	2	1	1	4
Percent of total student responses	11.1	22.2	11.1	11.1	44.4
7. This class increased my understanding of how GIS, GPS, and RS could be used to solve a problem in Biology or another science course.	1	1	1	5	4
Percent of total student responses	8.3	8.3	8.3	41.7	33.3

(table continues)

Questions	SD	D	ID	A	SA
8. This class increased my understanding of how GIS, GPS, or RS could be used to solve a problem in Mathematics III or another mathematics course.	1	2	3	2	5
Percent of total student responses	7.7	15.4	23.1	15.4	38.5
9. This class increased my understanding of how GIS, GPS, and RS could be used to solve a problem in social studies, geography, or history.	1		1	3	9
Percent of total student responses	7.1	0.0	7.1	21.4	64.3
10. This class increased my understanding of how GIS, GPS, and RS could be used to solve a problem in real life outside of school.	0	0	1	5	9
Percent of total student responses	0.0	0.0	6.7	33.3	60.0

SD = Strongly Disagree, D = Disagree, ID = Indifferent, A = Agree, SA = Strongly Agree

The survey was administered at the end of the course and was anonymous with no identifying markings for any of the participants. A faculty member of the school, other than the Primary Investigator (PI), administered the survey during the regular class period. The PI was not in the room and did not meet with the students at any point during the survey class period. Results were not viewed or tabulated until final grades from the class had been finalized. The survey questions can be seen in Appendix A.

Results

The surveys were completed and tabulated by first looking at the total responses from all survey items. Figure 1 displays the distribution of each of the 10 survey items. Agree categories (AC), responses of Strongly Agree and Agree, are very prominent on the chart as Figure 1 indicates. Further analysis revealed that of the total number of responses for all items 80.65% of the responses were in the AC. Additionally, in Figure 2 the total number of responses for each of the five Likert scale selections is represented. The pie graph reveals the large number of students that responded with a selection of Strongly Agree or Agree. Since the questions are asked from a positive frame, eg. "This class increased my understanding of..." the survey results reveal overall satisfaction in the course by the students.

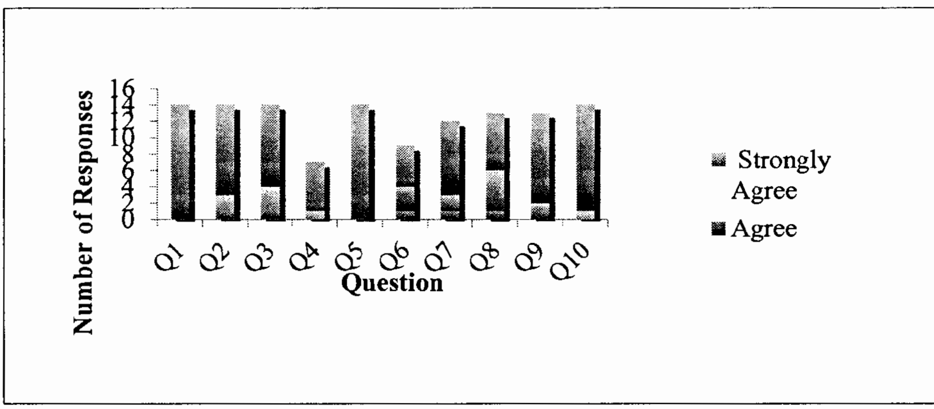

Figure 1. Geospatial Technologies Survey Responses

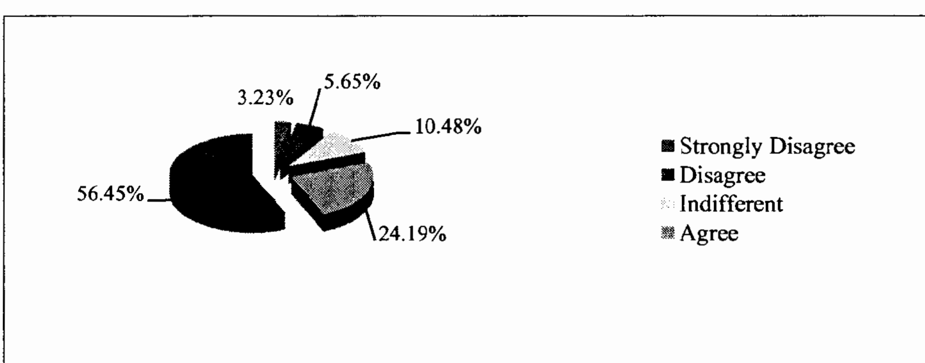

Figure 2. Percentage of All Survey Responses

Conclusions

The results of the survey given to the 14 high school students enrolled in the Applications in Geospatial Technologies course, indicates a high rate of satisfaction with the course. Over 80% of all responses to the survey questions were marked 4-Agree or 5-Strongly Agree. The results of this survey support the inclusion of geospatial technologies in the STEM-related areas of high school curriculum.

Atlanta Bike Route Problem

Participants and Instruments

Wigglesworth (2003) conducted research with middle school students in the Eastern part of the United States. His research investigated the route finding strategies of twenty-four students in twelve student teams. Each participant completed a background questionnaire and the Group Assessment of Logical Thinking (GALT) test. The GALT test was used to gather an understanding of student thinking processes. The data from the GALT test was then used to classify students as concrete thinkers, intermediate thinkers or formal thinkers.

Twenty-four students, having never been to Atlanta, Georgia, were presented with a problem which asked them to conduct a survey to discover what candy was the best seller each weekend at local movie theaters. The student's objective was to interview each movie theater manager (Wigglesworth, 2003). This fictitious survey was to be conducted each week and the students were to use bicycles as their transportation method from theater to theater. The student's task was to create a route from an initial business through four theater complexes to interview the theater managers, and then end at an ice cream parlor. The route students designed needed to avoid major highways and include the knowledge and skills they had learned from the GIS tutorial they participated in earlier in the study.

Results

The Atlanta Bike Route Problem (ABRP) yielded interesting results that were confirmed with the use of the GALT assessment, transcriptions of discussions and ArcView Network Analyst, a computer mapping program (Wigglesworth, 2003). The ABRP was a simplistic problem for the ArcVeiw network analyst. The network analyst solution chose a route through four movie theaters and then to the final business. Seventy five percent of the student pairs selected similar routes as the Network Analyst, but the student pair groups each selected different street routes. Because of the simplistic nature of the problem it could be assumed that students with a range of cognitive abilities could solve the problem. However, when one looked for the best route the task became more difficult.

This research provided evidence that students with previous map experience displayed a more reasoned approach to solving the problem. The researcher concluded that before working with geospatial technologies teachers should use other visual devices such as organizers to help students configure their thinking and provide opportunities for discussion and reading to gain further knowledge of geospatial technologies (Wigglesworth, 2003).

Skills, such as the ability to find, read, and apply symbols from the map key to the map are beneficial to the student when working with geospatial technologies. The literature and current pedagogy regarding geospatial technologies in schools is squarely focused on teaching students to think spatially first, then developing geospatial technologies skills all incased in relevant projects for supporting student achievement (Coulter, 2007; National Research Council, 2006; Sinton, 2007). Moreover, Wigglesworth's (2003) experiment followed Merrill's (2006) instructional phases when he asked students to; use prior experience, demonstrate skills using a GIS, apply the skill through problem solving and use a real-world context from which to solve the Atlanta Bike Route Problem.

Transfer of Learning

Transfer of learning occurs in an environment where a learner discovers analogous connections between separate and distinct contexts as compared to the original learning milieu. Engle (2006) suggests that if a learner chooses to apply learning in a particular context, the learner then is likely to see the context of the original learning at least similar to the application context. Haskell (2001) links transfer of previous learning to the influence it has on new situations. Along with Engle's (2006) and Haskell's (2001) themes of contextual similarity and previous learning transfer requirements, Anderson et al. (1996) explain transfer from a situative perspective. Their thesis foundation centers on the specificity of learning to the situation in which it is formalized. The bond between previous learning contexts and present contexts when learning seems clear. Discovering contextual connections from previous learning is at the heart of transfer for the learner (Salomon & Perkins, 1989).

Intercontextuality

The linking of contexts, or intercontextuality, is hypothesized by Engle (2006) to heighten the chance of learning transfer from one context to another. Relevance is a key component in the creation of intercontextuality. When a learner sees the relevance of learning in a new context and applies their learned knowledge, intercontextuality is created. Moreover, Engle (2006) hypothesizes that when teachers make frequent references to both the past and future learning the framing of time in this way connects the contexts allowing students the ability to visualize connections and see a relevance of the learning in new and different ways. With the real world applications of geospatial technologies as Kerski (2003) refers, intercontextuality has natural applications in the geospatial technologies realm.

Study and Participants

Engle (2006) reports on a research team that used observation, recording devices and student work to try to understand four target research groups. Each of the fifth grade target research groups was assigned an endangered animal to focus their study and from which to prepare a report. One research group was chosen as the focus of Engle's (2006) study because this group, initially disinterested, exemplified transfer in their learning about whales. The fifth graders research study was framed around three activities, which hypothetically would encourage transfer and help to make generalizations: (a) reading in reciprocal teaching sessions an article about the fit of species to environments, (b) meeting in breakout groups to compare notes about how different animals do or do not satisfy a given survival need, (c) meeting in jigsaw groups to compare explanations to different species (Engle, 2006).

Results

There were significant challenges of this research. During the study a five-week teacher strike limited the flexibility in the curriculum schedule to take appropriate time to complete the reports. Modifications were made on the fly, to ensure the students did complete the reports, breakout sessions and reciprocal teaching sessions were suspended after the strike. The jigsaw stage was less effective because of the significant time issue the teacher strike imposed on the study (Engle, 2006).

Engle (2006) found that the framing of student activities did promote students transfer of learning, especially when activities took place outside of the classroom, allowing for more broadly referenced applications. The broad application of learning could have been helpful in cueing students to relevant application contexts outside the classroom. How the student's experiences in this study were framed and the intercontextuality that existed could lead one to further this study toward a situated theory of transfer.

Situated Learning

Anderson et al. (1996) posit that situated learning promotes the ideal that knowledge is specific to the situation in which it is learned. In their review of the literature Anderson et al. (1996) look to four claims as the focus of their review. The first claim is centered on action and its ties to situations in which it occurs. The second claim asserts that knowledge between tasks does not transfer. Thirdly, they examine the claim that abstract training is essentially not useful. Finally, the fourth claim Anderson et al. (1996) review is the imperative that instruction has to be presented in a specific context (p. 3-10).

