The purpose of this study was to investigate student and educator conceptualizations of Geographic Information Systems (GIS), Instructional Technology (IT), and GIS in schools. GIS in education research to date has not focused on the understandings of educators and students. Studying these conceptualizations may further investigation of GIS as an instructional technology in K-12 education. Representational drawings and interviews in this study illustrated spatial and linguistic conceptualizations based on Paivio’s (1991) dual coding theory and is situated in Roger’s (2003) diffusion of innovations theory.

This multiple-case study combines qualitative and phenomenographic research methods. Phenomenographic researchers seek to categorize the common understandings generated by a set of individual participants to better illustrate internal representations of phenomena. Data collected included three representational drawings and three semi-structured interviews from each participant. Participants were selected based on the criteria of equivalent GIS skills and training. The four educators represented varied K-12 settings and curriculum areas in secondary and middle schools. The two students were middle schoolers. Each session began with a participant generating a representational drawing on a focused research question. Subsequent interviews expanded on participant conceptualizations that emerged in the drawings and probed further understandings of the phenomena represented.
The data revealed participants’ allocentric and egocentric positions of observation. The common understandings emergent in the data provided context for the analysis of GIS, IT, and GIS in schools within the framework of Rogers’ diffusion of innovations theory. The data indicated that to date, IT is further advanced in schools’ adoption and implementation process of diffusion than is GIS, which is located in Rogers’ (2003) initial stages of matching and agenda-setting. The confluence of participants’ understandings of GIS and IT provided insights into awareness issues, uncertainties, and questions that must be examined in schools’ innovation decision making.
To all of the teachers in my life

Not all who wander are lost.

--J.R.R. Tolkien
BIOGRAPHY

Shannon White was born in Williamsburg, Virginia. She attended Radford University in Virginia where she double majored in History and Social Sciences. Shannon minored in education however did not pursue teaching in the traditional school setting. Shannon returned to Williamsburg and worked at Colonial Williamsburg for three years. Her experiences teaching in the non-traditional, museum setting influence her teaching to this day.

Shannon moved to Raleigh, North Carolina in 1998 to pursue her graduate studies in Social Studies education at North Carolina State University. She met her husband, Tom Luther at that time. She and Tom have no children but have an enthusiastic and neurotic dog, India.

It was also during this time that she enrolled in the first Geographic Information Systems (GIS) in Education course in the nation taught at an institution of higher education. Shannon completed her Masters of Education with a concentration in Social Studies in 2001. She subsequently completed a GIS certificate and began to pursue her interests in instructional technology.

Throughout her graduate career Shannon has co-instructed and instructed the GIS in Education course and numerous geography courses. In addition, Shannon has been provided opportunities during her graduate work to teach Middle Grades Social Studies Methods and Materials and assist in the development of a research based educational facility in the College of Education. Her interests in instructional technologies were facilitated by numerous research and consulting positions where she was able to extend her creativity through computer-based media.
ACKNOWLEDGEMENTS

There are numerous people who have supported me through this journey that is known as a dissertation. I would like to first acknowledge the following friends and family who have often put their lives on hold for what was needed for me to get to this place.

First, I must recognize my very patient and supportive husband, Tom for his role in this process. This dissertation and my graduate work would not have been completed without your encouragement. At times you put your life on hold for me to pursue my goal, for that I cannot thank you enough. I look forward to a time in our marriage when I am not a student and you can return to school and I can reciprocate.

My family has given me encouragement in so many ways over the years I do not know where to begin. My mother, Jan Allen, has taught me through example. And she has given me opportunities to expand my horizons; travel to unknown places; and try new things. My mother has always encouraged me to pursue my goals on my terms and for that I cannot say thank you enough. Bill, her husband, always provides a quiet balance our often-boisterous family. His quick wit has not gone unnoticed and is greatly appreciated.

My father, Steve White, has provided me with a keen sense of individuality balanced with the importance of community. His ability to never meet a stranger has not gone unnoticed and I find is invaluable. The sense of community I inherited from him reverberates each time I return home and walk through the door of the store and am greeted by so many familiar faces. Dad fostered my curiosity about the world and nature through our various family “adventures.” Lorraine, his partner, always has a story to make you laugh and a smile of encouragement when things aren’t always 100 percent.
My sister, Crystal and my dear friend Amy have been with me through thick and thin. Both of you challenged me to excel academically, especially when classes, college and coursework were the farthest thing from my mind. I know that no matter the distance and time I can always rely on you for support and friendship.

My dear friends Mike Fahy and Christy Thompson, you have known when it was necessary to get me out of the books. Your timing is eerie at times. Christy, we have struggled through higher education together, although at different schools and for different purposes but now we can both see the light at the end of the tunnel. I think it was worth it. Mike, without your technical assistance over the past years I would not have been as interested in technology as I am. Your patience and willingness to share all of the new ideas and “gadgets” have been priceless.

I owe a debt of gratitude to the educators, the students, and their families. Without your willingness to participate and support this research through your precious personal time this research would not have occurred. I cannot thank you enough. I hope that you know how invaluable you were in this process.

My colleague and friend, Barbaree Duke, your invaluable insights from the real world of K-12 education have always been a ‘reality check’ for me. For many reasons this research also would not have occurred with out you. Your support, especially during those “crunchy” times was priceless. I look forward to our new adventures, research, and work in the future.

My committee members must also be commended for their role in this research. Dr. Marsha Alibrandi, had it not been for you I would never have been introduced to this entity we know as GIS. Your guidance has been inestimable and your enthusiasm has been infectious. Had you not taken me under your wing as a graduate student I would not have
had the experiences at conferences, in schools, and at the university that I have had. I know we will continue to work together in the future but I want thank you for all that you have done for me to date.

Dr. Alan Foley, you have challenged me from the first moment I stepped into one of your classes. You encouraged me to read and think about subjects that I had not previously been aware. Your, almost omniscient, way of knowing when I needed to be pushed and how to facilitate the process in a way that worked for me was essential. And of course your sage advice, “just get it done” will echo in my ears for years. I look forward to future collaboration with you.

Dr. Joseph Kerski, your energy and passion for geography and all things “geo” have been a great inspiration. Thank you for your keen insights and words of encouragement as I have moved through this process. I hope to continue to work with you and create a new awareness of the need for geography and spatial understandings. I have enjoyed our confluence trips and look forward to many more.

Dr. Ellen Vasu and Dr. Peter Hessling, I would like to thank you both for the time and attention you have given to my work. You both have encouraged me to begin to step out of my own understandings and think more globally about the impact of the research and the questions we should be asking as researchers.

There are many others who also have provided me with support and friendship through this process. I would like to thank John Ogburn for his assistance with the initial graphic design of several of my figures. Pat Dalton for the early edits of my writing and an ear to bend. Dr. Candy Beal for her encouragement and patience with me especially in this
last year. Thanks to Scott Lennon and MeiMei Davis, for the technical help and back-up space for this research. Please forgive me if I have left anyone out.

There are some things you learn best in calm, and some in storm.

Willa Cather, *The Song of the Lark*, 1915
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CHAPTER ONE
INTRODUCTION

What is in a name? Some say that a person's name influences who they are. I was named after a place, Shannon Hill, Virginia. As a child I wondered why I was named after this place. It was a rural community an hour and a half from my hometown, Williamsburg. I would stare at the map of the Virginia and see myself on the map. Perhaps it was just the beginning of my research interests in Geographic Information Systems (GIS) in K-12 settings. A GIS is, in the simplest sense, a high tech mapping and analysis tool. Who we are is tied to place -- all of our experiences occur somewhere.

Chapter Introduction

This chapter will provide an overview of this research study and an introduction to the key concepts and terminology. This chapter begins with an introduction to the study and is followed by the purpose of the study. The research questions investigated in this study and the nature of the study complete the overview of the research. The research overview is followed by background information for the reader. Within the background information the reader is introduced to Geographic Information Systems (GIS) through a description of how a GIS works. A history of the technology and its use(s) in various industries is provided. As the discussion shifts to an educational focus, an overview of the broader field of instructional technology (IT) as it relates to this study is provided. This is followed by a discussion of GIS integration in K-12 education in the US. This chapter concludes with an overview of the nature of this study followed by an overview of chapters 2 through 5.

Introduction to the Study

The emergence of computer technologies in the classroom has introduced a new dimension of instruction for the classroom teacher. Teachers are currently expected to meet
curriculum and technology standards from kindergarten through grade twelve.\(^1\) According to the National Educational Technology Standards for Teachers (NETS-T):

Teachers must be prepared to empower students with the advantages technology can bring. Schools and classrooms, both real and virtual, must have teachers who are equipped with technology resources and skills and who can effectively teach the necessary subject matter content while incorporating technology concepts and skills. Real-world connections, primary source material, and sophisticated data-gathering and analysis tools are only a few of the resources that enable teachers to provide heretofore unimaginable opportunities for conceptual understanding” (International Society for Technology in Education, 2000).

Geographic Information Systems, or GIS, can meet some of those needs addressed as technological advantages. A GIS is a spatially based technology, which allows the user to visually represent data in the forms of maps, charts, aerial images, satellite images and even 3-D representations. In the most simplistic sense it allows the user to create high tech maps however, the power of a GIS is in the analysis and geographic inquiry that may take place when examining multiple layers of data. Demographic data and natural resource data may be compared with hazardous waste sites and ground water resources with the touch of a button. Locational inquiry and relationship inferences may be examined through the spatial medium of the map. Behind each GIS map layer is a database of information that may be user created, purchased or downloaded.

GIS is found around us every day from the weather maps we see on television to the directions we may query from a website (such as *MapQuest.com*). These exemplify users

\(^1\) Curriculum specific standards may be according to national and/or state educational organizations, such as the National Council for the Social Studies ([http://www.socialstudies.org/standards/](http://www.socialstudies.org/standards/)) for social studies education or North Carolina Department of Public Instruction ([http://www.ncpublicschools.org/curriculum/](http://www.ncpublicschools.org/curriculum/)) National technology standards for pre-K to grade 12 students can be found through organizations such as International Society for Technology in Education (ISTE) ([http://cnets.iste.org/student/s_book.html](http://cnets.iste.org/student/s_book.html)).
displaying GIS data rather than using GIS as an analytical tool. Individuals can collect data and display the spatial relationships found within the data. Each individual who uses a GIS may develop a line of inquiry and analysis of specific geographic data that may differ from another individual with the same data. The potential for GIS in the classroom is in the ability for students to coordinate, represent and analyze the cultural, demographic, socio-economic and physical landscapes of the world.

As a spatial tool for the classroom, GIS allows students to investigate their community and world dynamically. Students can ask questions and draw conclusions based on the visual, quantitative, and qualitative data they explore using a GIS. Returning to the NETS-T expectations of teachers using technology, GIS can provide students with data collection experiences in the real world which they can then bring into a virtual context throughout much of the K-12 curriculum. Students and educators are able to make data driven decisions using a GIS. They can examine and integrate primary source information, gather their own data or use existing data and analyze the data in critical and meaningful ways. Although it is a tool often found in the business world, GIS is not commonly found in US schools to date.

**Purpose of the Study**

Research about GIS in K-12 education is still a relatively new field of inquiry in comparison to GIS research in other industries. As early as 1990, there had been a push toward a research agenda for this field. Educational researchers have begun to evaluate research questions such as: who is using GIS; how is it being implemented; how does it affect student understanding and cognition; and how is learning impacted by GIS? (Keiper, 1995, Audet, 1993, Kerski, 2000, 2003, Baker, 2003, Crabb, 2001). In addition, researchers
are examining both past and present training methods. Research in GIS in education has included both quantitative methods, such as surveys (Kerski, 2003), pre- and post-test analysis of content knowledge understanding (Baker, 2002), and qualitative methods, such as the case study provided by Crabb (2001).

In my exhaustive search of the literature, I have not found studies examining student and/or teacher conceptualizations of GIS or studies attempting to explore how students and teachers understand the technology. Research by Audet in 1993 investigated cognitive implications of GIS specifically linked to problem solving skills. His research was among the first in the field to investigate GIS in education and began to tie GIS to instruction and technology.

However, through my own experiences teaching and observing novices learning and integrating GIS into their own curricular areas and interests, a number of questions began to arise in my mind. These questions included: What connections, if any, do students and educators make between GIS in the world and GIS in the schools? Are there any similarities that may be drawn by these individuals between their understandings of instructional technologies and GIS? Answers to this line of inquiry may provide GIS researchers, GIS educators, and GIS software manufacturers with a better frame of how this technology may, or may not, be integrated into K-12 education. These queries, based in my own experiences as a GIS educator, were the initial stages of the development of the research questions for this study, further discussed in the next section.

GIS is a technology based on spatial understandings. In order to better understand the conceptualizations of educational users of GIS it is important to investigate their understandings based on spatial cognition theories and existing research protocols. Mavers,
Somekh and Restorick (2002) investigated student conceptualizations of information and communication technologies in Europe. Their phenomenographic research using students’ representations and interviews was central in the development of this study. Their research will be further discussed in the review of literature and methodology (Chapters 2 and 3 respectively). The relationship between linguistics and image based representations to spatial cognition is discussed later in this chapter. In this study I use student- and educator-created representational drawings as the basis of interviews to begin to understand individual conceptualizations of GIS in the world, instructional technology and GIS in schools to investigate the research questions that follow.

**Research Questions**

This study is structured by multi-case study research and phenomenographic research methods further explained in the methodology in chapter 3. Participant created representational drawings and semi-structured interviews were the primary data collected for analysis in this study. With the purpose of this study in mind (understanding how students and educators conceptualize GIS, IT and GIS in schools), the use of drawings and interviews enable the researcher to investigate individual spatial and linguistic understandings of these topics. This is framed by spatial cognition theory as explored further in the literature review in chapter 2.

Through the use of these methods and data sources I explore the common understandings of GIS, instructional technology, and GIS in schools between and among the participants using phenomenographic research methods. In order to contribute to the understandings of GIS by educators and students, my research is founded on the following key questions:
1. How do students and educators conceptualize GIS?
2. How do students and educators conceptualize Instructional Technology?
3. How do students and educators conceptualize GIS in schools?
4. What similarities or differences exist between how students and educators perceive these three ideas?
5. How may educator and student conceptualizations of GIS and instructional technology inform future GIS implementation in K-12 schools? How may these conceptualizations inform pre-service teacher education, and professional development for educators?

The first question investigates student and educator conceptualizations of GIS in the broadest and was the focus of the first of three interviews. While the middle school students and the educators were requested to participate in the study based on the completion of GIS coursework, this interview provided an indication of the scope of their understanding of the technology. This first set of drawings and interviews were guided by this initial research question. The data provided by the subjects may also be used to compare documents of their conceptualizations of GIS in schools. In addition, this question also investigates how the participants view GIS in the context of the world. The GIS coursework that all of the participants completed included an experience with community outreach and partnership in GIS that may, or may not, influence this perception. In addition, I was curious about whether GIS in education would be included or omitted from this perspective.

As the research becomes more focused toward the participants’ understandings of GIS in schools, I felt it necessary to investigate their understandings of instructional technology. The second research question: “How do students and educators conceptualize instructional technology?” is intended to provide an understanding of how they understand instructional technology and/or technology used in K-12 classrooms. This perspective is important because it provides context for the participant’s understandings of instructional
technology use in schools. The data from the interviews focused on this question may also be compared to the GIS in schools data for similarities and differences. As illustrated within the literature review, the diffusion of innovations issues surrounding IT may help illustrate the decision-making process that must be made regarding GIS. How students and educators conceptualize IT may benefit the GIS in schools community of researchers, educators, and software developers in the common understandings that exist between GIS and IT in the framework of the diffusion of innovation theories.

The third and final interview was derived from the third research question: How do students and educators conceptualize GIS in schools? This question is important to the GIS in education research as it explores more deeply how students and educators understand and view GIS in the K-12 schools. This question was intended to provide insights as to which curricular areas are tied to the participant understandings of GIS as well as who might use GIS and where it might be found in a school. This question may also provide information regarding how students and educators view how and where GIS is or might be used in schools.

The fourth question investigates the overall understandings of GIS, IT and GIS in schools among and between the participants. The categories of understanding that emerge through the data will provide a framework for the common conceptualizations of these phenomena. My curiosity regarding the differences of the perspectives was based on an assumption of the different experiences between students and educators in the school environment. I felt it was important to include both student and educator perspectives in this research as their roles and experiences in K-12 education are different. Students travel through a number of classes, curricular areas and pedagogical approaches every day.
Educators are often tied to one classroom and are knowledgeable in their curricular area and may, or may not, make connections to other subject areas or other classes. I wondered whether the students would provide a broader perspective of these topics based on their schooling experiences. Or would the students only be able to make connections to the subjects they found interesting? How would educators, in contrast, view the connections between the technology and the curriculum?

Those common understandings of GIS, IT, and GIS in schools by educators and students are the basis of the final research question. How these findings may inform GIS implementation in K-12 schools, pre-service education and professional development will be further discussed within chapter 5 in a discussion of the implications of this research. This question is based on an assumption that there is a perceived value in integrating GIS within existing K-12 school structures and curricula. If GIS is adopted as an innovation in education, findings from this question might provide insights for future implementation, training and integration of this technology.

GIS is in the earliest stages of adoption in education whereas instructional technology is more widespread in U.S. schools. Investigation of the conceptualizations of GIS and GIS in schools by students and educators may help GIS in education researchers, educators using GIS, GIS software developers and instructional technologists understand how, where, and why GIS may be integrated in the curriculum, if at all. Investigating the student and educator conceptualizations of IT, GIS, and GIS in schools may contextualize the technology within the existing curriculum structures of instructional technology. Or this investigation may yield the differences that students and educators envision between GIS and IT. The conceptualization and cognition issues surrounding GIS and IT facilitates further
understanding of the decision process involved with the adoption of an innovation such as GIS.

**Nature of the Study**

This study is focused on educators who completed a college level GIS in education course at a land-grant university in a southeastern mid-sized city. (See Appendix A for demographic information regarding this population). In order to compare and contrast student and educator conceptualizations, the study also included students at the middle school level who learned GIS through a similar model of instruction to the teacher participants. The middle school students had completed a minimum of two semester-long GIS courses that included skill sets equivalent to the graduate level course work. One of the constants within the structure of this study was that one of the college level instructors was also the instructor of the middle school students for at least one GIS course. For more information regarding the course content in the college level and middle school GIS class see appendices C and D respectively.

In this study I investigated individual understandings through a series of three interviews. The focus of the first interview was GIS in the world. The second interview focused on the participant’s understanding of instructional technology. The third and final interview focused on the conceptualizations of GIS in schools. Each interview began with a thirty minute time period to draw a representation based on the topic of the interview. The representation was the basis of that interview that followed. The combination of the verbal and image-based data collected in this discussion is grounded in spatial and linguistic cognition and was analyzed using phenomenographic methods.
Phenomenography originated in Sweden in the 1970s. Original writings in this field began with Ference Marton in 1981. This qualitative approach is empirically based. Marton (1986) notes, “It is a goal of phenomenography to discover the structural framework within which various categories of understanding exist. Such structures (a complex of categories of categories and description) should prove useful in understanding other people’s understandings” (p. 34). Phenomenographic researchers seek to categorize the understandings of individual learners in order to better understand the phenomena from a common grouping of individual’s understandings. These categories are often referred to as categories of description. In phenomenographic literature, this emergence of the categories of understanding (or description) from the data is a key characteristic of the analysis.

The understandings of educators and of students of GIS, IT and GIS in schools is important for future research in this field as well as an examination of current GIS instructional methods. Often researcher or industry interests are the impetus for integration of new technologies in the classroom. I was more interested in a bottom-up rather than top-down approach in my research through eliciting the conceptualizations generated by the educators and the students regarding GIS and IT.

It is important to me that the voices of these early innovators in the adoption of GIS in education are heard. If they do not see value in this technology or ways it might be implemented in the schools, this may inform future decisions that are made regarding GIS in their educational settings. Finally, my discussion may inform applications of Rogers’ model of diffusion of innovations.
**Background of the Problem**

While GIS is ubiquitous in post-modern lifestyles saturated by satellite-based communications and media, and while diffusion of innovations theory would place school GIS integration at its earliest stage on the diffusion curve, there remains the question, why integrate GIS into schools? I address this first by discussing the scope of GIS, and follow this with a comparison of GIS components and the required technology skills as they relate to the NETS standards for students.

Perhaps the most overarching problem in GIS integration is that while GIS is ubiquitous in the world it remains “invisible” to educators and students as an instructional technology. GIS is found in our lives daily in weather mapping; Internet-based site and direction locators; automobile site and direction locators; local, state, and federal property and tax mapping; real estate applications; demographic analysis; and in other areas. I therefore provide a broader explanation of GIS to build toward a discussion of the specific parts of the problem my research is intended to illustrate.

**Defining GIS and its Components**

Geographic Information Systems, according to Longley, Goodchild, Maguire and Rhind (2001), have not been defined in any singular way. The simplest explanation is that a GIS allows the user to use, analyze, and create high-tech maps. However, a GIS is more complex than that statement implies. A GIS can spatially represent tabular data that it draws from a database; it can model this information; and the information can be manipulated. The spatial representation of data is most typically a computer-generated map; however it may also include a 3-D visualization of a landform or a cityscape.
A GIS has several components. A GIS is a system of hardware (computer(s) and the necessary peripheral components) and software used for geographic analysis. In addition to the hardware other essential components of GIS include “data, people, training, and sound analysis methods for interpreting the results generated by the GIS” (GIS.com, 2000-2001). The most important aspect of using a GIS is to begin with a question that has a spatial reference. To begin the inquiry a GIS requires a georeference as the starting point. A georeference is a known point on the Earth’s surface. Georeferences tie locations to a GIS through coordinate systems such as latitude and longitude (as in a GPS) or through geocoded data fields such as street addresses (as in MapQuest.com)

A user with a geographic inquiry can begin by viewing existing data and/or may import, collect and create data. GIS data sources can vary depending on the user and the creator. Most data that is available to the general public is derived from government agencies. The map seen in Figure 1 is a visual representation of Wake County, North Carolina. The data found in this map was accessed through the county GIS office. Many state, local, and federal agencies use GIS for homeland security, watershed management, wildlife management, coordination of emergency services, and many other diverse purposes. For further discussion of state, local and federal uses of GIS O’Looney (2000) and Walford (2002) address such issues. There are also numerous companies that offer GIS data such as ThinkBurst Media, Inc. (formerly GeoComm International Corporation) who maintain the GIS Data Depot (2003). In addition, there are numerous public and private organizations and companies that provide aerial photographs and satellite imagery that may be integrated into a GIS as separate layers of the map.
The data layers available in this GIS project are found in a table of contents to the left of the visual representation in Figure 1. As seen in this example, the visible layers of the map have a checked box next to them in the table of contents, these include: major roads, lakes and ponds, public open spaces and the Wake County boundary. In order to view other data layers, aerial images, or satellite images the user must check them “on.” The layers are then digitally updated onto the visual representation or map. Examples of the various types of data and ways of viewing them in a GIS will follow.
Layers of a GIS map are said to be dynamic. The visually represented data are derived from a tabular database and a user can move between the two seamlessly, including selection of data. Information that is selected in the database will display within the map and vice versa. This concept is further illustrated through the example provided in Figure 2. In Figure 2 the polygon features of open spaces and water layers have been “turned off” and are no longer visible to the user on the map. The roads and county boundary are still visible and the public schools layer of data has been added to the representation. The database information can be seen in the table at the bottom right of the screen, where selected record, in this case “Olds Elementary,” in the database is highlighted in a blue tone. The corresponding point feature representing the location of the elementary school is selected in the same blue tone in the middle of the map. A point, line or polygon feature, (or multiple features) can be selected from the map and the corresponding record(s) will be selected within the database and vice versa.
Figure 2. Screen shot of a selected feature in the tabular database. A selected feature (highlighted) in the tabular database which corresponds to a point feature on the map. The corresponding point is selected in the same color. (Map created by author. Data source: Wake County GIS Office, 2004)

The information for each layer of the map found in the tabular database may be any number of fields the user creates. The visual representations produced in a GIS are useful as geographic displays of the data as well as for spatially based analysis. The information displayed is drawn from the database. The user determines which fields to present visually. Data in a GIS database may include numeric, Boolean and/or text based information. While all three types of fields are included in this database only one is currently displayed on the map; each field of the database may be added as a separate ‘layer’ of information. The text based codes indicating “type of building” were used to determine the visual representation of
the data shown in Figure 3. Within the Attributes of Public Schools database the numeric
data is representative of internal school ID codes, building capacities and a number of mobile
classrooms. The Boolean coded ESL field of the database distinguishes the schools with and
without English as a Second Language programs with a yes, represented by a “Y” or a no
represented with an “N” (see Figure 3). Text based fields may include strings such as a name
or abbreviated name for a location, a code for the status or type of school (E=elementary,
M=middle, O=optional or alternative school, etc), or it might include the physical address of
the building, administrator contact information, school districting codes or website addresses.