Claim 1: Action is Grounded in Context

The central claim of situated learning thought is that action is grounded in the context or situation in which it occurs. This claim has been supported by research and has also been over generalized to infer that all learning and transfer is context bound. General knowledge can be transferred. An example of this is in Carraher, Carraher and Schliemann's (1985) account of Brazilian street children that were adept at completing mathematics operations when conducting sales on the streets, but were much less successful when asked to use the same skills in a school context. Carraher et al. (1985) findings may suggest that concrete thought is inexorably tied to the context in which the learner had applied the skill.

Claim 2: Knowledge Does Not Transfer Between Tasks

Anderson et al. (1996) examine a second claim, "Knowledge does not transfer between tasks" (p. 6). The examination conducted by the researchers reviewed transfer theory from as far back as 1844 and 1858 in Weber's work, from Throndike and Woodworth in the very early 20th Century, to Gick and Holyoak in the 1980's. Anderson et al. (1996) through their research has come to the following conclusions regarding transfer between tasks, (1) there can be either large amounts of transfer, a modest amount, no transfer at all, or even negative transfer, (2) transfer varies from one context to another depending on the shared components, and (3) the learner attention during learning impacts the level and amount of transfer. In addition, Anderson et al. (1996) are supported by Singley and Anderson (1989) in their findings that revealed the amount of direct cognitive connection between tasks influenced the amount of transfer.

Claim 3: Training by Abstraction is of Little Use

In a review of this claim Anderson et al. (1996) position that the strong advocates of apprentice type learning view typical school instruction as of little use. In apprenticeship learning the apprentice would receive on-the-job training in specific skills that they would continually use toward the success of specific responsibilities. Apprenticeship learning can be effective in areas requiring highly skill-based activities for the completion of tasks. However the application of apprentice-type schooling in all walks of life would fail, especially in jobs that require a problem solving application. In problem solving applications the abstract learning of a school setting could prepare future workers with a reservoir of learning opportunities.

Abstract learning, however, can be ineffective if the content of the learning and the application on the job don't match (Anderson et al., 1996). The authors make reference to a Los Angeles police officer being told to forget their academy training by veteran officers. This opinion by veteran police officers could reveal disconnections between what is presented for learning and what is required in the field for successful law enforcement.

Anderson et al. (1996) support the effectiveness of abstract instruction. As proof in a study completed by Biederman and Shiffrar (1987) 36 college age students with no experience, were asked to identify the sex of day old chickens. The pretest-posttest study asked the subjects to view 18 pictures of chicken genitalia and identify the chicken as male or female. Subjects were told that equal numbers of male and female chickens were pictured. Following the pretest half of the group was given an instruction sheet to identify the sex of a chicken. The other group was given no instruction sheet and both groups were asked to identify a new set of pictures. The group that received the instruction sheet was able to correctly identify chicken gender 84% of the time. Biederman and Shiffrar (1987) found that with a small amount of abstract instruction novices could perform this task at the same rate as experienced professionals, who spent years practicing their skill. Anderson et al. (1996) cite several examples of concrete and abstract instruction combinations to be more effective than either form in isolation.

Claim 4: Instruction Needs to be Done in Complex Social Environments

Anderson et al. (1996) investigated several views of learning among them, learning is essentially a social phenomenon and complex problems are central to the success of instruction. The combination of these social and complex environments will then afford the learner the necessary context to take the skills required to complete a task. However this theory fails to recognize research that supports the claim that learning in parts can be a valuable way to learn. The authors mention activities such as playing a musical instrument, participating on sports teams and employment opportunities in the tax field as examples of skill acquisition that may be better served to the learner in parts. Musicians frequently practice alone prior to coalescing with others in an orchestra, athletes spend significant amounts of time practicing skill prior to performance in games, and accountants can learn tax laws and technology skills prior to consulting with clients. Each of these activities requires participants to develop specific knowledge and learn skills to apply their learning in complex ways (p. 9).

The result of the Nielsen et al. (2011) case study showed that geospatial technology skills and their application might be enhanced by isolated introduction first, followed by application. Building on the results of the Nielsen et al. (2011) case study, this investigation will examine the application of geospatial technology skills in the core areas of science and mathematics after initial introduction and application in a social sciences context.

Situated Learning Conclusion

While each of the claims that Anderson et al. (1996) approaches in their paper is supported with research, there is evidence that the reciprocal of their argument is also true. There are examples where geospatial technologies have been presented in an in-service opportunity, or abstractly, prior to classroom opportunities (Baker et al. 2009; Bednarz & Audet 1999; Kerski 2003). Simply put, geospatial knowledge and skills may be best learned in situations or context, or geospatial knowledge and skills may best be learned abstractly.

Five Types of Knowledge

Haskell (2001) has identified five types of knowledge; (a) declarative-about things, (b) procedural-how to, (c) strategic-cognitive processes, (d) conditional-when to apply knowledge and (e) theoretical-explanatory connections (p. 101). Each knowledge type has its own uniqueness's that in reality are difficult to distinguish one from each other. The differences among the knowledge types are minute, however Haskell (2001) believes that declarative knowledge is at the heart of transfer, which leads into the others. Haskell (2001) states five reasons that declarative knowledge is the most vital for transfer; (a) it provides the "preconditions necessary for the other four kinds of knowledge", (b) it can include or initiate the other four, (c) it can assimilate new knowledge, (d) it can facilitate the elaboration of new knowledge and (e) it can help facilitate mental models for understanding (p. 101).

Haskell's Levels of Transfer

Calais (2006) reviewed Haskell's (2001) taxonomies of transfer of learning. Calais (2006) found that Haskell (2001) described six levels of transfer which are; (1) nonspecific transfer, (2) application transfer, (3) context transfer, (4) near transfer, (5) far transfer and (6) displacement or creative transfer (p. 2-3). Each transfer level has it's own characteristics which require increasing awareness of past learning connections to new contexts (Calais, 2006). Level 1 and 2 do not promote transfer as such because each level is a repurposing of previous learning. Level 3 is largely taking what was learned in a different context and applying that learning to a new context, which does not fully engage transfer to occur. Level 4, 5 and 6 require the student to learn something new for transfer to take place. Near, far and creative transfers are each centered on new learning which is cultivated from previous experiences. Furthermore it is clear that in Haskell's (2001) view for noteworthy transfer to happen, new learning has to occur in order for each transfer level to be actualized.

Haskell's (2001) Kinds of Transfer

A second way Haskell (2001) views transfer is by classifying the kinds of transfer that occurs. The kinds of transfer may each seem it's own state, yet Haskell warns that kinds of transfer can be connected one to another in any way; the kinds of transfer are not exclusive to one another. Each of the 14 kinds of transfer Haskell (2001) has identified has its own characteristics and reveals a transfer mode that supports learning. The focus of each kind of transfer is the quest for new knowledge as the learner chooses which mode of transfer to apply to new learning situations. For a list of Haskell's (2001) 14 kinds of transfer see Appendix B.

Transfer of Learning – Conclusion

Transfer of learning can occur in various forms, continuously and in all contexts and situations for learners. Barnett and Ceci (2002) make an important point, "There is little agreement in the scholarly community about the nature of transfer, the extent to which it occurs, and the nature of its underlying mechanisms" (p. 612). There is, however, agreement that transfer in fact does occur.

The purpose of this study is to investigate the transfer of geospatial technologies skills and knowledge from social sciences to the other, STEM related, core areas of science and mathematics among ninth grade students. Specifically this study seeks to describe student application and transfer of geospatial technology skills to the core area courses of Earth Science and Integrated Mathematics 1. Haskell's (2001) research on "levels of transfer" provided the theoretical framework for this study.

Hypotheses and Research Questions

Hypothesis 1:

The experimental group will show statistically significantly higher ability to identify geospatial technology skill transfer from U.S. History than will the control group.

Hypothesis 2:

The experimental group will show statistically significantly higher mean assignment score than will the control group.

Hypothesis 3:

The experimental group will show statistically significantly higher content post-test score than will the control group.

Hypothesis 4:

The experimental group will show statistically significantly higher ability to identify geospatial technology skill application than will the control group.

Hypothesis 5:

The experimental group will show statistically significantly higher abilities to apply deeper levels of transfer than will the control group.

The research question of this study is:

What is the relationship between interdisciplinary transfer of geospatial technology skills from a social sciences context to student achievement in the STEM-related core courses of Earth Science and Integrated Mathematics among ninth grade students?

CHAPTER 3

METHODOLOGY

The purpose of this study was to investigate the transfer of skills and creation of geospatial technologies knowledge from social sciences to the other STEM-related, core areas of science and mathematics among ninth grade students. Specifically this study sought to describe student use and transfer of acquired geospatial technologies skills and knowledge to the STEM-related curricula demands of the core area courses of Earth Science and Integrated Mathematics 1. Haskell's (2001) research on "levels of transfer" provided the theoretical framework for this study (see Appendix I).

This chapter will start with a description of the subject. Following will be explanations of the recruitment processes and procedures. Next the chapter will discuss the contexts of the classes and class projects involved in the study. The chapter will conclude with a description of the geospatial technologies questionnaire.

Subjects

Participants of this study included 30 of the 36 members of the ninth grade class that were enrolled in American History, Earth Science, and Integrated Mathematics 1 courses in the spring semester. No other students were eligible for the study. Students were assigned to class sections at the beginning of the school year by school administrators and were used as intact study groups. Subjects in the experimental group of the Earth Science class also comprised the experimental group of the Integrated Mathematics 1 class. This format was congruent for the control groups of both classes.

Recruitment

A ninth grade teacher participating in the study sent an email letter of invitation to each ninth grade parent's primary email address (see Appendix C). The email invited the participation of the ninth grader in the study. The email included the parental permission letter in the body of the email as well as attached to the message. Parents were instructed in their reply to copy and paste one of the following two responses:

> I am fully aware of the nature and extent of my child's participation in this study as stated above and the possible risks arising from it. I have access to a printed copy of this form. I hereby agree to allow my son/daughter to participate in this study.
>
> I am fully aware of the nature and extent of my child's participation in this study as stated above and the possible risks arising from it. I choose not to allow my son/daughter to participate in this study. A.J. Spurr (personal communication, March 20, 2012)

The email also included an internet confidentiality statement (see Appendix C). The timing of the recruitment process coincided with parent teacher conferences at the school. This afforded parents who had not responded to the email invitation an extra opportunity to do so. If a reply was not received after four days a similar letter of invitation to participate and parental consent was mailed to the ninth grade student's home and included a self-addressed stamped envelope for return. The participating ninth grade teacher received the email and letter replies then coded student names with numbers to protect student anonymity.

Procedures

The procedures of this study included four parts. The first describes the initial introduction of all ninth grade students to geospatial technologies in U.S. History. The second part describes the organization of the experimental and control groups. The third part describes the courses of Earth Science and Integrated Mathematics 1. The fourth part describes the Geospatial Technology Questionnaire. See Appendix D for a schematic of the procedures.

U.S. History Course

All students in the U.S. History course were introduced to geospatial technologies through the course content. Specifically students were asked to use ArcGIS Explorer Online to create a map presentation based on United States Westward Movement in the 1800's. Students were assigned one of the historical trails of the Mormon Trail, Donner Party Trail, Oregon Trail, Transcontinental Railroad and Pony Express. Mapping the assigned trail using ArcGIS Explorer Online was the focus of the project. The students created an ArcGIS Explorer Online account to build a map using points, the measure tool and base maps, among other skills, in order to create an informative map about their assigned trail. Class presentations of the maps culminated the unit. Following the completion of the unit and before students were asked to use geospatial technologies in Earth Science or Integrated Mathematics 1, both treatment and control groups were given a geospatial technologies content assessment to gauge their geospatial technologies base knowledge of ArcGIS Explorer Online (see Appendix E).

The school's 1 to 1 computer configuration was integral to the U.S. History project. The school created two sections of ninth grade students and assigned a computer platform for each section at the beginning of the school year. One section had the use of

Macintosh MacBook computers and the other section had the use of Macintosh iPad computers. These school-created groups would be used for the remainder of this study.

Experimental and Control Groups

The experimental group in both the Earth Science and Integrated Mathematics 1 courses were instructed with geospatial technologies, and were also instructed to use geospatial technologies in their project completion. These students had the individual use of Macintosh MacBook computers. The experimental group was pre- and post-tested over the content of the curriculum.

The control group, in Earth Science and Integrated Mathematics 1, were instructed without the use of geospatial technologies. The control group was not asked to use geospatial technologies in their project completion and had individual use of Macintosh iPads. The control group was pre- and post-tested over the content of the curriculum with the same questions as were given to the experimental group.

Earth Science and Integrated Mathematics 1

Subjects in the experimental group Earth Science class plotted earthquake distribution data. They acquired the data from the U.S. Geological Survey's earthquake web site and were asked to use data from a one-week window around their last birthday. Using ArcGIS Explorer Online the experimental group projected the data, about one thousand points, onto a map to visualize the distribution of earthquakes around the globe. Subjects compared the location of earthquakes and the location of tectonic plate boundaries. The maps the subjects created required them to plot points, use the measure tool and choose an appropriate base map at minimum. Other ArcGIS Explorer Online tools were also used in the creation of the maps.

The Earth Science control group completed the same activity using a traditional paper map. They plotted points and measured distanced, but did not have the luxury of a selection of maps for their presentation. Class time limited hand point plotting to one hundred points.

In Integrated Mathematics 1 both experimental and control groups were given the same student project. The project asked students to look at five consolidated school districts in Iowa. Each school district included three Iowa communities. The objective was to find the optimum placement of a high school in relation to the three communities using geospatial technologies to find the circum-center of the school district. There were four focus questions of the student projects:

- Where would the optimum placement of the high school be and how far away is it from each of the towns?
- Explain how you found the optimum placement of the high school for this consolidated school district.
- In each case, how far away is the actual high school from the optimum high school? Which one of the school districts was the closest to the optimum placement of the their actual high school?
- What other factors might influence the placement of a high school for a newly consolidated school district (name at least two)? Explain.

The experimental group used ArcGIS Explorer Online to complete their project. They projected points, used the measure tool and choose an appropriate base map for their project. The control group used traditional paper maps to complete their project. They plotted points and measured distances with rulers. As was the case with the Earth Science control group, they did not have the luxury of a digital map selection.

Both experimental and control groups for each class were pre and post tested with multiple-choice curriculum content assessments. Each was designed, administered and scored by the classroom teacher. The pre and post assessment content and administration were identical within Earth Science and Integrated Mathematics 1 courses. Both the experimental and control groups were presented the same curriculum during instruction. Inclusion of geospatial technologies in the experimental group represented the sole difference between treatments.

Questionnaire

Following the completion of the target activities, the experimental group completed an in class questionnaire focused on their use and application of geospatial technologies in the STEM-related courses of Earth Science and Integrated Mathematics 1. Central to the questionnaire was how study subjects transferred skills from the ArcGIS Explorer Online skill experiences received in U.S. History to the completion of their projects in Earth Science and Integrated Mathematics 1. The following items on the questionnaire specifically compared the use of points, the measure tool and base maps:

> 3. Explain the similarities of how you used points in the Earth Science / Earth Quake project compared to the U.S. History Westward Expansion project.

5. Explain the similarities of how you used the measure tool to measure distances to complete the Earth Science / Earth Quake project compared to the U. S. History Westward Expansion project.

7. Explain the similarities of how you used basemaps to complete the Earth Science / Earth Quake project compared to the U.S. History Westward Expansion project
(For complete questionnaire see Appendix F)

Following the completion of the target activity the control group completed a similar in-class questionnaire, which inquired about the potential use and application of geospatial technologies in the STEM-related courses of Earth Science and Integrated Mathematics 1. The following questions from the Integrated Mathematics 1 control group questionnaire exemplify the central theme of the study.

3. Explain the similarities of how you could use points in the Integrated Mathematics 1 / School Consolidation project compared to the U.S. History Westward Expansion project.

5. Explain the similarities of how you could use the measure tool to measure distances to complete the Integrated Mathematics 1 / School Consolidation project compared to the U. S. History Westward Expansion project.

7. Explain the similarities of how you could use base maps to complete the Integrated Mathematics 1 / School Consolidation project compared to the U.S. History Westward Expansion project
(For complete questionnaire see Appendix I)

The questionnaire contained eight open-ended questions in which the subjects were asked to respond to each question in two to five sentences. Question one asked subjects for their subject identification number. Questions two, four and six were paired with the following question to prepare student thinking. The following paired questions from the Earth Science Experimental Group Questionnaire exemplify this connection.

> 2. Explain how you used point or pins in the Earth Science / Earth Quake project.
>
> 3. Explain the similarities of how you used points in the Earth Science / Earth Quake project compared to the U.S. History Westward Expansion project.

Questions three, five and seven specifically examined learning transfer from U.S. History to Earth Science or Integrated Mathematics 1. Rubrics that mirror Haskell's levels of transfer (see Appendix J through N) were used to assess subject responses.

<u>Analysis</u>

A rating team was formed to assign a transfer score to each subject response to questions three, five and seven. The rating team consisted of a K-12 teacher with 20 years of teaching experience and no prior teaching experience with geospatial technologies; a tenured university professor who had taught geospatial technologies courses and authored professional articles with educational geospatial technologies themes; and the primary investigator of this study. The rating team had no contact with the study subjects nor did they have access to the subject's name during the rating of questionnaire responses. Each member of the rating team was given two three-ringed binders. The study investigator provided these binders to each rating team member at independent meetings. During the independent meetings each rater was informed as to the contents of which questions of the questionnaire to rate. One binder contained subject responses to each of the questionnaire items and one binder contained blank rubrics as well as a rubric with sample responses for reference. Following their independent ratings, the rating team convened to discuss their ratings and establish a consensus score for each subject response. The consensus scores were used in the Chi-square statistical analysis of the questionnaire responses.

CHAPTER 4

RESULTS

The purpose of this study was to investigate transfer of geospatial technologies skills and knowledge from social sciences to other STEM-related, core areas of science and mathematics among ninth grade students. Specifically this study sought to examine student application and transfer of geospatial technology skills to the core area courses of Earth Science and Integrated Mathematics 1. Haskell's (2001) research on "levels of transfer" provided the theoretical framework for this study.

This chapter will discuss the results of each of the assessments as well as the analysis conducted with the t-test and chi-square statistic. Each of the hypotheses, paired with the appropriate statistic, will be discussed and analyzed.

The aim of the first analysis was to determine if there was any difference in baseline knowledge of ArcGIS Explorer Online between the experimental and control groups. An independent sample t-test was run on the geospatial technology skills assessment subject scores. A mean score of 28.33 from a possible 36 points was calculated for all participants. When separated into study groups, the experimental group mean ($M = 27.57$, $SD = 4.36$) and control group ($M = 29$, $SD = 4.21$) showed a difference (-1.4286). The independent samples t-test mean score comparison ($t = -0.91$, $p = 0.19$) indicates no statistically significant difference in the transfer of ArcGIS Explorer Online skill and knowledge between the two groups. It is worth noting that all participants had the same treatment and that the focus of this assessment was the skills used of ArcGIS Explorer Online (see Table 2)

Table 2

Geospatial Technologies Content Assessment

	Experimental	Control
N	14	16
Mean	27.57	29
Standard Deviation	4.36	4.21

Hypothesis 1, which assessed the ability of subjects to identify geospatial technology skill transfer, was tested with the Chi-squared (X^2) statistic, showed no statistical significance between experimental and control groups for either the Earth Science or the Integrated Mathematics 1 group. Earth Science questionnaire item three (ESQ3), which examined the ability to create geospatial technology points using ArcGIS Explorer Online on a base map showed no statistical significance X^2 (1, N=27) = 0.33, p = .43. Earth Science questionnaire item five (ESQ5), which examined the ability to use the ArcGIS Explorer Online measure tool showed no statistical significance X^2 (1, N=27) = 2.97, p = 0.91. Finally, Earth Science questionnaire item seven (ESQ7), which examined the ability to choose an appropriate base maps with ArcGIS Explorer Online showed no statistical significance X^2 (1, N=27) = 0.2, p = 0.62 (see Table 3)

Integrated Mathematics 1 questionnaire item three (IMQ3) which examined the ability to create geospatial technology points with ArcGIS Explorer Online on a base map showed no statistical significance X^2 (1, N=30) = 1.67, p = 0.20. Integrated

Mathematics 1 questionnaire item five (IMQ5) which examined the ability to use the ArcGIS Explorer Online measure tool indicated no statistically significant difference between experimental and control groups X^2 (1, N=30) = 1.70, p = 0.18. Finally, Integrated Mathematics 1 questionnaire item seven (IMQ7) which examined the ability to choose an appropriate base maps with ArcGIS Explorer Online showed no statistically significant difference between the experimental and control groups X^2 (1, N=30) = 1.66, p = 0.20 (see Table 3).