<table>
<thead>
<tr>
<th>Shape*</th>
<th>STATUS</th>
<th>CAPACITY</th>
<th>ESL</th>
<th>SCHOOLCODE</th>
<th>NAMESHORT</th>
<th>NAMELONG</th>
<th>CORECAPACITY</th>
<th>MOBILEUNIT</th>
</tr>
</thead>
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<td></td>
<td>106</td>
<td>MARTIN</td>
<td>MARTIN</td>
<td>870</td>
<td>7</td>
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<tr>
<td>Point</td>
<td>O</td>
<td>225 N</td>
<td></td>
<td>18</td>
<td>MARTY PHILLIPS</td>
<td>PHILLIPS</td>
<td>144</td>
<td>3</td>
</tr>
<tr>
<td>Point</td>
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<td>125 N</td>
<td></td>
<td>125</td>
<td>MIDDLE CREEK</td>
<td>MIDDLE</td>
<td>649</td>
<td>0</td>
</tr>
<tr>
<td>Point</td>
<td>H</td>
<td>1714 N</td>
<td></td>
<td>1704</td>
<td>MIDDLE CREEK</td>
<td>MIDDLE</td>
<td>1714</td>
<td>0</td>
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<tr>
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<td>2314 N</td>
<td></td>
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<td>MILLER</td>
<td>503</td>
<td>0</td>
</tr>
<tr>
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<td>2122 Y</td>
<td></td>
<td>2122</td>
<td>MILLERBRIDGE</td>
<td>MILLER</td>
<td>1606</td>
<td>23</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td>Point</td>
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<td>510 N</td>
<td></td>
<td>150</td>
<td>HOOFER SQUARE</td>
<td>HOOFER</td>
<td>780</td>
<td>5</td>
</tr>
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<td>154 N</td>
<td></td>
<td>154</td>
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<td>OLD KINNEM</td>
<td>127</td>
<td>1</td>
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<tr>
<td>Point</td>
<td>U</td>
<td>1500 N</td>
<td></td>
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<td>OLD KINNEM</td>
<td>OLD KINNEM</td>
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<td>Point</td>
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<td>510</td>
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<td>NORTH</td>
<td>503</td>
<td>3</td>
</tr>
<tr>
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<td>115 Y</td>
<td></td>
<td>115</td>
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<td>4</td>
</tr>
<tr>
<td>Point</td>
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<td></td>
<td>125</td>
<td>NAE GROVE</td>
<td>NAE GROVE</td>
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<td>5</td>
</tr>
<tr>
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<td>1255 N</td>
<td></td>
<td>1255</td>
<td>OLD GARNER</td>
<td>OLD GARNER</td>
<td>5999</td>
<td>5999</td>
</tr>
<tr>
<td>Point</td>
<td>O</td>
<td>1255 N</td>
<td></td>
<td>1255</td>
<td>OLD GARNER</td>
<td>OLD GARNER</td>
<td>5999</td>
<td>5999</td>
</tr>
</tbody>
</table>

**Figure 3.** A closer view of tabular data in a GIS. The selected record, number 101-Olds Elementary, is only one of 117 records with numeric, Boolean and text based attributes as seen in the headers of the table. This data is displayed as a point feature geographically. (Data source: Wake County GIS Office, 2004)
As mentioned previously, each layer of information of the map can be turned on and off to show different spatial aspects of a location, such as population, political boundaries, streets, elevation, hydrography, vegetation, and more. The user can also change the level in which they are viewing the data. The view of the data in Figure 1 was of major roads and natural attributes of the entire county whereas, in Figure 4 the data displayed is the streets and the public schools and the view is “zoomed in” toward the selected school. The map scale is changed slightly to enable the viewer to see more closely the proximity of Olds Elementary to other schools located in the central part of the county. The view of the map has changed in this figure and so has the view database information for the selected record. Figure 4 provides the reader with an alternative view of the database information about the school within a small window that identifies only the attributes from the table that are relevant to the feature clicked on in the map (Olds Elementary school in this example). Additionally, other documents such as photographs, scanned images, links to the World Wide Web and other multimedia may be connected to specific geographic features. In the GIS project provided in this example, a compressed digital image of the school is linked to the symbol for the school (see Figure 4). A user can provide multiple perspectives of the same data point from a visual representation of the geographic location to any of the database information or multimedia documents.
Figure 4. A “closer view” of the selected school record with multiple data links displayed in the GIS. The selected school, as represented by the blue dot in the center of the map, is visually represented at a different scale. The GIS software provides the user alternative views of the data. By clicking on the point feature representing the school only the attributes relative to that point might be displayed or other documents may be linked through the database, in this case an image of the front of the school. (Map created by author. Map data source: Wake County GIS Office, 2004)

The use of remotely sensed images such as satellite images and aerial photos enhances the spatial representations in a GIS. These images taken from airplanes and satellites high above a location can provide a “bird’s eye view” of a location to aid in the analysis of the geographic features and vegetation. The use of infrared, color, and black and white aerial imagery can provide a base map for other visible GIS layers. The point (the school), line (streets), features and polygon (pond) features are overlaid onto the aerial
image. The image provides context for the tabular based GIS data. As shown in Figure 5, in a color aerial photograph, features such as baseball fields, neighborhoods, buildings, and open spaces are instantly apparent.

Figure 5. A color aerial image of the selected school and the surrounding area... A color aerial image of the selected school and the surrounding area. GIS data layers such as streets and ponds are displayed on top of the aerial image. (Map created by author. Data source: Wake County GIS Office, 2004)

The user can change the scale of view of remotely sensed images as simply as s/he changed the view of the geographic features. The user can “zoom in” to take a closer look at a data point and the surrounding area. A black and white aerial view of Olds Elementary
School when zoomed in can elucidate features such as parking lots, neighboring homes, proximity to streets and other buildings (see Figure 6).

Figure 6 “Zooming in” in scale to a view of the school property using a black and white aerial image. The school building, the large white structure in the center of this view, is seen in context to the neighboring structures and landscape.

As mentioned previously, Figures 1, 4, 5, and 6 all display geographic information collected and created in one county at different scales. The data was all within one project and the user could move from a county-wide perspective to a more centralized area within the county and then to a block-level perspective. The focus in this instance was one school but the data possibilities are limitless. A GIS can begin at a global perspective of a topic of interest and move to a very specific location based on the decisions of the individual using and/or creating the data.
Three-dimensional representations are also possible using GIS. Images and aerial photographs can be integrated into a computer-based map to permit simple points, lines and polygons to become interactive for the user. The user can select the layers and scale s/he wishes to display. In other words, a user investigating a county-wide data set may be able to zoom out to investigate patterns that are county-wide as well as zooming in to a neighborhood, house, park, or smaller area of study to investigate the data layers at that level.

Images and multimedia may be linked to the map to create a robust display of geographic information. GIS professionals and students can collect their own data, create their own databases, and document their findings in a visually engaging format. The data can be viewed at differing scales and various types of geographical data can be added and removed from a project with the click of a button. While the presentation and re-presentation of tabular data can be stimulating visually, the power of the GIS is in the analytical and spatial capabilities of the software.

Beyond Representation to Comparative Analysis

There is much more power in GIS than the visual representation of tabular data for a given location. GIS can also be used to analyze the spatial representations. With these possibilities also comes responsibility, a responsibility to represent and re-present the data ethically and based in sound decision-making in the processes of collecting, storing, creating, and displaying the data.

The manipulation of legends and symbols carries an important ethical responsibility when using the software. Users can change the maps they create to display what they want, the way they want it. As one would question a statistic s/he reads, so should one approach a map with similar caution. As Monmonier (1996) indicates, maps are
powerful sources of information and must be manipulated with caution. The products of a GIS are as important as the data. Data that are omitted in the tabular format will change the visual representation. However, even if the data set was close to reality, how the user chooses to present the data can lead to misrepresentation and misunderstanding for the map-reader. The collection, analysis, and display of data each require careful consideration so as not to bias the visualization or representation.

The technology and cognitive skills required in manipulating these layers of information relate directly to all of the ISTE National Educational Technology Standards for Students. The standards and goals are foundational to the development of activities and lessons for technology literate students who “achieve success in learning, communication, and life skills” (ISTE, 2000). The six categories of the NETS standards met when using GIS technology range from: ‘basic operations and concepts’ (1), ‘social, ethical and human issues’ (2), to ‘technology productivity, communication and research’ (3, 4, & 5), to ‘technology problem-solving and decision-making tools’ (6).

GIS data representations can vary depending on the user and the creator. Most data that is available to the general public is derived from government agencies. O’Looney (2000) discusses numerous state, local, and federal uses of GIS in his text Beyond Maps. O’Looney provides his readers with real world examples of GIS utilization in public utilities, emergency services, law enforcement, land use planning, and economic growth planning as well as for examination of neighborhood services. While one city or county may use the same base layers of information --the outline of the county/city, the city streets and demographic data -- additional layers of information may be included based on the specific needs of the person or agency using the GIS. Emergency services might be
concerned with traffic patterns at given times of the day for faster ambulance mobility. The streets information and where businesses districts and residential districts are located would be important to that study. Additional layers to the base map might include stoplights and locations of hospitals.

Law enforcement might geocode their information for certain crimes such as drug related arrests or prostitution arrests. Adding this information to the base layers may cause the map to have a very different focus. The demographics may be compared to the high-risk areas for the crimes. Law enforcement might find that the incidents of prostitution are typically located within a certain proximity to an inexpensive motel, or that drug arrests are most commonly found within certain proximity of a number of abandoned houses. A neighborhood watch group examining crime within their neighborhood may use the same base layer data and crime data. They could then “zoom in” to their neighborhood and examine the localized data, thus enabling them to target those areas of known criminal activity for revitalization projects. While law enforcement officials may be examining a city or county for spatial patterns the local neighborhood group uses the data for an area of study that is more confined.

The cautionary note to this is that the representation of the data is only as good as the data collected and the methods selected to display the data. Access to demographic data is very simple in the U.S. as the U.S. Census bureau provides it. However to what scale it is displayed and how the user chooses to categorize the data are important considerations. O’Looney (2002) notes “GIS can also be used in clever but ethically questionable ways to undermine privacy rights or to create policies or political decision-making process that violate traditional notions of equity” (p. 182). Questioning the data and the representations in
GIS is as critically important to questioning statistical data and statistical outputs. These
deep understandings of the limitations of data and the ethical responsibility of the creator of
the data link directly to the NETS standards for social, ethical and human issues.

A Brief History of GIS and its uses

Geographic Information Systems were developed in North America in the 1960s as an aid to map
digitization for Canadian land inventory (Coppock & Rhind, 1991; Longley, Goodchild, Maguire, & Rhind, 2001). As noted by Michael DeMers (2000), the term ‘geographic information systems’ is the U.S. terminology for the system. Throughout the world the terminology may differ. For example in Europe GIS stands for Geographical Information Systems, while in Canada it may be referred to as Geomatics or Geomatique. Depending on the discipline that is using the system it may still have other equivalent naming structures, such as natural resources information systems or spatial information systems. For the purposes of this paper I will use the U.S. referent of, Geographic Information System(s) and the acronym GIS. As interest grew in digital cartography in the 1970s and 80s, Howard Fisher, at the Harvard Laboratory for Computer Graphics, began work on a computing system that would analyze spatial data (Foresman, 1998). Many universities during this time were pursuing similar investigations into the feasibility of computer-based mapping and spatial analysis.

In the U.S. it was not until the 1980s that interest and use of GIS by state, local and federal government agencies began to increase (Coppock & Rhind, 1991; Warnecke, 1995). Longley, et al (2001) have labeled the 1980s as the “Era of Commercialization.” Many companies such as Environmental Systems Research Institute (ESRI) and MapInfo Corporation emerged during this time to offer GIS to government entities as well as
companies and individuals. This “commercialization” also led to GIS use across continents, such as use in Australia, Brazil, Japan, UK, India, and Ghana. GIS is now employed by well over a million users worldwide and is enjoying an “Era of Exploitation” (Longley et al., 2001). This commercial growth in GIS across national borders, business sectors and agencies has led to the exploitation of GIS as technological innovation. According to the theory of diffusion of innovations postulated by Everett Rogers (1962 and 2003), the observability of the usefulness of an innovation such as GIS across these borders “is the degree to which the results of an innovation are visible to others” (p. 266).

As this exploitation of GIS by numerous users across the world takes place, the expectation of potential need of knowledgeable GIS users is increasing. According to a June 2004 article in Geospatial Solutions:

According to a DoL [Department of Labor] summary analysis provided to Geospatial Solutions, today's $5 billion market for geospatial technologies is set to explode to $30 billion in just a year. DoL's forecasts were developed in collaboration with industry associations and educational institutions. (p. 1, 2004)

Because, as I stated earlier, GIS remains “invisible” to many educators, its adoption lags behind other applications as an instructional technology. This need in the workplace for understanding and knowledge of GIS may then be expected of K-12 education. Based on rapidly expanding workplace GIS, the potential need for knowledgeable GIS users implies that schools should proactively incorporate GIS into the curriculum. One possibility of curriculum integration using GIS is within the existing constructs of instructional technology.