Table 3

Questionnaire item 3, 5, 7 Results

Question	df	Sample Size	X^2 Value	Significance Level
		Earth Science (ES)		
3 (Q3)	1	27	0.33	0.43
5 (Q5)	1	27	2.97	0.91
7 (Q7)	1	27	0.20	0.62
		Integrated Mathematics 1 (IM)		
3 (Q3)	1	30	1.67	0.20
5 (Q5)	1	30	1.70	0.18
7 (Q7)	1	30	1.66	0.20

Table 4

Earth Science Question 3

		Experimental	Control	Total
Level 1	Count	6	8	14
	Expected Count	6.7	7.3	14.0
	% within Group	46.2%	57.1%	51.9%
Level 2	Count	7	6	13
	Expected Count	6.3	6.7	13.0
	% within Group	53.8%	42.9%	48.1%
Total	Count	13	14	27
	Expected Count	13.0	14.0	27.0
	% within Group	100.0%	100.0%	100.0%

Transfer Level 1= Nonspecific/Application, 2 = Context, 3 = Near and 4 = Far/Creative

Table 5

Earth Science Question 5

		Experimental	Control	Total
Level 1	Count	5	10	15
	Expected Count	7.2	7.8	15.0
	% within Group	38.5%	71.4%	55.6%
Level 2	Count	8	4	12
	Expected Count	5.8	6.2	12.0
	% within Group	61.5%	28.6%	44.4%
Total	Count	13	14	27
	Expected Count	13.0	14.0	27.0
	% within Group	100.0%	100.0%	100.0%

Transfer Level 1= Nonspecific/Application, 2 = Context, 3 = Near and 4 = Far/Creative

Table 6

Earth Science Question 7

		Experimental	Control	Total
Level 1	Count	9	10	19
	Expected Count	9.1	9.9	19.0
	% within Group	69.2%	71.4%	70.4%
Level 2	Count	4	4	8
	Expected Count	3.9	4.1	8.0
	% within Group	30.8%	28.6%	29.6%
Total	Count	13	14	27
	Expected Count	13.0	14.0	27.0
	% within Group	100.0%	100.0%	100.0%

Transfer Level 1= Nonspecific/Application, 2 = Context, 3 = Near and 4 = Far/Creative

Table 7

Integrated Mathematics 1 Question 3

		Experimental	Control	Total
Level 1	Count	9	15	24
	Expected Count	10.4	13.6	24.0
	% within Group	69.2%	88.2%	80.0%
Level 2	Count	4	2	6
	Expected Count	2.6	3.4	6.0
	% within Group	30.8%	11.8%	20.0%
Total	Count	13	17	30
	Expected Count	13.0	17.0	30.0
	% within Group	100.0%	100.0%	100.0%

Transfer Level 1= Nonspecific/Application, 2 = Context, 3 = Near and 4 = Far/Creative

Table 8

Integrated Mathematics 1 Question 5

		Experimental	Control	Total
Level 1	Count	7	13	20
	Expected Count	8.7	11.3	20.0
	% within Group	53.8%	76.5%	66.7%
Level 2	Count	6	4	10
	Expected Count	4.3	5.7	10.0
	% within Group	46.2%	23.5%	33.3%
Total	Count	13	17	30
	Expected Count	13.0	17.0	30.0
	% within Group	100.0%	100.0%	100.0%

Transfer Level 1= Nonspecific/Application, 2 = Context, 3 = Near and 4 = Far/Creative

Table 9

Integrated Mathematics 1 Question 7

		Experimental	Control	Total
Level 1	Count	9	15	24
	Expected Count	10.4	13.6	24.0
	% within Group	69.2%	88.2%	80.0%
Level 2	Count	4	2	6
	Expected Count	2.6	3.4	6.0
	% within Group	30.8%	11.8%	20.0%
Total	Count	13	17	30
	Expected Count	13.0	17.0	30.0
	% within Group	100.0%	100.0%	100.0%

Transfer Level 1= Nonspecific/Application, 2 = Context, 3 = Near and 4 = Far/Creative

Hypothesis 2 investigated the mean assignment scores of the experimental and control groups. This hypothesis could not be assessed. The Earth Science and Integrated Mathematics 1 classes did not include daily assignment scores for the study project. Therefore, no data were available to analyze.

Hypothesis 3 examined the pre- and post-test difference scores of both groups. The pre-test score was subtracted from the post-test score to yield the difference score and those scores of both groups were then calculated and examined using independent t-test. The Earth Science t-test resulted in t(26) = 1.01 p = 0.322. Integrated Mathematics 1 t-test statistic indicated t(24) = -1.58 p = .126. There was no significant difference between groups nor was there enough evidence to reject the null hypothesis (see Table 10 and 11).

Table 10

Pre and Post-test Content Mean Scores

Earth Science

Group	*N*	Mean	Standard Deviation
Experimental	13	17.4615	6.25986
Control	15	15.0667	6.25604

Integrated Mathematics 1

Group	*N*	Mean	Standard Deviation
Experimental	13	1.3846	2.39925
Control	13	2.8462	2.30384

Table 11

Pre and Post-test Content Difference Scores

Earth Science

N	df	t	Significance	Mean Difference
27	26	1.010	.322	2.39487

Integrated Mathematics 1

N	df	t	Significance	Mean Difference
25	24	-1.584	.126	-1.46154

Hypothesis 4 examined the subject's ability to identify higher levels of geospatial technology skill application. Using the X^2 statistic, Tables 4 through 9 indicate no statistical difference between the experimental and control groups. In addition, Table 2 indicates p-values in excess of .05 for Q3, Q4 and Q5 of Earth Science and Integrated Mathematics 1. ESQ5 data displayed the lowest p-value = 0.13 while IMQ5 data received the highest p-value = 1.70.

Hypothesis 5 compared the deeper levels of transfer between the two groups. An examination of Table 4 through 9 reveals that students scored at Level 1, nonspecific-application and Level 2, context transfer levels only. There was no Level 3, near transfer or Level 4, far/creative transfer identified through the transfer rubrics by the rating team.

The next and final chapter offers a discussion and implications of the findings reported in this chapter.

CHAPTER 5

DISCUSSION

The primary purpose of this study was to investigate transfer of skills and creation of geospatial technologies knowledge from social sciences to the other STEM-related core areas of science and mathematics among ninth grade students. Specifically, this study examined participants' use and transfer of acquired geospatial technologies skills and knowledge to STEM-related demands of the core area courses of Earth Science and Integrated Mathematics 1. Haskell's (2001) research on "levels of transfer" provided the conceptual and theoretical framework for this study (see Appendix J). This investigation sought to combine Collins and Halverson (2009), Coulter (2007), Mackaness (2003), Nielsen et al. (2011), Prensky (2001) and Wiske and Beatty (2009) and with Haskell's (2001) theories of transfer to examine subject transfer ability with geospatial technology skills from one classroom context to another academic setting.

As was reported in the previous chapter, five hypotheses and one research question were examined. The first hypothesis, which expected the experimental group to show significantly higher ability to identify geospatial technology skill transfer than the control group was not supported. The second hypothesis, which sought to demonstrate that using geospatial technologies would have a positive impact on mean assignment scores, was not supported. The third hypothesis investigated the difference in content post-test scores of the study participant groups and was not supported by the data. Hypothesis 4 expected experimental participants to demonstrate a higher ability to identify geospatial technology skill application than the control group was not supported by the data. Hypothesis 5 which investigated the abilities of the experimental participants to apply deeper levels of transfer was not supported by the data.

The following sections will provide a discussion of these findings. Before delving into the interpretation of the results, it is helpful to give a brief description of the context of the study beyond what is described in Chapter 3.

Context

It will be helpful in contextualizing the results reported in Chapter 4 and this interpretation in Chapter 5 to give a short explanation of the study. First all ninth grade students were presented with a geospatial technologies project in the United States History course. The project centered on a Westward Movement trail. The students were to examine and research the trail and use the GIS tool ArcGIS Explorer Online to complete the project. Students were to complete the project marking locations with the points or pins tool, measuring appropriate distances from one point to another using the measure tool and by choosing an appropriate base map. Following the completion of the geospatial technologies map and class presentation the students were asked to complete the Geospatial Technologies Content Assessment online. This multiple-choice assessment was designed to gauge student's ability to use the ArcGIS Explorer Online tool as can be seen in Appendix E. The results indicated there was no significant difference between the experimental and control groups (see Table 2). Following the completion of the Geospatial Technologies Content Assessment the Earth Science and Integrated Mathematics 1 instructors began their projects with geospatial technologies inclusion.

The Earth Science and Integrated Mathematics 1 teachers were asked to take a unit of instruction that they taught in the past without technology and infuse geospatial technologies into it with one section of students, the experimental group. The other group of students were instructed exactly the same as in the past without technology and no geospatial technologies. The only difference between the two groups was the use of geospatial technologies with the experimental group.

Earth Science Overview

The distribution of Earthquakes in relation to fault lines was the focus of the geospatial technologies based project in Earth Science. Students in the experimental group acquired data from the U.S. Geological Survey's earthquake web site and were asked to use data from a one-week period around their last birthday. The experimental participants used ArcGIS Explorer online to project the data onto a map giving visualization to the data. The control group completed the same project using paper map, pencils and rulers.

Integrated Mathematics 1 Overview

The consolidation of Iowa school districts was the focus of the Integrated Mathematics 1 course. Students were to study and investigate a current Iowa school district that previously consolidated at least three Iowa community school districts. The task was to find the optimal place for a high school that incorporated factors such as the circum-center of the communities, equal distance from each community, roads and physical geography of the area. The experimental group used the points or pins, measure tool and base maps from ArcGIS Explorer Online to complete this project and the control group used Iowa road maps, rulers and pencils.

Experimental Groups were Expected to Identify Geospatial Technology Skill Transfer

Study participants in the experimental groups did not show a statistically higher ability to identify geospatial technology skill transfer than the control group. Table 3 displays significance levels from 0.02 to 0.91, higher than the norm of 0.05. There are possible explanations for these results. For one study participants may not have interpreted a difference between the projects they were asked to complete. They may have seen the project in U.S. History and the other core areas as requiring essentially the same skills as previously learned. If this were true, study participants may not have a reason to explore the use of deeper levels of transfer. Secondly, study participants may not have realized there were more applications with the ArcGIS Explorer Online program than the points, measure tool and basemaps. This simplistic view of the program may not have allowed study participants to learn new skills and transfer these skills to new situations in new ways. Thus, near and far/creative transfer may have never been discovered.

Connection Between Use of Geospatial Technologies and Assignment Scores

Hypothesis 2 focused on a connection between the study participants that used geospatial technologies and increased assignment scores. During the study classroom teachers were given the latitude to choose what projects they wanted to do and how to proceed with the projects. The primary investigator met with the classroom teachers four times prior to the start of the study. During these meetings the classroom teachers were asked to teach a unit of study just as they had in the past, which included pre-tests, assignments and post-tests. Both of the Earth Science and Integrated Mathematics 1 classroom teachers chose not to have students complete daily assignments. They instead chose to focus their student's efforts fully toward the geospatial-related project in the class. Because of this decision by the classroom teacher's data for hypothesis 2 could not be obtained.

Difference in Content Pre- and Post-Test Between Groups

Hypothesis 3 of this investigation focused on the differences in content pre- and post-test scores between the experimental and control groups. Each of the study participants completed content pre- and post-tests for both Earth Science and Integrated Mathematics 1. The following discussion is a comparison of the experimental and control groups from Earth Science and Integrated Mathematics 1 classes.

Earth Science Group Comparison

The Earth Science group's pre-test, post-test scores were compared. The data showed that the experimental group mean difference was 2.39 points higher than the mean of the control group. This mean difference however is much less than the standard deviations of 6.26 for the experimental and control groups indicating there is no significant difference between the two Earth Science groups (see Table 10 and 11).

The small difference in the mean scores of the two groups could reflect the small number of participants (N). Pagano (2001) points out that the mean of a set of scores is sensitive to each score in the distribution. In practical terms the small N of this study may have increased the influence of each study participant's score to the mean of each group. Conversely, with a larger N, each study participant's score may be less influential on the group's mean ultimately changing the outcome of the study or increasing the difference between the means of the two groups.

Another postulation for the similar pre-test, post-test scores may include that correct responses on the pre- and post-tests were not dependent on participants using geospatial technologies. Simply put, study participants who used the paper and pencil project format may have gained as much knowledge about the contents of the project as those who used geospatial technologies. This assumption may have been revealed through assignment scores at specific points in the unit. The results may also suggest the ArcGIS Explorer Online user may have been using the program in a simplistic way, using only the features of point, measure tool and basemaps. Questioning participants about those skills only may have diminished the known depth of understanding of other skills students used. If study participants had been queried about the use of other features of the program such as creating new layers, adding symbols, lines and queries the results may have shown that study participants did use ArcGIS Explorer Online tools in new and different ways.

Moreover, it is likely that using ArcGIS Explorer Online may have just been another way to do the same old thing. The technology itself may not have impacted the activities to a degree that allowed for a depth of understanding by the experimental group to stand out. Finally, since all study participants were in the same school this study had no way to protect against participants talking about their work with this project.

Statistically, the impact of geospatial technology infusion was not significant in Earth Science. In the qualitative investigation, question eight, which asked why use geospatial technologies revealed more similarities than distinct differences between the two groups. Expectedly, study participants in the experimental group responded to this question in more detail and many referenced the Earth Science project topic of earthquakes (see Appendix O). However, looking deeper into subject responses visualization of the data or seeing that data on a map was a common theme of both groups. One experimental group participant responded to the question by stating, "To better visualize where certain events occurred" and another wrote, "Creating a map for a research project a visual aid is a very good way to convey information for any project" (see Appendix O). When data is projected onto a map, patterns of the data may emerge allowing for further analysis of the data to occur. Similarly a control group participant stated, "It gives you a visual aid when explaining your findings and learning". Another was more specific about what could be shown with a map, "…it shows detailed things in certain base maps, and it allows you to see where trails are, and rivers, and earthquakes, volcanoes, and other things" (see Appendix O). These responses illustrate the similarity of understanding exhibited by the experimental and control groups.

Integrated Mathematics 1 Group Comparisons

Subjects in the experimental and control groups completed a pre- and post- test using an 8-point content assessment for the unit. Table 10 shows the mean score for the experimental group's improvement measured 1.38 points with a standard deviation of 2.39 (see Table 10). The mean improvement for the control group measured 2.84 points with a standard deviation of 2.30. Additionally, the control groups raw score mean (5.79) was .33 of a point higher than the experimental group (5.46) (see Appendix R). The higher mean difference for the control group was slightly larger than twice the improvement by the experimental group. Contributing to this perplexing result is a lower post-test score achieved by three of the 13 participants in the experimental group (see Appendix R). Several factors may have contributed to these lower post-test scores. Study participants might have been absent for some of the unit project and missed important components, which may have caused study participants to be confused by the test questions. The three lower post-test scores combined with the low numbers of the experimental group contributed to the control group's higher mean difference.

Study participants in both the experimental and control groups of the Integrated Mathematics 1 class were also asked why one would use geospatial technologies. Two themes emerged from both the experimental and control group participant responses to this inquiry. First, the majority of participants made a comment about measuring distance. One participant commented, "…if you are trying to plant a garden you could map it out and use the measure tool and figure out how it would look" (see Appendix P). A participant from the control group looked back to their use of geospatial technologies in U.S. History when they stated, "So you can plot, measure and locate where people have been in history and see what they encountered while traveling" (see Appendix P) This is not surprising since a major piece of the school district consolidation project in the class dealt with measuring distances. Both groups were instructed to measure distances on the map to find the circum-center of the consolidated district. Secondly, participants from both groups made comments about base maps. One participant in the experimental group compared base maps with 2-dimientional maps commenting that the efficiency of ArcGIS base maps were superior than paper maps because you can move between several maps and chose one that best fits your data (see Appendix P). Another commented, that base maps are available on a wide range of topics (see Appendix P). Overall the experimental and control groups saw similar value in using ArcGIS with this project.

Demonstrating a Higher Ability to Identify Geospatial Technology Skill Application than the Control Group

The identification of geospatial technology skills and application was hypothesis 4's central theme. To examine this hypothesis study participants completed a questionnaire at the end of the Earth Science and Integrated Mathematics 1 projects. The questionnaire consisted of seven open-ended questions that centered on the geospatial technologies skills students used to complete the geospatial technologies project in Earth Science or Integrated Mathematics 1. The questionnaire had two iterations. The first asked participants in the experimental group to recount their experiences with points or pins, the measure tool, base maps and to provide reasons why they would use ArcGIS Explorer Online to display data. The second iteration was given to the control participants and was focused on what they could have done with ArcGIS Explore Online to complete the geospatial technologies projects (see Appendix F, G, H and I). For a graphic display of the study procedures see Appendix D.

Questions three (Q3), five (Q5) and seven (Q7) asked study participants to compare their experience with ArcGIS Explorer Online in U.S. History with either Earth Science or Integrated Mathematics 1 projects. Q3 inquired about using pins or points, Q5 centered on using the measure tool and Q7 focused on using base maps. Each question was specific in its comparison focus. As an example Q3, Q5 and Q7 from the Earth Science Experimental Group Questionnaire items are provided below.

> 3. Explain the similarities of how you used points in the Earth Science / Earth Quake project compared to the U.S. History Westward Expansion project.
>
> 5. Explain the similarities of how you used the measure tool to measure distances to complete the Earth Science / Earth Quake project compared to the U.S. History Westward Expansion project.
>
> 7. Explain the similarities of how you used basemaps to complete the Earth Science / Earth Quake project compared to the U.S. History Westward Expansion
> project.

Once all of the questionnaires were completed by the study participants a rating team consisting of a K-12 teacher with no geospatial technologies teaching experience, university professor who teaches courses about geospatial technologies and the primary investigator used transfer rubrics to rate each of the student responses independently. The transfer rubrics were created from Haskell's (2001) theories of transfer (see Appendix K, L, M, N). Once the independent ratings were completed the rating team met and through discussion decided on a consensus score for each item for each study participant. The consensus scores were used to compare the experimental and control groups. The ratings team concluded that only the minimum requirements from transfer levels 1, nonspecific application and 2, context, were met by student responses to questionnaire inquiries.

Higher levels of transfer were not evident in the student responses to questionnaire items Q3, Q5 and Q7. There could be many reasons for this. In his work on transfer Haskell (2001) cites content-to-content transfer as learning a skill in one subject and employing that skill in another (p. 31). Participant responses to Q3, Q5 and Q7 may exemplify content-to- content transfer as described by Haskell (2001). The participants may not have distinguished any significant geospatial skill requirement differences between the projects in U.S. History and Earth Science or U.S. History and Integrated Mathematics 1. Consequently, the participants may simply have used the same ArcGIS Explorer Online geospatial processes in Earth Science and Integrated Mathematics 1 as they had previously used in U.S. History. If this were the case the required geospatial skills needed to complete the projects in Earth Science and Integrated Mathematics 1 may not have required students to think beyond their current knowledge limiting transfer levels to nonspecific/application and context.

If the study participant's viewed the U.S. History to Earth Science or U.S. History to Integrated Mathematics 1 projects as similar or the same the projects may not have promoted new learning as Haskell (2001) claims to be a requirement for higher levels of transfer (p. 30). If this were the case study participants may not have explored other skills and techniques they could have used to complete or enhance the Earth Science or Integrated Mathematics 1 projects. Additionally, if study participants carried a narrow view of ArcGIS Explorer Online skills, limited to marking points, measuring distances and changing basemaps, to Earth Science and Integrated Mathematics 1 the higher levels of near or far and creative transfers could have simply been suppressed or not explored at all. A next step for this study may be to compare geospatial skill transfer between two course projects that require the use of different features of ArcGIS Explorer Online. A study environment that includes vastly different projects between subject areas may afford more opportunities for higher levels of transfer.

A time element could be another factor in the lack of higher levels of transfer appearing in this study. Study participants completed all three projects over a six-week period. If there had been a longer time between the U.S. History and Earth Science and Integrated Mathematics course projects there may have been a significant difference in transfer between the experimental and control groups. Moreover, if the study had been conducted longer than six-weeks with more projects there may have been a significant difference in transfer revealed.