**Defining Instructional Technology**

Researchers, educators and educational associations focused on the use of computer technologies with students in instructional settings use the twofold terminology of *instructional technology* and *educational technology*. Each of these phrases implies
different connotations regarding the use of computers in the classroom. Some authors assert that they are synonymous while others make a clear distinction between the two terms. The discussion within this paper will focus on instructional technology as it relates to computer technologies used in the classroom during instruction to meet curriculum objectives. The following overview of the two terms may help further an understanding of my choice in terminology.²

One of the contentions that emerge in the discourse regarding educational technology and instructional technology is that the terms are synonymous. Educational technology is defined by the Center for Applied Research in Educational Technology (CARET) as ‘the full range of digital hardware and software used to support teaching and learning across the curriculum’ (Center for Applied Research in Educational Research, 2003). CARET further includes in their definition: “That includes desktop, laptop, and handheld computers and applications; local networks and the Internet; and digital peripherals such as cameras, scanners, and adaptive devices. It generally does not include older analog media such as film and overhead projectors. Important to note in the discussion of educational technology is the often confused term of technology education,’ which CARET states “refers to specific training about technology itself, often as part of an industrial arts or vocational program” (2003). Roblyer (2003) describes media and audiovisual communication, human and non-human address of instructional need, vocational training, and computers under the umbrella of educational technology. Given that Geographic

² Additional readings that include the synonymous nature of educational technology and instructional technology can be found in the essay “Educational Technology. A Question of Meaning” by C. Gentry found in Instructional Technology (Anglin, 1995)
Information Systems are computer-based technologies; this discussion will focus on computer technologies rather than the plethora of other technologies that may be more characteristically defined as educational technology.

After one narrows the focus of educational technology to computer-based technologies there still exists, in the discussion of the term ‘educational technology,’ the inclusion of the **supporting** aspects of instruction and teaching --not simply the instructional characteristics of education. Different researchers, authors, and organizations have maintained a more inclusive definition of educational technology to incorporate all of the administrative uses of technology. Larry Cuban (1986) notes, “[t]eachers and administrators are the primary users” of computers due to the ability to store and retrieve student information (p. 78). These storage and retrieval efforts might include grade reporting, attendance records, library operations, and communications among faculty, administrators and district leaders.³ While Cuban comments on the record keeping ability of computers he also describes instructional technology from his perspective:

> What I define as useful instructional technology, then, is any device available to teachers for use in instructing students in a more efficient and stimulating manner than the sole use of the teacher’s voice. Hardware and software, the tool itself; and the information the tool conveys define the technology. (1986, p. 4)

Throughout the late 1980s and the 1990s the number of computers in schools in the U.S. increased. According to the National Center for Educational Statistics (NCES) the number of instructional computers in schools in 1995 was reported as approximately 5,621,000 whereas in 2002 it was reported the number of computers was 10,711, 000 (NCES, 2002).

³ For further discussion regarding uses of technology in the management of education see Richard C. Forcier’s *The Computer as an Educational Tool: Productivity and Problem Solving*, pages 61-67(1999).
As computer technology increased in the classroom, the shift from computers as record keeping tools to instructional tools began.\footnote{See Tompson and Schmidt (2004) for a more detailed description of technology shifts in K-12 schools and an overview of some of the prevalent issues that have arisen during these changes.}

By 1994 the field of instructional technology had emerged as “a sub-set of educational technology, based on the concept that instruction is a subset of education” (Roblyer, 2003, p. 52). Over time, the Association for Educational Communications and Technology (AECT) revised their definition of educational technology. By 1994, the definition created by Seels and Richey (1994) omitted the term educational technology and inserted ‘instructional technology.’ The authors claimed:

the term ‘Instructional Technology’ (a) is more commonly used today in the United States, (b) encompasses many practice settings, (c) describes more precisely the function of technology in education, and (d) allows for an emphasis on both instruction and learning in the same definitional sentence, the term ‘Instructional Technology’ is used in the 1994 definition but the two terms are synonymous. (Seels and Richey, p.5 as quoted in Januszewski, 2001, p.106)

The case was made that instructional technology had developed into a distinct profession and discipline of study that should be embraced by AECT. For the purposes of this paper I will use ‘instructional technology’ as it pertains to instruction and design of computer technology for use with students in support of existing curriculum. And, as stated previously, the focus will be limited to computer-based technology in order to discuss Geographic Information Systems within the context of instructional technology

Where is GIS in Schools?

Many of the factors a school or district must evaluate when integrating instructional technology are also important in the consideration of GIS integration in K-12 schools. An
overarching question of why use instructional technology, or GIS, is crucial to many administrators, parents, and researchers. In addition, concerns regarding infrastructure needs, personnel issues, economic considerations, and curricular integration methods are significant to this discussion. The latter concerns are discussed in detail in the next chapter.

The discourse within GIS in K-12 education initiated with anecdotal reports of early school innovators and classroom guides (ESRI Educational User Conference proceedings, 1998-2004; EdGIS Listserv, 2001-2005; ESRI, 1995). There was soon a realization for the need for research and a focused agenda. In order to validate the need for GIS use in education, a focused agenda was put forth for research however there still exist numerous deficits in the agenda and the research being conducted (Baker & Bednarz, 2003). GIS has developed into a technology that can be used as a resource tool for educators. I propose in the following literature review that as GIS is introduced into the schools it should be examined as an instructional technology. Historically, GIS in schools has developed as a content specific technology. As an instructional technology it can be distributed throughout the curriculum. In the world outside of the schoolyard the model of GIS use is one of distributed networks, multiple users and varying needs and functions.

Although GIS was first demonstrated in the 1960s it was not until it became a popular tool for businesses in the 1980s that educators and software companies began to consider its usefulness within educational settings (Deal, 1998; Longley, Goodchild, Maguire, & Rhind, 2001). It was not until the early 1990s that Robert Tinker (1992) published an article addressing the use of technology for mapping purposes that GIS emerged as a technology for use in educational settings. This article was the first among many science education publications that would lead in the investigation of GIS as an educational tool (Baker, 2001).
Audet (1993) points out that “The Core Curriculum in GIS from the National Center for Geographic Information and Analysis (NCGIA) was “the first project to develop GIS curriculum materials” (p. 7).

GIS use in K-12 classrooms has been slowly growing in popularity over the past decade. Kerski’s (2003) findings from survey research of secondary teachers who owned a GIS software package showed strong uses of GIS in science and geography courses. Other courses such as computer science, social studies, history, language arts and mathematics were also represented in the survey results but not as significantly as science and geography (Kerski, 2000, 2003).

GIS is not limited to any one curriculum or subject area as maps and mapping can be tied to most any curricular topic. Educators must decide whether GIS may increase understanding or analysis of a topic of study. If GIS is a tool that may assist in student understanding, educators must also decide how students might participate when using the technology. Baker and Case (2000) suggest that introducing minimal student involvement with GIS may include data that is “presented to students in a map-based format, to help them observe patterns” (p. 25). With more student involvement and extended GIS analysis, “students can also interact directly with data and create new maps with data they have collected, overlaying the maps with thematic layers” (Baker and Case, 2000, p. 25).

Within the GIS in education literature there are many examples of how GIS might be incorporated into elementary, middle and secondary classrooms. In addition, educators and researchers have discussed how and why GIS might be used in many different subject areas. A more detailed discussion of curriculum and grade level integration is provided in the discussion to follow. GIS integration is not limited to US classrooms. Examples of it can
also be found in Canada, Great Britain, Australia and New Zealand. GIS can be found in elementary classrooms to university level classes. Students can participate in real world and community projects using GIS in both traditional classrooms, as in the cases described by Audet and Ludwig (2000), and nontraditional school settings as described by Friebertshauser (1997).

GIS use is not limited to one particular age or grade. In one of the earliest studies of GIS in the classroom Keiper (1996) studied a fifth grade classroom using GIS software. His findings “suggest that GIS in the elementary classroom can be extremely motivating and well received” (Keiper, 1996, p. 106). GIS can also be found in many US middle schools according to the anecdotal evidence. Duke (2005) offers educators practical advices for incorporating GIS in middle schools. Research in middle school GIS integration has examined larger issues surrounding the technology. Baker (2002) conducted research in a middle school investigating issues of efficacy, attitude and achievement when integrating GIS in a project based learning (PBL) science unit. Broda and Baxter (2002) recommend integration of geospatial technologies based on the “variety, rigor and interdisciplinary instruction that are needed in middle and high schools” (p. 50). Theses authors suggest the intellectual needs of the adolescent are met when using GIS as well as higher order thinking skills and a variety of Gardner’s multiple intelligences.

The exact number of elementary and middle school educators who are teaching with GIS or teaching how to use GIS are not known at this time. Kerski (2000, 2003) found in his research of secondary school GIS implementation that only two percent of high schools in the US own GIS software. This seminal research begins shed light on the slow rate of adoption of GIS by educators as compared with users in other industries. Prior to the survey
results published by Kerski, findings regarding secondary school use of GIS were similar to those in elementary and in middle level literatures. Abbott (2001) investigated student perceptions of ability to solve problems based on pre-and post-activity surveys. Abbott’s (2001) quantitative results of the high school subjects yielded no differences in the perceptions of ability to problem solve, however his qualitative findings led to further questions of motivation in the classroom through the use of this technology. Other research on the influence of GIS in student attitudes, thinking skills, and motivation was conducted by West (2003). He found improved student attitudes when using GIS, which he contributed to increased bearing to the study of geography and “focused thought” (West, 2003, p. 270).

Reports from educators provide experiential evidence of classroom use of GIS help to broaden our understanding of how individual teachers and teams of educators are using GIS in the classroom. Many of the descriptions and examples offer encouragement and ideas to other classroom teachers of how to implement this tool into their own curriculum. The experiences of these early innovators and adopters of GIS in education help guide research on initial uses of the technology. This literature leads to a better understanding of how teachers are integrating GIS as well as where in the K-12 curriculum GIS may be valued.

As noted previously, GIS in education research points toward use of the technology primarily in geography and science classrooms followed by other subject areas such as social studies, language arts and mathematics. Geography education is seemingly the easiest fit for GIS integration. Kemp and Goodchild (2002) stress the importance of understanding and interpreting geographic information, whether it is technology based or not, and point to that argument for GIS in geography education. Integrating GIS in geography courses at the high
school level can be relatively easy and partnerships between K-12 schools and universities can expand the available resources for educators (Patterson, Reeve and Page, 2003).

Environmental education is often centered in a blend of both the principles of geography and science education. Therefore, GIS integration incorporation into environmental education has often enabled students to work in partnerships with their community (Ramirez, 1995; Alibrandi, 1997, 1998, 2003; Audet & Ludwig, 2000). Partnerships allow students and educators access to material resources that they may not have or be able to afford otherwise such as hardware, software, data and other peripherals. More importantly, partnerships can provide educators and students the human resources for problem solving, real world application sharing and support for learning where GIS is found outside of the classroom.

Using GIS as a tool for inquiry based learning and real world problem solving can be appealing to students and teacher in science education. Early articles in GIS in science education included examples of the types of software and the integration of GIS and the scientific process in middle and high schools (Fazio & Keranan, 1995, McWilliams & Rooney, 1997). Other examples of GIS in the classroom describe how mapping could be used to extend existing curriculum and topics of study (Eareckson, 2002, Hagevik, 2003). Mapping natural habitats of plant and animal life, water quality studies, locations of natural hazards and other science investigations bring the world outside of the classroom inside the classroom walls.

Bringing the outside world into the classroom is not a new idea for most social studies teachers as the curriculum focus is on people, places and events of the world. Studies of world cultures, community history, political decision-making and philosophies from
macro levels to micro levels of human existence can be found in social studies curricula. Map making and map interpretation are not new concepts in the social studies. Traditional uses of maps, tables, graphs and charts in textbooks and pull down maps in social studies classrooms aid in student understanding of the context of historical, social and cultural events. GIS software can be used to represent oral histories or significant events for a community (Alibrandi, Beal, Thompson & Wilson, 2000, English & Feaster, 2002). The spatial context of historical events, community change and socio-political occurrences may be explored using numeric and visual representations with GIS thus allowing the numbers and locations to come alive for students. (Alibrandi, 2003, 2001; Sarnoff, 2001; Bloom & Palmer-Moloney, 2004). GIS can complement the traditional methods with the technological advantages of unique visualizations, user created maps and data analysis beyond a simple table in a text or a static map pulled down in a class.

Peterson (2000) discusses the power of GIS to help students visualize the quantitative data values often used to generalize locational information in economics courses. Students studying economics can begin to analyze the relationships between population demographics, natural resources and economic indicators (such as GNP, gross national product, or per capita GDP, gross domestic product). The ability to visualize spatially numeric or other data collected is one of the most powerful aspects of GIS. Additionally, students can create their own representations of that data, incorporating images, text and other multimedia.

These examples provide an overview of where and how GIS might be found in the existing K-12 curriculum and grade levels. In order to critically examine GIS in the context of current K-12 schooling structures certain limitations should be addressed. Keiper (1996) found “a constant warfare between enthusiasm and frustration” while the students used GIS
in the classroom (p. 105). The tension Keiper alludes to is most often coupled with a
discussion of the complexities of the software and the limitations of the hardware in the
classroom or school. West (2003) and Alibrandi (2003) also noted discomfort with the
complexities of the software for both teachers and students. It is important to note however
that this discussion is not unique to GIS technologies. The integration of instructional
technologies in classrooms in the US has sparked similar debates over perceived benefits and
constraints. The challenges of integrating GIS in the K-12 classroom will be addressed
further in the literature review within Chapter 2.