Applying Deeper Levels of Transfer

Hypothesis 5 of this study investigated the experimental group's ability to apply deeper levels of transfer than the control group. Like each hypothesis before it, hypothesis 5 was not supported by this study. Several of the previously stated reasons could also have impacted the realization of this hypothesis. Student's could have not realized the depth of the use of ArcGIS Explorer Online, small participant numbers, completion of the study project may not have been dependent on geospatial technologies, and students communicating about the study outside of class may all have played a role in the failure of hypothesis five. Additionally Haskell (2001) points to many theorists who agree that numerous examples of outcomes aid in the transfer of learning from one subject to another. In the case of this study and the lack of attainment of the hypotheses it may be any or none of the previously mentioned reasons or it possibly could simply be the lack of an instructional strategy that influenced the outcome.

Limitations

As with all studies, this investigation has limitations. The sample for this exploratory setting was small. It was difficult for the study participants to convey a geospatial technology skill at Haskell's (2001) higher levels of transfer. A future study may employ a larger sample given the sample in this study was small.

The construction of the questionnaire may have been limiting. The questionnaire consisted of eight open response questions taking into account the writing ability and stamina of the ninth grade study participants. The short answer questionnaire format did not allow for follow up probing questions to clarify a study participant's written response. If given a chance to expand on their responses, study participants may have shown a greater ability to transfer geospatial skills from one core subject to another.

The construction of the Geospatial Technology Questionnaire rating team may have provided another limitation for this study. The inclusion of the Primary Investigator on the rating team may have influenced other rater's scores or inhibited their comments during the discussion phase of the rating. This could have influenced the rating team's consensus score, which was used in the statistical analysis of this study. In the future, it may be wise to remove the primary investigator from the rating team and recruit a K-12 instructor who is familiar with geospatial technologies from another school to serve as the third rater on the rating team.

A final limitation may have been the classroom instructor's lack of experience using geospatial technology. The classroom instructor's limited experiences with geospatial technology prior to this investigation may have negated subtle influences of teaching experience veteran teacher's typically employ. Kerski (2003) pointed out that one barrier to geospatial technology use is the lack of pre- and in-service training. To counter this influence in the future providing teachers with more in-service opportunities on how to use geospatial technologies in the classroom may be beneficial.

Future Directions

This study was conducted with 30 participants in a small high school with a total of 120 students. If in the future this study was conducted in a larger school with more study participants the results may be more positive toward the hypotheses. A larger school may also afford the investigator opportunities to employ multiple classrooms and multiple student groups. Using multiple schools or multiple student groups within a school to increase the participant population may provide a researcher with necessary data to more fully examine transfer of geospatial technologies between core subject areas.

In addition, future studies could be based on the following questions to more fully examine the impact and transfer of geospatial technologies in K-12 settings:

- Would follow up interviews show different and richer results in questionnaire responses of geospatial technology study participants?

- What impact would an elementary level introduction of geospatial technologies have on student achievement in high school?
- How do curricular examples during teaching that include geospatial technologies impact the transfer of geospatial technology skills for students?
- Do students show a greater interest in classes that incorporate geospatial technologies in K-12 settings?
- Do problem-based projects that encourage geospatial technology use increase student achievement among high school students?
- Are students more likely to go into a profession based on geospatial technologies if they had a geospatial technologies class in their K-12 school experience?

These are just a few questions that could form the basis of future studies to strengthen the use of geospatial technologies in K-12 institutions. The inclusion of geospatial technologies in the K-12 setting provide a rich opportunity for future research and have the potential to play a significant role in enhancing the relevancy of education in our schools.

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APPENDIX A:

APPLICATION IN GEOSPATIAL TECHNOLOGIES SURVEY

Do not write your name on any part of this survey!
Please use the following scale to answer question 1-10:
1—strongly disagree
2—disagree
3—indifferent
4—agree
5—strongly agree

1. This class increased my understanding of spatial thinking as it applies to life spaces or the world we live in.
   (Examples might include wayfinding, navigation, assembling parts for a model or building project, or packing a car to minimize the space that's used)

   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:
2. This class increased my understanding of spatial thinking as it applies to scientific understanding or visualizing the arrangement of the natural world.
   (Examples might include thinking differently about varying scales such as the structure of atoms, the geologic structure of the Earth or the arrangement of the solar system/universe.)

   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:
3. This class increased my understanding of spatial thinking as it applies to the relationship among objects that have a spatial distribution or character.

   (Examples might include order or sequence of event occurring across space such as population change or the similarity of dissimilarity among the pattern or sequence of phenomenon such as the relation of economic activities to particular roads or traffic patterns.)

   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:
4. This class increased my understanding of how GIS (Geographic Information Systems) might be used to solve a problem.
   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:
5. This class increased my understanding of how GPS (Global Positioning Systems) might be used to solve a problem.

   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:
6. This class increased my understanding of how RS (Remote Sensing) might be used to solve a problem.

   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:

7. This class increased my understanding of how GIS, GPS, and RS could be used to solve a problem in Biology or another science course.

   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:
8. This class increased my understanding of how GIS, GPS, and RS could be used to solve a problem in Mathematics III or another mathematics course.

   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:
9. This class increased my understanding of how GIS, GPS, and RS could be used solve a problem in social studies, geography, and history.

   1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
   Please list an example:

10. This class increased my understanding of how GIS, GPS, and RS could be used solve a problem in real life outside of school.

    1-strongly disagree 2-disagree 3-indifferent 4-agree 5-strongly agree
    Please list an example:

APPENDIX B:

HASKELL'S (2001) KINDS OF TRANSFER

Kind of Transfer	Description
1. Content-to-Content	Using knowledge from one content area to learn content of another
2. Procedural-to-Procedural	Applying procedures from one skill to another skill
3. Declarative-to-Procedural	Helps one to take learning into action
4. Procedural-to-Declarative	Helps one to acquire additional abstract knowledge when we already have practical experience with it
5. Strategic	When one gains knowledge concerning cognitive processes by observing one's cognitive activities while learning
6. Conditional	When one applies learning from one context to another
7. Theoretical	When one is able to transfer in-depth understanding of cause and effect relationships from one area to another
8. General or Nonspecific	When past knowledge is transferred to another seemingly unrelated situation
9. Literal	The direct application of knowledge to a new learning situation
10. Vertical	When learning requires prerequisite skills
11. Lateral	When past learning is transferred to identical level in learning hierarchy
12. Reverse	Modifying mental patterns relative to similarities in new situations
13. Proportional	An abstract type of transfer
14. Relational	When one perceives two things sharing the same structure, despite any relationship

APPENDIX C:

HUMAN PARTICIPANTS REVIEW PARENTAL PERMISSION

Your student has been invited to participate in a research project conducted through the University of Northern Iowa. The University requires that you give your signed agreement to let your child participate in this project. The following information is provided to help you make an informed decision about whether or not you want your son/daughter to participate.

The study, *Transfer of Geospatial Technology skills from Social Studies to other core areas of Science and Mathematics* will be conducted over approximately a four-week period during the spring of 2012 within the context of the regular course curriculum and will occur during the regular class period. Students will be introduced to geospatial technology skills (ie. mapping, GPS point plotting, use of satellite imagery and others) as embedded curricular pieces of United States History. The study will focus on the student's transfer of these skills into other core areas of Earth Science and Integrated Mathematics I. A geospatial technology skills assessment, pre and post content tests and an online questionnaire will be used to gather data. Each of the assessments, tests and questionnaire will take approximately 30 minutes to complete and will be taken during regular class time. Specifically, the Earth Science and Integrated Mathematics I unit content tests will be used to investigate the impact of geospatial technologies on student content learning. The results of the assessments will be used to determine what transfer of learning, if any, occurred and what differences in learning were impacted by the use of geospatial technologies. Participation in this study will allow the researcher access to this data.

As with any study, there may be some discomfort when students are asked to reveal their perceptions about their choices of learning options for fear that it may reflect negatively on the teacher. To minimize this, the classroom teacher will not have access to any questionnaire responses.

Student confidentiality will be maintained at all times. Specifically regarding the student questionnaire, the student's confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the internet by any third parties. No student names or identifying marks will be used on any future publications of this research.

If you would like additional information, please feel free to contact the researcher via email at curt.nielsen@uni.edu or via telephone at 319.273.2608. You may also contact the office of Human Participants Coordinator, University of Northern Iowa, at 319.273.6148, for answers to questions about rights of research participants and the participant review process.

Below you will find the consent form, which asks for your consent or refusal to participate in this study by completing online geospatial technologies skills assessment and questionnaire. Participation in this study is strictly voluntary. If you choose to allow your child to complete the geospatial technologies skills assessment and questionnaire they may choose to withdraw at any point in the study. **In either case *please* reply to this email as soon as possible.**

The student's confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the internet by any third parties.

Please copy and paste one of the following responses to this invitation in a reply email along with a **typed signature**.

I am fully aware of the nature and extent of my child's participation in this study as stated above and the possible risks arising from it. I have access to a printed a copy of this form. ***I hereby agree to allow my son/daughter to participate in this study.***

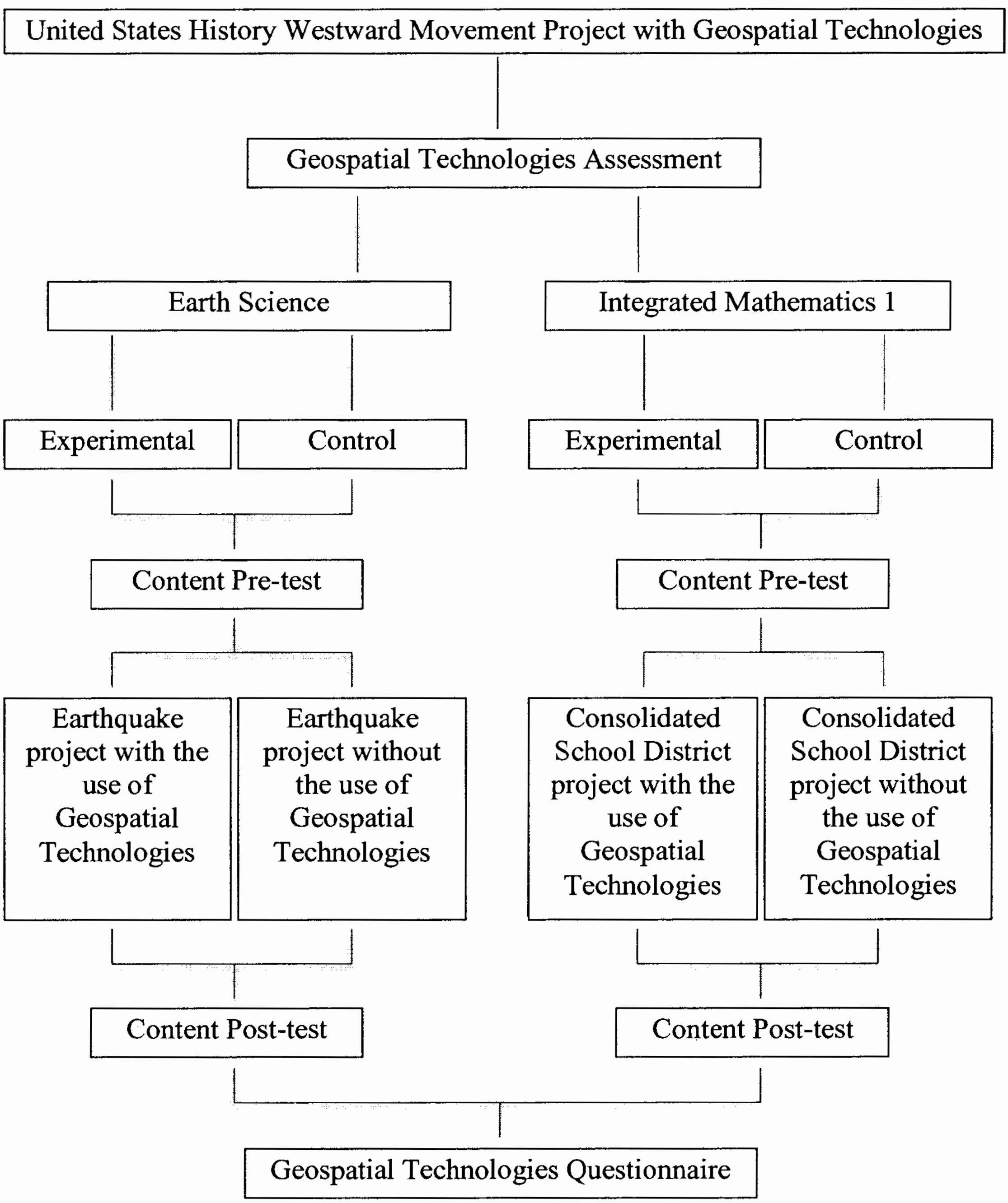
I am fully aware of the nature and extent of my child's participation in this study as stated above and the possible risks arising from it. ***I choose not to allow my son/daughter to participate in this study.***

Sincerely,

Curtis P. Nielsen
Malcolm Price Laboratory School Instructor
Doctoral Student, University of Northern Iowa

APPENDIX D:

STUDY FLOW CHART



APPENDIX E:

POST US HISTORY GEOSPATIAL TECHNOLOGIES CONTENT ASSESSMENT

The following questions are meant to discover your knowledge of ArcGIS Explorer Online that you used in U.S. History. Please answer the questions to the best of your ability. **CHECK ALL POSSIBLE ANSWERS FOR EACH QUESTION**

1. To create a point or pin with *ArcGIS Explorer Online* you must:
   a. click the add features icon,
   b. click stick pin, pushpin or cross
   c. click the center of the map and drag to place the point
   d. click the map to place the point

2. To create a line with *ArcGIS Explorer Online* you must:
   a. click the add features icon
   b. click the measure tool
   c. locate the point from which you want to start a line and click
   d. drag to the point you want to end and double click

3. The Base map tool on *ArcGIS Explorer Online* allows the user to:
   a. change to a different base map
   b. take a picture of the map
   c. has several maps to choose from
   d. record base map features

4. The imagery base maps on *ArcGIS Explorer Online* can be described as:
   a. one giant satellite picture taken from space
   b. two hemispheric satellite pictures seamed together
   c. thousands of satellite pictures seamed together
   d. four hemispheric satellite pictures seamed together

5. The Add Features tab on *ArcGIS Explorer Online* includes all of the following except:
   a. pins
   b. text
   c. pictures
   d. shapes

6. Map notes on *ArcGIS Explorer Online* refers to all of the following except:
   a. text added to a map by the map creator
   b. is indexed in the layers tab
   c. can be removed
   d. are only visible to the map creator

7. In *ArcGIS Explorer Online* you can
   a. change base maps
   b. print
   c. save
   d. add content

8. In *ArcGIS Explorer Online* the Add Content tool allows you to:
   a. add content from the internet
   b. import content from CD-ROM
   c. save content to the My Content tab
   d. choose from content in My Content tab

9. To use the measure tool on *ArcGIS Explorer Online* you:
   a. can use more than one unit of measure
   b. click a point on the map to highlight it
   c. drag the line from that point and click
   d. can measure an area

10. Describe how to mark a point on *ArcGIS Explorer Online*.

APPENDIX F:

QUESTIONNAIRE EARTH SCIENCE – EXPERIMENTAL GROUP

In U.S. History you completed a project on Westward Expansion using *ArcGIS Explorer Online*. Imagine you are introducing a **new student** to *ArcGIS Explorer Online* and in **4 or 5** sentences respond to each of the following items. **BE SPECIFIC AND DETAILED IN YOUR RESPONSES.**

1. Enter your student identification number given to you by your teacher.

2. Explain **how** you used points or pins in the Earth Quake Distribution Project.

3. Explain the *similarities* of **how** you used points in the Earth Quake Distribution project compared to the U. S. History Westward Expansion project.

4. Explain **how** you used the measure tool to measure distance to complete the Earth Science project.

5. Explain the *similarities* of **how** you used the measure tool to measure distances to complete the Earth Science project compared to the U.S. History Westward Expansion project.

6. Explain **why** you might choose a specific base map to complete the Earth Science project.

7. Explain the *similarities* of **how** you used base maps to complete the Earth Science project compared to the U. S. History Westward Expansion project.

8. Explain and provide reasons (more than one) **why** one would use geospatial technologies, such as *ArcGIS Explorer Online* to display and analyze data.

APPENDIX G:

QUESTIONNAIRE EARTH SCIENCE – CONTROL GROUP

In U.S. History you completed a project on Westward Expansion using *ArcGIS Explorer Online*. Imagine you are introducing a **new student** to *ArcGIS Explorer Online* and in **4 or 5** sentences respond to each of the following items. **BE SPECIFIC AND DETAILED IN YOUR RESPONSES.**

1. Enter your student identification number given to you by your teacher.

2. Explain **how** points or pins could be used in the Earth Quake Distribution Project.

3. Explain the *similarities* of **how** you could use points in the Earth Quake Distribution project compared to the U. S. History Westward Expansion project.

4. Explain **how** you could use the measure tool to measure distance to complete the Earth Science project.

5. Explain the *similarities* of **how** you could use the measure tool to measure distances to complete the Earth Science project compared to the U.S. History Westward Expansion project.

6. Explain **why** you might choose a specific base map to complete the Earth Science project.

7. Explain the *similarities* of **how** you could use base maps to complete the Earth Science project compared to the U. S. History Westward Expansion project.

8. Explain and provide reasons (more than one) **why** one would use geospatial technologies, such as *ArcGIS Explorer Online* to display and analyze data.

APPENDIX H:

QUESTIONNAIRE INTEGRATED MATHEMATICS 1 – EXPERIMENTAL GROUP

In U.S. History you completed a project on Westward Expansion using *ArcGIS Explorer Online*. Imagine you are introducing a **new student** to *ArcGIS Explorer Online* and in **4 or 5** sentences respond to each of the following items. **BE SPECIFIC AND DETAILED IN YOUR RESPONSES.**

1. Enter your student identification number given to you by your teacher.

2. Explain **how** you used points or pins in the Integrated Mathematics project.

3. Explain the *similarities* of **how** you used points in the Integrated Mathematics project compared to the U. S. History Westward Expansion project.

4. Explain **how** you used the measure tool to measure distance to complete the Integrated Mathematics project.

5. Explain the *similarities* of **how** you used the measure tool to measure distances to complete the Integrated Mathematics project compared to the U.S. History Westward Expansion project.

6. Explain **why** you might choose a specific base map to complete the Integrated Mathematics project.

7. Explain the *similarities* of **how** you used base maps to complete the Integrated Mathematics project compared to the U. S. History Westward Expansion project.

8. Explain and provide reasons (more than one) **why** one would use geospatial technologies, such as *ArcGIS Explorer Online* to display and analyze data.

APPENDIX I:

QUESTIONNAIRE INTEGRATED MATHEMATICS 1 – CONTROL GROUP

In U.S. History you completed a project on Westward Expansion using *ArcGIS Explorer Online*. Imagine you are introducing a **new student** to *ArcGIS Explorer Online* and in **4 or 5** sentences respond to each of the following items. **BE SPECIFIC AND DETAILED IN YOUR RESPONSES.**

1. Enter your student identification number given to you by your teacher.

2. Explain **how** points or pins could be used in the Integrated Mathematics project.

3. Explain the *similarities* of **how** you could use points in the Integrated Mathematics project compared to the U. S. History Westward Expansion project.

4. Explain **how** you could use the measure tool to measure distance to complete the Integrated Mathematics project.

5. Explain the *similarities* of **how** you could use the measure tool to measure distances to complete the Integrated Mathematics project compared to the U.S. History Westward Expansion project.

6. Explain **why** you might choose a specific base map to complete the Integrated Mathematics project.

7. Explain the *similarities* of **how** you could use base maps to complete the Integrated Mathematics project compared to the U. S. History Westward Expansion project.

8. Explain and provide reasons (more than one) **why** one would use geospatial technologies, such as *ArcGIS Explorer Online* to display and analyze data.

APPENDIX J:

HASKELL'S (2001) LEVELS OF TRANSFER

Level of Transfer	Description
1. Nonspecific	Demonstration of learning that is not uniquely applied.
2. Application	Applying previous learning to a specific situation.
3. Context	Applying previous learning to a slightly different situation
4. Near	Learning is transferred to situations that are closely related but not identical to previous situations
5. Far	Applying learning to contexts that are very different from original learning contexts
6. Displacement or creative	The discovery of similarities between old and new learning, which a new concept is then created.