In order for educators to decide whether or not GIS, or any potential
instructional technology, should be integrated as a tool for their classroom or school they
must consider whether the technology is “a best fit.” If there are other methods or
technologies that will increase student understanding, achievement, and knowledge then GIS
need not be the first choice. For educators or educational institutions to make a decision for
or against a tool for any topic or curricular goal educators must be aware of the possibilities
and strengths of the tool as well as the weaknesses.

In this investigation I examine student and educator conceptualizations of GIS, IT,
and GIS in schools. Through the collection of representational drawings and interview data a
more meaningful understanding of the ways in which the participants conceptualize these
technology landscapes are elucidated. The image-based and linguistically based data
demonstrate not only how individuals cognitively store and process their understandings of
GIS and IT but also how they spatially externalize that knowledge.

The study participants were selected based on their equivalent skills in GIS and their
roles as students, classroom teachers and support staff in order to examine the three concepts
from multiple perspectives. The inclusion of all of these perspectives was important because the different roles the individuals represent in schools provide unique perspectives of the strengths and weaknesses of GIS, IT, and GIS in schools.

To date the research in GIS in education has not focused on what the students and educators think about the technology. They ways in which these early adopters of this innovation view the strengths and weaknesses of it will influence the diffusion process. If they do not find value in the use of GIS they will not suggest its use to others. If they conceptualize GIS as an innovation that is beneficial they will share it with their peers. This study begins to shed light on the conceptualizations of GIS, IT and GIS in schools in the context of the diffusion process. The voices of the participants provide their understandings of these subjects and the commonalities and differences they envision among them. Student and educator conceptualizations may assist GIS in education researchers in co-constructing a meaningful path toward a decision regarding GIS in schools.

**Overview of the Chapters**

Within this chapter, the purpose of the study, the research questions and the nature of the study were introduced. This was followed by three sections that provide background information for the reader regarding GIS, IT and GIS in schools the focus concepts of the initial research questions. There was an overview of how a GIS works and a brief history of the development of the technology. Next, an overview of instructional technology was presented. This led to a discussion of GIS integration in educational settings. This background information provides context for the literature review, methodology, data analysis, and implications.
Within the review of literature found in Chapter 2, I discuss schools’ decision making process for instructional technology and GIS as innovations in education. The process and the considerations of adopting a new innovation are framed by a discussion of Everett Rogers’ (2003) diffusion of innovations theory. Rogers’ “categories of adopters” within educational institutions are central to in his description of the process of innovation. In the discussion of this first part of Rogers’ theory parallels are drawn between GIS and IT integration in K-12 education. This is followed by a discussion of the continuum of decision makers in any organization from the individual to the collective and finally authoritative decision-making. As the discussion shifts toward organizational decision-making and diffusion, the contexts for GIS and IT integration is discussed.

The discussion shifts in the latter part of the review of literature to examine the pedagogical considerations of incorporating instructional technology and GIS in the K-12 curriculum. Within this discussion, I address the need for mapping and spatial knowledge and understanding within current K-12 public schools in the US. Integral to any discussion of spatial understanding and spatial knowledge is the issue of spatial cognition. This discussion is pivotal to the methodology of this study. Paivio’s (1991) dual coding theory is based on the concept that individuals cognitively store experiences linguistically as well as in images. Dual coding theory is based on both spatial and linguistic cognition. This theoretical perspective helps frame my phenomenographic research methodology presented in Chapter 3.

Chapter 3 provides a detailed description of the methodology that is supported by dual coding theory in order to better understand the ways in which the participants encode the ideas. Framed by the research questions this study required a spontaneous
representational drawing for each topic. Each representational drawing was used as the basis of the subsequent interview. This approach investigates both the linguistic and the image based understandings of the participants; thus leading to an analysis of the commonalities and differences among the educators and students. This approach is based in qualitative multiple case study research and complemented by phenomenographic methods.

Chapter 4 introduces the reader to the study participants. Data collected during the interviews is discussed, including the representational drawings and pertinent data from the transcribed interviews. Phenomenographic methods aided in the creation of “categories of description” of the common understandings of the concepts. This method also aids in identifying differences between and among the participants.

A discussion of the implications of this study can be found in Chapter 5. Additionally, discussions of other key research points, for further investigation, are identified. Discussion points for this chapter include the importance of multiple perspectives and voices (Public Participation or PPGIS), a need for larger studies and study populations, the importance of qualitative research in GIS in education and IT research, and potential directions GIS in education may take in the future.
CHAPTER TWO

REVIEW OF LITERATURE

Introduction

In the previous chapter I provided an introduction of the study. Through the use of multi-case study and phenomenographic methods, this study investigates student and educator conceptualizations of GIS, IT and GIS in schools. The data collected includes participant drawn representations and semi-structured interviews. Dual coding theory guides the methodology of this study and will be described in further detail in this chapter. The following literature review will be framed by diffusion of innovations theory.

In this chapter I have framed the discussion of GIS and IT adoption within Everett Rogers’ (1965, 2003) theory of diffusion of innovations. The discussion begins with an overview of the diffusion of innovations theory. Specifically, the categories of adopters of new innovations, the continuum of decision makers and organizational adoption issues are addressed. The issues that are brought forth by this discussion of GIS and diffusion of the technology as an innovation include: existing GIS use in K-12 classrooms, development of GIS in education applications, and Internet-based mapping. As the discussion shifts from GIS to IT, with respect to diffusion and adoption of innovations, infrastructure and hardware needs, training and staff development and pedagogical considerations will be explored. The discussion of pedagogy in K-12 schools is essential to the dialogue of spatial skills and understandings in current schooling. This perspective leads to further discussion of mapping and spatial cognition which are used to frame the methodology of this research as well as provide ties to GIS technology through the visual representation and exploration of data.
The voices and perspectives of the educators and students in this study will supplement the emerging research in GIS and instructional technology (IT) in K-12 education. Often student and educator voices are muffled by the newest legislation or initiatives that are passed down to them. If asked what they think about an educational innovation, such as new technologies or pedagogical approach, both students and educators will often gladly offer their opinions. Their perspectives will most likely differ based on their experiences and understandings of the educational system. As stakeholders in K-12 education, the ways teachers and students conceptualize understandings of a certain body of knowledge or discrete tasks may enable others to approach the knowledge or tasks more effectively. The research questions of concern in this study examine those different perspectives of teachers and students and examine similarities as well. How a student or teacher conceptualizes and visualizes their understandings of a phenomenon such as GIS technology may inform whether it should be implemented, how it might be integrated into existing structures of schooling and how decisions might be reached about a new innovation in education.

As many technologies emerge for use in the classroom educators, parents, administrators and other educational stakeholders ask: “Why use the technology?” and/or “What is its benefit?” Lockard and Abrams (2004) argue, “The question is not whether to use computers but rather how best to use them” (p.3). This assumption seems to be based on: the growing number of computers in schools; financial assistance for schools in the area of technology and technology integration; and state and federal standards and initiatives, such
as the ISTE National Educational Technology Standards (NETS) and No Child Left Behind (NCLB), respectively; that encourage computer technology integration.\(^5\)

The critics of computer technology use in schools are slowly becoming silenced as the increasing numbers of computers are purchased and integrated into classroom settings. Voices such as Armstrong and Casement (2000), Larry Cuban (2001), and Todd Oppenheimer (2003) draw quiet attention to the larger questions of why and how K-12 schools are using computer technologies with students. These authors question whether computers are aiding learning in the classroom or detracting from it. The authors address the national trends with computers in education as well as provide observations and interviews with K-12 students and educators.

The proponents of computers in the classroom offer a rebuttal of emerging research, societal needs for technology literate graduates and business or workforce expectations. Miller (2001) notes, “[m]any parents, business people, and teachers support technology infusion because they see it as inevitable and necessary for adult life” (p. 44). This external pressure on schools is also supported by Roblyer’s (2003) justification that students of the information age will be required to have a technological, informational, and visual literacy. In addition, she suggests that technology use can be rationalized by its motivational nature, its unique capabilities, and the development of new approaches to instruction (2003, p. 10-14). The supporting evidence for each of these is addressed in depth with research studies to _________________

\(^5\) Curriculum specific standards may be according to national and/or state educational organizations, such as the National Council for the Social Studies (http://www.socialstudies.org/standards/) for social studies education or North Carolina Department of Public Instruction (http://www.ncpublicschools.org/curriculum/) National technology standards for pre-K to grade 12 students can be found through organizations such as International Society for Technology in Education (ISTE) (http://cnets.iste.org/students/s_book.html).
support her points. While there are no definitive answers to questions of whether technology is necessary in 21st century K-12 education, new research in the area of instructional technology continues to emerge.

**Diffusion of Innovations Theory: Framing IT and GIS adoption**

This shift in instructional methods and tools has not been immediate. The adoption and use of any new idea or technology happens over time. Everett Rogers’ (2003) work in diffusion of innovations theory may be used to better understand the processes and persons involved in instructional technology and GIS diffusion in K-12 schools. Everett Rogers (2003) theorizes, “the main elements in the diffusion of new ideas are: (1) an innovation (2) that is communicated through certain channels (3) over time (4) among the members of a social system” (p. 36). The model of this process is seen in Figure 7.

*Figure 7. The Diffusion Process. From Diffusion of Innovations, by Everett Rogers, 2003, p. 11. Copyright 2003.*
There are three specific elements of his theory that are relevant to the issues and considerations of IT and GIS in K-12 settings. First, Rogers “categories of adopters” model is significant to the discussion of individual educators regarding critical decisions in the adoption of innovations. Second I will enhance Rogers’ discussion of “decision-makers” as it applies to educational innovations. Finally, I will discuss the stages of the innovation process as they relate to organizational adoption of innovations.

The process of diffusion differs for each innovation. As seen in Figure 7, this process is dependent on time. The rate of the process can be very swift or extend for much longer periods. It is the same s-shaped curve for the three innovations in the figure however the rate is different for each.

The s-curve for Innovation I in the figure could be likened to Internet adoption in K-12 schools in the U.S. The percent of schools with Internet access in 1994 was 35% according to a National Center for Educational Statistics (NCES) report (2004). Eight years later, in 2002, that percentage was reported as 99% (NCES, 2004). While that number may represent one computer in the main office of the school, the adoption of Internet access was swift with this percentage more than doubling in less than 10 years. The percent of computers that were designated for instructional use with Internet access follows a similar trend. In 1995 the percentage of instructional computers with web access was 8% and by 2002 it climbed to 90% (NCES, 2004). This is explosive adoption and implementation of this innovation.

The s-curve for Innovation II, as seen in Figure 7, stretches out over more time. The curve is less “steep” than that of Innovation I. This curve might represent instructional technology adoption. The NCES statistics include the reported number of computers used
for instructional purposes from 1995-2002 in the United States. In 1995, NCES reports there were 5,621,000 computers in schools designated for instructional use (2004). By 2002, that number had grown to 10,711,000 (NCES, 2004). While we do not know how often, when or where these computers were used in the schools these statistics do give us a snapshot of the rate of change of instructional technology from a very broad perspective. This growth did double in the seven year time period reported; however, it was not as exponential in growth as the Internet access. Based on these statistics one could see a similarity of the adoption of instructional technology to the s-curve presented as Innovation II in Figure 7.

Innovation III, in Figure 7, shows the slowest rate of adoption and diffusion over time. I suggest that this curve is more like the adoption and diffusion of GIS in K-12 education in the U.S. While NCES does not have statistics regarding GIS use in schools we have early research that indicates that the number of users and the slow diffusion rate of GIS. Kerski’s (2000, 2003) survey of 1,520 secondary school teachers represents a sample of the 1,800 individual educators in the US that were known to own a GIS software package. In addition, he found less than 5 percent of U.S. high schools owned a GIS package (Kerski, 2003). This was the first study to tabulate the users of GIS in the education realm. Kerski (2003) compares these numbers to the 500,000 total GIS users worldwide reported by ESRI in 1999. This study has given researchers a starting point to begin to discuss the slow adoption rate of GIS in education comparative to other industries.

One of the better-known features of Rogers' theory is his model of the categories of adopters of innovations (See Figure 8). Within a discussion of innovation theory and instructional technology, Surry (1997) observes: “Technology's advance may be inevitable, but it is gradual. Instructional technologists should, therefore, look to the potential adopters
to show us ways to gradually introduce our innovations into their societies” (¶41).

Understanding role and perceptions of instructional technologists and other potential adopters in educational settings may facilitate improved decision making processes. Rogers labels individuals within the innovation model with five adopter categories: innovators, early adopters, early majority, late majority and laggards. These categories are based in their openness to innovation. He further explains common traits and types of these categories of individuals.