APPENDIX K:

SCORING RUBRIC EARTH SCIENCE EXPERIMENTAL GROUP

Student Number:
Q3: Explain the *similarities* of **how** you used points in the Earth Quake Distribution project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

Q5: Explain the *similarities* of **how** you used the measure tool in the Earth Quake Distribution project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

Q7: Explain the *similarities* of **how** you used base maps in the Earth Quake Distribution project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

APPENDIX L:

SCORING RUBRIC EARTH SCIENCE CONTROL GROUP

Student Number:
Q3: Explain the *similarities* of **how** you could use points in the Earth Quake Distribution project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

Q5: Explain the *similarities* of **how** you could use the measure tool to measure distances to complete the Earth Science project compared to the U.S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

Q7: Explain the *similarities* of **how** you could use base maps to complete the Earth Science project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

APPENDIX M:

SCORING RUBRIC INTEGRATED MATHEMATICS I EXPERIMENTAL GROUP

Student Number:
Q3: Explain the *similarities* of **how** you used points in the Integrated Mathematics I project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

Q5: Explain the *similarities* of how you used the measure tool to measure distances to complete the Integrated Mathematics I project compared to the U.S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

Q7: Explain the *similarities* of **how** you used base maps in the Integrated Mathematics I project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

APPENDIX N:

SCORING RUBRIC INTEGRATED MATHEMATICS I CONTROL GROUP

Student Number:
Q3: Explain the *similarities* of **how** you could use points in the Integrated Mathematics project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

Q5: Explain the *similarities* of **how** you could use the measure tool to measure distances to complete the Integrated Mathematics project compared to the U.S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

Q7: Explain the *similarities* of **how** you could use base maps to complete the Integrated Mathematics project compared to the U. S. History Westward Expansion project.

Level	Response Description	Student Response	Score
Nonspecific Application	•Subject references an application of learning to a same or similar situation •Subject cites specifics of previous learning that is applied to a different situation.		1
Context	•Subject takes what is learned and applies to another different situation		2
Near	•Subject takes previous knowledge and transfers it to new situations that are closely similar to but not identical to previous situations.		3
Far/Creative	•Subject applies learning to situations that are quite dissimilar. •Subject shows insights in interactions of new and old learning.		4

APPENDIX O:

EARTH SCIENCE QUESTION 8

Explain and provide reasons (more than one) **why** one would use geospatial technologies, such as *ArcGIS Explorer Online* to display and analyze data.

Experimental	Control
1 reason would be because when your using a geospatial map you get a clearer view of what your trying to see, you control what your doing and can find almost anything about the earth you would like to, and another reason is that it is accessible to anyone that possess a computer so your not having to wait for someone to get done with a 2 dimensional map	It is useful for integrating different cartographic devices and uses into a simple app that may be accessed for free by anybody willing to do so. It is also useful for analyzing and organizing information gathered from the device.
If I wanted to find the area of something/where, the distance between two locations, the directions to get somewhere or the name of a location.	Plan a route for a vacation/trip. Locate towns or buildings, places
-Creating a map for a research project A visual aid is a very good way to convey information for any project -Using a map to keep track of data and important points or events Keeping track of notes with a visual program online would be much easier than a notebook, because you can access it anytime.	Because you can use the map features to help you find information and data
I would use this again for other projects because if the project has to do with finding or exploring places then I would use it because it is very helpful. It is just really helpful because you get to see anything you would like to and it's amazing!	To show in detail landmarks and other features.
1. The maps are very basic and detailed 2. It is simple (once you get used to it) 3. This specific program is best for analyzing data	because it shows detailed things in certain base maps, and it allows you to see where trails are, and rivers, and earthquakes, volcanoes, and other things
One might use these types of technologies for displaying data for a presentation, personal use, or for a thesis on that subject.	-it gives you a visual aid when explaining your findings and learning. -it shows you the relationships between locations -allows you to include technology in your project.
There are many reasons to us ArcGIS Explorer Online. Such as to find a certain place, to put points on areas, to see how large an area is, to be able to electronically plot points and find data, to find earthquakes, tectonic plates, trails, to find information about a certain town/state/country ect.	It is a better tool than something like Google maps for measuring distances and areas. You can also use many more base maps in ArcGIS than Google maps.
To better visualise where certain events occurred. To help discover patterns in data one is analyzing.	Easy to use and can use it anywhere
You could use it to map out a vacation that you want to take, or find and map where other members of your family lives. If you want you could put pins on all the places you've been in the	Mapping a trip to better understand how far you've traveled Displaying dangerous roads in a state or town this would be more suitable for snowy like weather

world.	
ArcGIS is able to display a map and give a good idea of where things are. For example, a base map with tectonic plates would be helpful for a project on earthquakes, because you can see where the plate boundaries are. You can also see multiple points at once with ArcGIS, so you can compare.	One reason is that your map is available to you anywhere you have Internet. One other reason is that you can easily change the type of map you are looking at.
It is easy to use. There are a lot of things you can do to help the assignment.	Because it's a really accurate data source with limitless possibilities of using maps to calculate geological data

Taken from:
http://www.surveymonkey.com/MySurvey_Responses.aspx?sm=oHDvzsvjmLBmGNmMHuUbaNozfs17n23PCLsdJtZT8lA%3d, August 6, 2012.

http://www.surveymonkey.com/MySurvey_Responses.aspx?sm=fWsUyVWYcw0NmBvIgXguhouhVPUArDLEclFpqoStmGg%3d, August 6, 2012

APPENDIX P:

INTEGRATED MATHEMATICS 1 QUESTION 8

Explain and provide reasons (more than one) **why** one would use geospatial technologies, such as *ArcGIS Explorer Online* to display and analyze data.

Experimental	Control
Geospatial technologies are useful for analyzing data such as distances, locations, and areas. Also, they help display data for projects involving the listed subjects. They are a good choice for conveying data for trying to place a building in a specific area. Finally, geospatial technologies help find ares of selected areas, and using that information to determine the cost of the land, or the optimal location for a building near that plot of land.	It show places clearly, it gives tool such as measure, and it plots points and pins.
to see how far a place is and to see the area of something	It is accessible from anywhere with internet. It helped if other people can get to it. You don't have to have a bunch of papers, you can have everything on one map and put it on different layers.
Measuring distances, finding midpoints, finding the fastest routes, learning an area and finding locations. I would likely use the program for more common uses than actual math or History.	ArcGIS provides a simple and effective way to arrange data using base maps and pins (with further features such as text and pictures). The data can then be shared with others. It is a useful tool for creating presentations of any sort. Base maps are available for things ranging from historic American trails to worldwide fish populations.
You would because if you are assigned a project that you need to see the places on a map then you would want to use ArcGIS because it is just a more resourceful way to apply you techniques and skills. Another way would be if you just want to see your house or your town then you can just have fun and create a map of where you live, where you want to go and things like that.	i dont know, sorry
For a thesis, a project like we did, or for personal benefit.	To plot point, to show clearly each landmark/street/ect.
Because it is easy to use and there are a lot of things you can do	Sever weather or houses or trails
It could be used to find a better place to place buildings or schools or other stuff. It could also be used to look at places where there is open spaces.	It gives you a good idea of the space you are working with. There are a lot of helpful tools. everything is digital so you can modify it easily.

I think two reasons for why we would use geospatial technologies technology would be that they are much more efficient then using the somewhat older, 2 dimensional maps because they are not updated like ArcGIS and you can't switch from base map to base map and also you can be more specific with something like ArcGIS beign able to zoom in and out for more accuracy	One, being that it's a helpful, up to date, accurate measuring, locating source. Another, that is helpful is that it comes out in several different base maps for certain kinds of projects
1. Detailed base maps 2. Decently easy to use tools	To gain knowledge of a town or city and to get the distances of the route they traveled during a trip or excursion.
To measure distances, see geographic features, for any project involving distances, for a project like ours that combines geography and math.	ArcGIS helps you to keep track of important locations, measure distances between locations, and clearly map out paths or trails.
to get a birds eye-view or if you are trying to plant a garden you could map it out and use the measuring tool and figure out how you would want it to look.	So you can plot measure and locate where people have been in history and see what they encountered while traveling. You can plan a route if you wanted to travel the same route as some of these people in history
To help get a visual, to plot points, to find a place, to make an area shot.	To show closed highways and streets in a state To show the distance between two locations
to be able to visualize, and solve problems that relate to problems having to do with maps	Map out towns and found distances from pn point to another.
So you would have to print it out and it's easy to get to and always have	It would be easier for students to learn how to work maps
	It would be easier and more convenient. And it's more fun.
	I don't know
	So you can see things more clearly, it is interactive, it is easy to use

Taken from:
http://www.surveymonkey.com/MySurvey_Responses.aspx?sm=FHeBnLH37j%2fPLNRP6kY02zeLc1PFKoTOfIsYfzgNUb4%3d, August 6, 2012.

http://www.surveymonkey.com/MySurvey_Responses.aspx?sm=2gLlePYcwjx%2fUt0Ci4GcUQwOd2JZf3XzPO5z25lOj7o%3d, August 6, 2012.

APPENDIX Q:

EARTH SCIENCE CONTENT PRE- AND POST-TESTS

EXPERIMENTAL GROUP				CONTROL GROUP			
Subject ID	Pre-Test	Post-Test	Difference	Subject ID	Pre-Test	Post-Test	Difference
10106	10	36	26	10043	14	36	22
10045	8	23	15	10044	6.5	26.5	20
10281	16.5	32	15.5	10202	11.5	29	17.5
10090	5	25.5	20.5	1565	10.5	20	9.5
10127	11.5	25	13.5	1507	15	36	21
10082	9	23	14	1508	9	15	6
10091	11	35	24	10307	13	21	8
10041	15	28	13	10289	5	18.5	13.5
1516	13	32	19	10194	13	16	3
10208	18	36	18	1537	18.5	38	19.5
10050	18	41	23	10046	5.5	24.5	19
10085	15	38	23	1513	16.5	34.5	18
10063	11.5	14	2.5	1514	9	32	23
				10295	9	24	15
				10064	5.5	16.5	11
Mean	12.42	29.88	17.46	Mean	10.77	25.83	15.07

APPENDIX R:

INTEGRATED MATHEMATICS 1 CONTENT PRE- AND POST-TEST

EXPERIMENTAL GROUP				CONTROL GROUP			
Subject ID	Pre-Test	Post-Test	Difference	Subject ID	Pre-Test	Post-Test	Difference
10106	0	6	6	10043	4	8	4
10045	3	3	0	10044	6	5	-1
10281	5	3	-2	10202	6	6	0
10090	1	4	3	1565	2	6	4
10127	5	7	2	1507	1	7	6
10082	5	4	-1	1508	3	7	4
10091	5	7	2	10307	4	8	4
10041	6	3	-3	10194	4	3	-1
1516	5	7	2	1537			0
10208	3	5	2	10046	2	6	4
10050	5	8	3	1513	5	6	1
10085	4	7	3	1514	3	7	4
10063	6	7	1	10295	2	5	3
				10064	2	7	5
Mean	4.08	5.46	1.38	Mean	3.14	5.79	2.64