Rogers characterizes innovators as “venturesome” who often have a “desire for the rash, the daring and the risky” (2003, p. 282-3). Early adopters have “respect” within their social systems and “decreases uncertainty about a new idea by adopting it, and then conveying a subjective evaluation of the innovation to near peers through interpersonal networks” (Rogers, 2003, 283). In a school this might be a teacher who is respected and often considered on the cutting edge of instructional technology use. As a respected individual he or she may influence other teachers’ decisions regarding software adoption or use of new hardware.

Rogers characterizes early majority adopters as “deliberate.” These adopters of innovation “may deliberate for some time before adopting a new idea” and generally are not leaders within their social structures (Rogers, 2003, p. 283-284). A teacher who seeks a workshop or in-service about a new technology or instructional method based on curiosity or observation of others success might be considered an early adopter. S/he might be talked into a workshop by an early adopter. While late majority adopters approach innovations “with a skeptical and cautious air, and the late majority do not adopt until most others in their system have already done so” (Rogers, 2003, p. 284).
Those individuals who are resistant to instructional technology of any kind would in Rogers’ model be considered as “laggards” or “late adopters” or may simply never adopt the innovation. Rogers’ (2003) notes “[r]esistance to innovations on the part of laggards may be entirely rational from the laggards’ viewpoint, as their resources are limited and they must be certain that a new idea will not fail before they can adopt” (p. 284-285). Often these individuals are isolated within a larger social network. These individual characterizations are complicated in K-12 schools by competing organizational pressures and lack of funding toward innovation in instructional methods.

The categories of adopters are important to an examination of instructional technology and geographic information systems as most educational institutions have persons who fall into each of these categories. GIS in education is in the earliest stages of this diffusion theory and the users at this time are most likely considered “early adopters”. Instructional technology (IT) though is, seemingly, further along in the diffusion model. Instructional technology diffusion among individual educators falls within the latter stages of early majority into the initial stages of the late majority classification. There are still individuals who have not adopted instructional technologies for classroom use. Instructional technology is present in schools at varying degrees and educators are using televisions, VCR’s, and computers in varying degrees. Computer based IT such as the use of word processing may be commonplace for typing reports and internet use for research may be found more often than digital video and other more sophisticated technologies in the classroom.
Figure 8. Adopter Categorization on the Basis of Innovativeness. “The innovativeness dimension, as measured by the time at which an individual adopts an innovation or innovations is continuous. The innovativeness variable is partitioned into five adopter categories by laying off standard deviations (sd) from the average time of adoption (x)” (p. 281). From *Diffusion of Innovations*, by Everett Rogers, 2003, p. 281. Copyright 2003.

It is important to note that innovations such as IT or GIS may not ever meet with 100% acceptance within the social structures of organizations such as schools or districts. The acknowledgement of the different characteristics of adopters within an organization may provide a precursory view into how an innovation may influence the rate of diffusion. Examination of the different reasons and rates of adopter receptivity to an innovation is an important consideration of *how* and *when* an organization may begin to consider adoption and implementation of an innovation.

In addition to the individuals within the internal social system, Rogers notes that there are often external “change agents” who are experts concerning the innovation. In the instances of IT or GIS they might be an individual such as an Apple computer education specialist or an employee of a GIS software manufacturer such as ESRI. These agents may
seek out the early adopter to aid in the change process of adoption. The early adopter as noted previously is usually well respected in the social structure (the team, the school, the district) and has influence over the adoption of innovation by others. In the case of instructional technology this individual may be sought out by change agents within the school system, such as a curriculum coordinator for a subject area or grade level, to help initiate the diffusion process to other educators.

External change agents may vary in their position or title however their goal is to increase the rate of adoption and help the social system better understand the connection between the innovation and the potential benefits. They may try to identify resistance to the adoption of the innovation (or product) that they represent. Numerous companies, such as Apple, Dell, Microsoft, ESRI and Intergraph have created education outreach departments or contacts to aid in the decision-making processes when adoption of their innovative approach might be considered for educational purposes. As explained more fully in the methodology, ESRI’s products and educational support were fundamental to the GIS in Education course from which the educator participants were selected.

**Continuum of decision makers**

Rogers explains that within organizations there are three types of innovative-decisions. I view this as a continuum in which decisions about innovations may be made (see Figure 9). On one end of the continuum the individual makes the decision regarding adoption of the innovation. At the other end of the spectrum is the authoritatively based decision making. At this end the leader, administrator or other authority figure implements the innovation without input from others in the organization and there is an expectation that
all members will adopt the innovation. Between these two on the spectrum would be innovative decision making by more collaborative means (Rogers, 2003, p 403).

Often in more successful implementations of an innovation there is a key individual who has respect in the organization that influences the diffusion of that innovation. Identification of these individuals in schools would be key to adoption strategies by the facilitators of GIS and other instructional technology advocates.

![Figure 9. Continuum of innovation decision makers in organizations.](image)

**Organizational Adoption and Diffusion of Innovations**

The types of decisions made in an educational institution are important as is the process an organization considers for the diffusion of an innovation. The five stages of the innovation process as defined by Rogers shown in Figure 10 are defined within pre- and post-decision making activities (initiation and implementation respectively). Rogers (2003) explains there must be a “perceived need” of the innovation and a match to the goals of that organization (p. 421-423). Once the needs and matched goals are understood, a decision for or against adoption will be made. Next the organization must carry out that decision. Rogers calls this activity the implementation stage, which would involve a modification of existing structures in the organization, clearly defining the relationship of the innovation (IT and/or GIS in this case) and then making the innovation a common practice of the organization. (Rogers, 2003, p 417-430)
With regard to instructional technology most schools have met the *Initiation* (I) stages of the diffusion model. National agendas regarding technology integration in the curriculum can be found in the ISTE National Educational Technology Standards for teachers and students (2000) and No Child Left Behind Act (2001). Once educational institutions have moved through the initiation stages they may proceed toward redefining, restructuring and clarifying in the *Implementation* (II) stage alluded to by Rogers.

**Initiation of Innovations: GIS in Classroom Use**

**Agenda-Setting**

As alluded to previously, GIS seems to be found within the earlier stages of the innovation process in educational organizations and therefore has a flatter “uptake curve.” Prior to organizational decision-making there must be an agenda set and an investigation of the potential match of the innovation. “The agenda–setting stage in the innovation process in the organization consists of (1) identifying and prioritizing needs and problems and (2) searching the organization’s environment to locate innovations of potential usefulness to meet these organizational problems” (Rogers, 2003, p. 422).
GIS in education agenda-setting. In 1996, a number of researchers came together to investigate where the GIS in education research needed to be focused. The EDGIS’96 group meeting produced a document that listed four key research points: pedagogy issues; curriculum issues’ software issues; and cognitive issues (EDGIS, 1996). These issues are still relevant to GIS in education research and diffusion today.

Regarding GIS in education research, Baker and Bednarz (2003) pose challenges: “A significant ‘needs assessment’ is required. What do we know so far about all aspects of learning with and about GIS? What are the gaps?” (p. 233). A number of researchers began to address this question; however there has been no clear plan or agenda among GIS researchers (Baker & Bednarz, 2003).

Kerski (2003) found in a national study that less than 2 percent of American high schools were using GIS. His research yielded numerous curricular applications, but science and geography were the most represented content areas. This finding is reflected in the initial research studies in GIS in education which did not cross numerous content area boundaries. The majority of the research is focused in science (Tinker, 2002; Baker 2002; Baker and White, 2003) and geography classrooms (Meyer, Betterick, & Olkin, 1999; Wanner & Kerski, 2000). While these works begin to make headway toward the goal of presenting a research-based answer to the question “why use GIS?” This point has not yet been firmly established by GIS in education researchers, nor has a critical lens been used to examine whether there is a need for GIS in the K-12 curriculum.

The larger struggle at this time for GIS in education may not be the focus and/or need for research that Baker and Bednarz are calling for. Instead GIS seems to be in the earliest stages of adoption and only after there is an “early majority” that have adopted
the idea of GIS in education will the research begin to emerge to clearly justify why GIS should be used in education on a larger scale. GIS researchers should use this time to investigate current educational users’ understandings of GIS; the fundamental characteristics of successful curriculum integration, and sustainability issues as grounding for the research to come.

**Matching: Development of GIS in Education Applications**

Next, an organization moves into what Rogers describes as *Matching*. “At this second stage in the innovation process, conceptual matching of the problem with the innovation occurs in order to establish how well they fit” (Rogers, 2003, p. 423). The discourse surrounding GIS and educational resources has been inundated with anecdotal accounts of teacher and student use of GIS. This discourse has shown the desire for the adoption of GIS as a tool for educators. If we examine GIS as an innovation within Rogers’ (2003) definitional theory of diffusion of innovations, GIS in education is still in the early stages of diffusion. “The relative advantage of an innovation [in this case, GIS in the curriculum], as perceived by members of a social system [K-12 education], is positively related to its rate of adoption” (Rogers, 2003, p. 265). Examining GIS in education from this diffusion theory suggests that the earliest users of the innovation, GIS, are beginning to spread their knowledge and understanding of it through social networks. Thus the anecdotal work of these “innovators and early adopters” functions as a collective voice against the resistance of an organization to move forward with the innovation. Kerski’s (2003) national study of GIS implementation demonstrates that “[m]ost teachers (88%; n=342) believed that the use of GIS makes a significant contribution to learning throughout secondary education” (p. 131). The teachers in this and other studies have begun to demonstrate where there is a
need for GIS as an innovation in the schools. The teacher responses reveal matches to curricular objectives and pedagogical concerns in multiple disciplines.

GIS software companies develop new products for their business customers with the need for more power, memory and speed. ESRI notes in their product brochure, *GIS for K-12 Education: Solutions for Students and Teachers* that “GIS is a resource-intensive technology. It works best on fast processors with significant RAM and sufficient storage space available” (ESRI, 2004). Schools are left behind in the wake of the new software rollouts because of the failing hardware and inability to maintain the same turnover as the business sector. In the spring of 2001, ESRI released a more powerful and user-friendly version of their software, ArcGIS 8.1 (ESRI, 2004). The hardware requirements at that time were impossible for most public schools to meet. One year later ESRI Press released *Mapping Our World: GIS lessons for educators* (2002), a GIS resource book which includes a one year license for schools of their ArcView 3.3 software. This software was the predecessor to ArcGIS. While the ArcView 3.3 product is currently still supported, the company will be phasing the 3.3 version out. Therefore, this text and software directed at K-12 users is a double-edged sword. The price is non-prohibitive, approximately sixty five dollars for one year license and companion lesson plans, but this also is an acknowledgement that the company is aware that schools cannot keep up with the constant upgrades in software (and the necessary hardware to run the software).

The GIS software on the market today is predominantly Microsoft Windows based. For schools with a majority of Apple computers with Macintosh operating systems the possibility of GIS integration is limited. ESRI’s last product that supported an Apple Macintosh computer was ArcView 3.0 which is no longer sold and is supported only on the
OS 8 and 9 platforms. ESRI in 2004 recognized this issue with the release of a freely downloadable product, known as Arc Explorer—Java Edition for Education or AEJEE. “Arc Explorer—Java Edition for Education is a version of Arc Explorer—Java, provided primarily for support of the Macintosh OS X platform, in addition to Windows” (ESRI, Arc Explorer, 2004, ¶1). If the diffusion process model, as seen in Figure 7, was overlaid onto the organizational decision making process model, seen in Figure 10, the stages an organization must move through in order to adopt an innovation are more clearly seen as dependent on the individual categories of adopters and the rate of “uptake” (See Figure 11). This is relevant to this discussion of software as we move into the decision making stage for an organization and then into implementation of an innovation if it is adopted.

*Figure 11.* Rogers’ Rate of Adoption overlaid on the Stages of Organizational Decision Making. Overlaying the Rate of Adoption and the Stages of Organizational Decision Making provides a framework of time and adopter types with the decision making process.
I suggest that GIS, is in the initiation stages with respect to education. The innovators and early adopters of GIS in education have worked through the matching processes and restructuring stages for themselves and are helping to clarify the need for GIS in education. However, as a whole, GIS in education has no more than a 20% adoption rate at this time but probably closer to a 5-10% adoption rate. I state this based on the correlating stages of decision-making (agenda-setting and matching) that GIS in education finds itself and the percent of adopters that may be found at this stage based on the Innovation s-curves. If GIS were a rapidly adopted innovation in education (as indicated by Innovation Curve I) it would be in the 20% adoption range located between agenda-setting and matching stages. However, as discussed previously, GIS adoption in education is more closely aligned with the Innovation curve III a 5% adoption rate.

An understanding of how the innovators and early adopters conceptualize GIS globally and GIS in schools may aid in understanding how GIS may or may not benefit existing K-12 schooling and curriculum. Any parallels between the two may illuminate how GIS may be tied to real world experiences. This is particularly important to the first and third research questions of this study, which focus on how the educators and students conceptualize these topics. The findings of this research may be able to inform this process of decision-making in the adoption process.

Interestingly, the software developers and those interested in marketing GIS in education have also begun to shift their products in the earliest stages of restructuring based on feedback from the innovators and early adopters. Software and hardware issues identified in the matching process are being restructured by GIS companies to help schools accelerate the rate of adoption. Creating cross-platform solutions and increasing the number of
Internet-based mapping services enables GIS to be used in schools where infrastructure and economic concerns are the limiting factors. In Figure 11, the marketing decision by the software manufacturers toward cross-platform and Internet-based GIS may accelerate the slow s-curve of GIS adoption. Through matching the technology and educational needs the GIS s-curve may better align with the s-curve of instructional technology as illustrated by Innovation II in Figure 11.

Baker (2005) adds to this dialogue with specific advantages of the use of Internet or web based mapping. Constraints such as hardware and infrastructure are lessened by the use of the Internet rather than computer based mapping. Baker (2005) suggests “the technical preparation time that is now required of teachers [with the use of Internet-based mapping] could be largely shifted back to focusing on instruction” (p. 47).

This is not to suggest that Internet based GIS mapping is the only solution or to the initiation decisions surrounding GIS. Baker (2005) posits, “The Internet-based environment is ideal for instigating geographic analysis in classrooms where such activities would have otherwise not occurred at all (p. 47). It is one approach that potentially may aid in the diffusion of GIS as an innovative educational resource.

There are limitations that must be considered in Internet-based mapping. Internet-based mapping generally does not have the robust analytical capabilities of a desktop GIS. Student exploration of data they have collected is also limited by web-based mapping. The innovators and early adopters may find the limitations of a web-based GIS frustrating. Another limitation is that before students can use web mapping it must be constructed by someone ahead of. These limitations must be considered by educators, web mapping service providers, and GIS software manufacturers.
Implementation of Innovation: Instructional technology classroom adoption and use

The final three stages of the decision-making process, implementation, occur after the decision has been made. The organization then must progress forward in the innovation process. This is known as the implementation of the innovation and the stages are defined by Rogers (2003) as: redefining/restructuring, clarifying, and routinizing. GIS was used as an example of the initiation stages of an innovation whereas instructional technology is an example of an educational innovation that is in the implementation stages. The understanding of the adoption of IT in these latter stages will be investigated in the study through research question two: How do student and educators conceptualize instructional technology? The conceptualizations would then be further developed than those of GIS in schools. I have framed this discussion of IT within the redefining/restructuring and clarifying stages. The data collected within interview two supports this assertion as discussed in Chapters 4 and 5.

Redefining/Restructuring

“Redefining/restructuring occurs when the innovation is re-invented so as to accommodate the organization’s needs and structure more closely, and when the organization’s structure is modified to fit with the innovation” (Rogers, 2003, p. 424). Economic impact, hardware and infrastructure needs are examples of concerns when educational institutions must consider how the innovation of instructional technology will redefine and restructure the organization.

Schools must also consider the economic impact of instructional technology. The economic concerns of technology integration and use begin with infrastructure matters such as architectural layout and room availability, electrical and other wiring needs. There are
personnel concerns such as hardware and software maintenance and updates of the technology. Additionally, educators must be trained, not only in how to use the technology, but more importantly how to integrate the technology effectively into the curriculum. These curricular decisions based on underlying pedagogy and learning theories influence how and what technologies are used in the classroom.

**Infrastructure and hardware needs.** The physical infrastructure of schools required to support computer technology has changed the layout and space use in the school. Computer labs are an instructional space in the school that were not part of school buildings of the 1970s and even into the early 1980s. Computer labs require wiring for Internet access and for additional electrical upgrades which when distributed through entire buildings are costly for school systems. Single computers in the classroom can be supported by one outlet in a classroom with Internet access as the school can afford or support it. The spending for technology in K-12 schools, Lockard and Abrams (2004) state, was projected to be between 6.1 and 8.22 billion dollars for the 2002-2003 school year. This is a costly venture for our schools.

Based on national statistics, Lockard and Abrams (2004) state by 2001 there were in the U.S. roughly 5.4 students per computer with Internet access. This change from 125 students per computer in 1983 was fairly rapid. However they note “numbers of computers do not tell the whole story. Many of the computers in our schools are too old and underpowered to support current software and lack significant hardware components” (p. 3). GIS technology integration in schools requires a fairly robust computer to perform spatial analysis, support the graphics and images, and power the database features.
As the number of children attending public schools in the U.S. increases, the need for instructional space in the schools has become a key issue. This shortage of space can be seen in the landscapes of schoolyards across the U.S. with temporary structures and trailers used for classrooms. Using wireless technologies and portable computers such as laptops and PDAs may be one solution to the use of computer lab space. This solution comes at a cost. Each portable computer must be purchased and maintained as well as the maintenance of wireless networks and projectors for classroom use. Administrators and school boards must weigh the cost of the hardware with other budgetary and space needs in the school.

Clarifying

If the organization moves toward implementation the fourth stage emerges. In this stage “clarifying occurs as the innovation is put into more widespread use in an organization, so that the meaning of the new idea gradually becomes clearer to the organization’s members” (Rogers, 2003, p.427). Within this stage, instructional technology adoption in education involves training and staff development as well as pedagogical considerations.

Training and staff development. In addition to the need for space, supporting infrastructure, hardware, and software, educators must be trained to use the technologies available to them. Alibrandi (2003) in her discussion of GIS describes and ‘ideal’ setting for GIS integration (p.49-52). Alibrandi also describes how students often exhibit a level of comfort with technology that their teachers do not. This issue can be an important variable.

Technology can change the way educators teach and/or it can supplement effective teaching methods. “Traditional approaches to learning are linear and reflect the structure of books as the central learning tool...[students] access information that is more interactive and non-linear” (Norton & Wiburg, 2003, p. 8). If educators are not only taught how to use
computer technologies and how to integrate technologies in a way that is different than other methods the effectiveness of the tool is questionable. Further suggestions on how technology training and staff development may take place are described by Roblyer (2003, p. 30-32) and Sharp (2002) includes detailed suggestions for computer technology integration in great detail.

An educator may find training in her/his district or school or s/he may also seek knowledge of a unique software or technology. When districts and schools train teachers to use technology there are economic considerations for staff development. National, state and local competency requirements may encourage educators to investigate technologies for their classrooms that they had not previously considered. Teacher training can also aid in the spread of innovations and adoption of technologies and ideas for integration.

GIS teacher training. Schools, districts, agencies, consultants and institutions of higher education offer GIS training for educators. With respect to GIS Kerski found:

No mandate requiring the use of GIS in the educational curriculum exists. However, a small percentage of teachers nationwide have taken it upon themselves to solve problems and conduct workshops to promote its implementation. Convinced of its benefits, these teachers amount to about 15 percent of survey respondents, and spend a great deal of personal time with GIS. (2003, p. 131)

GIS software is often cumbersome and non-intuitive for first time users (Parmenter & Burns, 2001). Daniel Sui (1995) suggested that there should be a distinction between teaching with GIS and teaching about GIS. Teachers teaching about GIS may focus on application issues in the world and the technical how-to problems that may be encountered using the software. Teaching with GIS, while often teaching new GIS skills, is not centered on the technology. The technology is simply a means to the end. That end may be a greater understanding of local ecology, human impact on the environment or juvenile crime analysis.
for a community partnership. The argument of teaching with technology or teaching about technology is paralleled in instructional technology literature. Norton and Wiburg (2003) stress: “Making wise choices about technology then depends on recognizing the ways in which it facilitates the things humans can do” (p. 51). Often teacher training in technology is focused on how to use the technology whereas the integration into the curriculum is vital to learning with learning is often lacking. As important in the educator’s decision making process to use technology effectively in the classroom is deciding when it is not appropriate.

**Pedagogical Considerations.** Educators consider educational methodology daily and make decisions on the appropriateness of the technique or tool for their students, classroom, and/or content areas. These curriculum design issues include how the educator will meet national state and district requirements of content as well as meeting the daily needs of her students. The use of technology does not exclude a discussion of the pedagogical approaches educators might apply to instructional technology integration. The technology should extend knowledge about the subject being studied. In much of the instructional technology literature there is a discussion of the dichotomous influences of objectivism and constructivism in instructional technology. ⁶

Objectivism is a structured way of approaching knowledge and meaning in the world. The basic assumptions of objectivism are that “meaning is something that exists in the world quite aside from experience. Hence the goal of understanding is ‘coming to know’ the entities, attributes, and relations that exist” (Duffy & Jonassen, 1991, p. 9). The objectivist approach tends to focus on a hierarchical diffusion of knowledge. The teacher, through direct

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⁶ For further discussion regarding this dichotomy see Morrison, Lowther, DeMeulle (1999, p. 5-36); Norton and Wiburg (2003, p. 17-41); Sharp (2002, p. 267-270) and Roblyer (2003, p. 51-82).
instruction, imparts knowledge to the students. Duffy and Jonassen noted that the objectivist view in instructional technology is deeply rooted. “Instructional design, and indeed instruction in general in the United States, has emerged from an objectivist tradition” (Duffy & Jonassen, 1991, p. 7). If all learners are subject to a lesson or activity that meets the instructional design structure introduced by Gagne, Briggs and Wager (1988), they will have acquired the same knowledge that can be assessed in the same manner according to objectivist learning theories. This is a prescriptive approach to employing a technology lesson rather than a subjective approach. For example, a teacher using objectivist methods when using technology will teach the students how to create a spreadsheet by “clicking through the steps” of how to enter data from a set of data provided by the manufacturer. Then they proceed to click through the steps of creating an equation. As the students are clicking through the steps they are simply mimicking a set of processes. This approach does not provide relevancy to the student’s lives or a subject area. If the students had collected their own data or were allowed to investigate the process of building an equation through discovery methods, the understandings of how a spreadsheet is created and equation features work could be transferred to other subject areas or knowledge.

This concept of objective approaches to teaching with IT has relevance to GIS integration in schools. Some might suggest that the use of existing data layers produced by GIS data warehouses, agencies and manufacturers would limit the utility of GIS to only viewing data from a singular perspective and restricts the user’s ability to explore beyond they data. This can be a valid perspective if the user is not engaged in the spatial analysis of the data. By simply adding data layers to create a “pretty map” that does not answer a question or problem the user is merely “clicking through the steps.” Or if blindly accepting
the data as “truth,” objective reality becomes what is found in the data. A healthy skepticism of existing data is necessary in the representation of phenomena that exist in the world and are displayed in a quantifiable manner.

However, I would argue that the meaning making in GIS is in its analytical functions. When examining the numeric figures of Gross National Product (GNP) of a number of developing nations with other layers such as population, educational attainment, and the physical location, an understanding of what those numbers represent is essential. If the country has a predominant desert landscape and only 5,000 of 100,000 persons have an education higher than the 8th grade and the GNP is low the interplay among factors should be considered. However, if the countries geographically located nearby have similar statistics but a radically higher GNP, the user must begin to consider other influences. It is the spatial analysis and meaning making from the numbers that are behind the map that shifts the technology from an objectivist-based teaching tool to a subjectivist position. This is how GIS used as a constructivist tool can strengthen spatial understandings and relationships for students.

Constructivists approach learning from a subjective and experiential perspective. “Constructivist notions of learning start with a simple proposition: Individuals construct their own understandings of the world in which they live” (Norton & Wiburg, 2003 p. 32). The theories that are often associated with constructivism include Dewey’s work from *Experience and Nature* (1925), Vygotsky (1978, 1986), Piaget (1954, 1970) and more recently Brown, Collins and Dugid (1989). The cognitivist approaches of psychology are often coupled with sociocultural theories in their influence on constructivism (Cobb, 1994; McNergney & Herbert, 2000; Roblyer, 2003). The influences of place/location, activity, and experience are
spatial aspects of learning that contribute to meaning-making and knowledge construction. Just as Gagné et al developed principles of instruction based on objectivist perspectives, Brooks and Brooks (1999) and Jonassen (1994) also have contributed principles for the constructivist instruction, Jonassen suggests that constructivist design should support: the construction of knowledge; a meaningful, authentic context for learning and using the knowledge they construct; collaboration among learners and with the teacher, who is more of a coach or mentor and not a purveyor of knowledge (1994).  

The discussion of constructivism within the context of this study is significant to the examination of the data through phenomenographic methods. The unique experiences and understandings are fundamental to the comparative focus of GIS, IT and GIS in schools found in research question three. Through their own constructions, students may develop multiple perspectives of materials, activities, and the tools that they use to develop knowledge. The tools examined in this study are those of instructional technology. How do instructional technology and constructivism frame learning for students? Constructivist approaches to learning may be applied to instructional technology. Using technology in collaborative learning, in the discovery process (e.g. investigating a phenomena using the Internet) and in the creation of products (e.g. digital graphics or maps) are examples of possible constructivist uses of technology.

The dichotomous nature of objectivism and constructivism can lead to a polarized view of learning theories, examining positive and negative aspects, when considering use of technology in the classroom. Roblyer (2003) suggests that blending the two approaches may

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7 Further descriptions of these points are presented in Educational Technology, May 1991, (Dick, 1991; Perkins, 1991; Duffy and Jonassen, 1991a) and September 1991(Duffy and Jonassen 1991b) and Jonassen (1994).
yield a better outcome based on the needs of individual learners. Many texts for teachers that are meant to aid in the development of instruction using technology expressly separate these two approaches. An example of this is the text *Integrating Computer Technology into the Classroom* (Morrison, Lowther, DeMeulle, & Stollenwerk, 1999).§

The oppositional nature of approaches to learning in instructional technology seems to return to the point made by Sui (1995) regarding teaching *with* or teaching *about*. When teaching about GIS the objectivist approach is often described GIS in education literature. Whereas, when teaching with GIS, the literature seems to acknowledge the constructivist approaches (Alibrandi & Palmer-Moloney, 1998; Alibrandi, 2003). As mentioned previously, much of the evidence is anecdotal, however examples that are brought to light by a review of the literature tend to focus on problem based learning methods (PBL) (Ramirez & Aithouse 1995) and constructivist methods of learning (Keiper, 1999).

*Routinizing*

The final stage of Rogers’ model of the decision-making processes is “when an innovation has become incorporated into the regular activities of the organization and has lost its separate identity” (2003, p. 429). Neither instructional technology nor GIS have reached this point in U.S. K-12 schools. Rogers also includes investigations of sustainability, the number of total adopters in an organization and how an innovation may be reformulated or recreated for the purposes of an organization as areas of interest at this stage (2003, p. 428-430). Educational users and organizations must address issues of sustainability, reformulation, and making the use of IT and GIS routine.

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§ Chapter three of this text approaches instructional technology from the objectivist approach and chapter four approaches instructional technology from a constructivist approach.
Often technology adoption is limited by discipline or content area and therefore it is not routinized. GIS, for example, is often found in mostly in two content areas in education: science and geography (Kerski, 2003). However, there is a potential for GIS use in all curriculum areas. Students travel daily through various disciplines. At times they are asked to note the interdisciplinary nature of a subject or theme, but this does not occur on a regular basis for most students. Technology and software are found infused in the curriculum of K-12 education. How we choose to use that technology is the key to helping students explore their world and construct knowledge.

GIS technology can allow students to investigate the world in spatial and tabular formats. Visual representations of data they have collected can lead to further inquiry and community participation. There is one problem. GIS is found in less than five percent of secondary schools in the U.S. according to Kerski (2003). If GIS is to find its way into K-12 schools, it must be considered an interdisciplinary tool.

The level of participation in the adoption of the innovation is also vital at this stage of the process. Individual resistance in an organization may occur. Yet there are individuals in place in many educational settings that may be able to assuage the uneasiness or trepidation of some educators. Instructional technologists are able to move across disciplines to help integrate technology in a variety of disciplines. Kerski (2003) found that teachers were most often introduced to GIS through in-service training. This training was by instructional technologists, outside consultants or by the one teacher in the school that was using GIS. If a member of one discipline conducts training, how readily would educators in other disciplines see GIS as a tool for their classroom? Investigations of GIS as a part of instructional technology are lacking.
Educators make decisions every day in the classroom about how they will introduce and share knowledge with students. Instructional technology is one approach. Educators must consider to what end they are using technology, such as GIS, as well as how they will integrate it into the curriculum. Instructional technologies and GIS should be considered one set of tools in a larger teacher toolbox that aid in student understanding in all classrooms. Educators must consider whether the tool they selected is to be used to supplement a lesson and student’s construction or understanding of the curriculum or merely technology for technology’s sake. The latter should not be the basis for using GIS or any instructional technology in the classroom.

Framing instructional technology and GIS with the models provided in Rogers’ diffusion of innovations theory help to evaluate the role of the individual and the organization in the adoption and decision-making processes of these educational innovations. The discussion of common understandings and conceptions help to frame the implications found in the examination of the linguistic and spatial data in research question five. Factors considered in this section, such as training and staff development, curriculum integration, economic issues and infrastructure needs, are important to technology integration in schools. GIS researchers and software providers must take into account these concerns when developing, distributing and publishing GIS materials for educational uses. The underlying pedagogical theories are important once teachers are trained or have an understanding of an instructional technology such as GIS. An awareness of when and how any technology is useful for student understanding and content knowledge is important to successful technology integration.
GIS brings a spatial awareness and geographic understanding to content areas. Computer technology skills such as spreadsheet creation, database querying, and end product design (maps in GIS) are integrated within GIS. Integration of GIS in classroom activities can be from a small 10-minute activity among multiple stations in the classroom or a semester or yearlong project. As with any classroom tool or technology long-term GIS projects or activities may require a deeper understanding of the software and its capabilities.

Maps, Spatial Behavior and Spatial Cognition

Individuals are confronted with maps on a daily basis. Geography education has not held a prominent position in American curriculum, in comparison to reading, science and mathematics education. Geographic literacy of the American public is often questioned. In 1988, a Gallup poll noted that, “Americans’ knowledge of world geography compares unfavorably with that of their counterparts forty years ago as well as their contemporaries in other industrialized nations” (Gallup & Gallup, 1988). These same results were found in the National Geographic — Roper 2002 Global Geographic Literacy Survey. It was found that “[o]ut of 56 questions that were asked across all countries surveyed, on average, young Americans [18-24 year olds] answer 23 questions correctly. Even on those questions where American young adults answered correctly, they still were ranked in the bottom third or below the half-way mark” (National Geographic - Roper 2002 Global Geographic Literacy Survey Results).

There is a need for increased spatial knowledge and geographic literacy. In the context of the social studies and environmental science classrooms, Marsha Alibrandi addresses the need for students to think spatially (1997; 2003). Evaluating visual literacy using GIS maps was investigated in 1996. The publication of the National Geography
Standards in 1994 initiated a push for improving GIS, geographic and spatial literacy (Kovalik & Lambdin, 1997; Geography Education Project, 1994). There is a common cultural assumption in North America that a sixteen year old is able to successfully navigate through space within an automobile. In my experience, driver’s education courses place a focus on the maneuvering of the vehicle rather than the spatial skill development.

One aspect of mapping and spatial behavior not given attention by educators is the role of the biological and neurobiological aspects of the human brain in spatial cognition. While student’s bodies are developing through childhood and adolescence their brain also is developing (Golledge & Stimson, 1997; Piaget & Inhelder, 1997; Vosniadou & Brewer, 1992). Through studies of spatial cognition, educators may be able to develop activities and lessons that aid in the development of spatial skills and awareness.

The study of GIS use in educational settings began with the research of Richard Audet (1993). Audet’s work began to justify why GIS should be used in K-12 settings with respect to child development. Studies and publications by Roger Downs, David Stea and Reginald Golledge helped to support the link between spatial cognition and mapping and GIS (Downs & Stea, 1977; Golledge & Stimson, 1997; Downs & de Souza, in press). Within the context of the classroom, the neurobiological and practical theories of spatial cognition may assist in the promotion of spatial skills that are important to child development. GIS and its capability to contextualize maps and spatial aspects of community, state, region, country and world will supplement that development.

The mind interprets multiple representations every day as we seek to navigate through the space in which we live: landscapes, diagrams, maps, signs, symbols, and graphic representations. How does our brain store, recall, and interpret these various stimuli? The
study of spatial cognition is one source for our beginning to understand the complexity of this process. A key question for educators is whether or not our current K-12 educational program helps our students develop these critical abilities so that they can more effectively navigate the spaces they inhabit and the representations they encounter.

In order to address these questions this section begins with a discussion of the history and theories of spatial cognition as they pertain to children and young adults, continues with a discussion of representations, and concludes with a consideration of the role of spatial cognition and representation in K-12 settings and K-12 educational research.

**Spatial Cognition**

Cognitive theories are often used in support of learning theories that are implemented in curriculum decisions (McNergney and Herbert, 2000; Roblyer, 2003). Cognitive development reflects the changes that take place in the mental processes of individuals (Woolfolk, 2001). These changes typically lead to more complex structures. According to Cohen (1985), “how an individual experiences the world (perception) and how an individual understands the world (cognition) are considered as integral to the dynamic interplay of person and environment” (p.2). This interplay is fundamental in the investigation of the field of spatial cognition and the ancillary fields that explore how the mind and the world are interconnected. “Spatial cognition, defined broadly, is the study of knowledge involving the interrelationships among people, objects, and space” (Devlin, 2001, p. xv). While spatial cognition is at center of the discussion, neuropsychology, concept mapping and spatial representation all are involved in understanding the relationships between people and space. Much of the work and discussion in these fields begin with the relevant writings on spatial cognition by Jean Piaget.
Piaget is best known for his theory of the four stages of cognitive development: sensorimotor, preoperational, concrete operational and formal operational (Devlin, 2001; Muuss, Velder, & Porton, 1996). In his work written with Barbel Inhelder, *The Child’s Conception of Space*, Piaget notes the importance of the haptic sense in the earliest stages of development. The proximity of objects and people to the infant is primary to his perception of space. This first stage is characterized by a lack of coordination between vision and grasp. There is no object permanence at this early stage. The sensorimotor stage follows with object recognition and later shape recognition and relationships between objects established by haptic exploration. As children grow older, the familiarity of objects and topological shapes are part of spatial development. The ‘progressive recognition of Euclidean shapes’ and eventual recognition of those shapes and representations are present by the (concrete and formal) operational stages (Piaget & Inhelder, 1997). Golledge (1997) simplifies Piaget and Inhelder’s stages of perception as “vague awareness,” classification/categorization of spatial characteristics, recognition and identification (p.227). The theory and stages attributed to the work of Piaget and Inhelder were the foundational pieces that would lead to further investigation of how individuals would process and externalize the spatial representations in their minds. This would also lead to questions of cultural and/or experiential influences.

Kevin Lynch’s *The Image of the City* (1960) investigated the external representations and common components of individuals’ mental maps of several major cities. Lynch’s investigation included interviews, sketches and fieldwork in the cities of Boston, Jersey City and Los Angeles. This study investigated features that were common to the subjects’ representations as well as the differences that were expressed in interviews about their mental images. The physical landscape of the city and the external representations of the mental
images were categorized by the following: paths, edges, districts, nodes and landmarks (Lynch, 1960, p. 47-48). This typology of the physical representations of the mental maps allowed Lynch to investigate the interrelatedness of the categories to better understand an individual’s perceptions of the environments in which s/he lived. One of the important points of investigation was to find the common landscapes and images people represented in sketch maps. These ‘public images’ were “the common mental pictures carried by large numbers of a city’s inhabitants” (Lynch, 1960, p. 7). A cultural commonality found in the mental images of a specific location leads to larger questions of how individuals learn and store information about the physical environment. Are these images culturally influenced or influenced by experience within the environment? Lynch (1960) suggests that culture and experience both play a role in the images of location that individuals have. From this seminal study, the first to combine sketch maps and interview data, Lynch offered suggestions for future design of cities and urban areas. He subsequently built the first urban studies program in the US at MIT. Could then the implications and findings of Lynch’s work be used in education? I shall return to this point in a discussion of concept mapping in K-12 education.

Lynch’s was one of the first studies to investigate the spatial relationship between the mind and the physical landscape. The categorization of the cognitive features of the physical space led to further research in spatial relationships among environment and individual in the fields of geography, psychology and ‘environmental perception.’ Throughout the 1960s and 70s, researchers began to investigate the spatial understandings and representations of children and adults to better understand the ideas Lynch brought to light.

Siegel and White’s (1975) work, in spatial behaviorism, focused on landmarks, such as routes and paths, as an aspect of experience and cognition. Their work in the 1970s was
based on the work of Piaget. The researchers postulated that, “Following the use of landmarks as individual references, the child next forms clusters of landmarks and ‘minimaps’ (Devlin, 2001, p. 11). Researchers, using Siegel and White’s work, have begun to study the changes that take place in children’s spatial cognition to better understand adult cognition.

**Dual coding: Spatial and Linguistic Cognition**

Paivio (1991) developed what is known as dual coding theory to explain how the brain stores and interprets experiences as representations and other cognitive constructs. Dual coding theory is based on:

A central assumption...that experiences are represented in concrete, modality-specific ways that reflect the original events on which mental representations are based. A verbal cognitive system represents and processes linguistic information, whereas a nonverbal system handles perceptual-motor information concerning environmental objects and events. The two representational systems are functionally independent, but appropriate experiences produce referential connections between the verbal and non-verbal systems, as well as associative connections among representations within each system. (Paivio, 1991, p. 161)

In dual coding theory, the unit of linguistically instantiated and stored information Paivio referred to as a *logogen* and the non-verbal representations are referred to as *imagens*. *Imagens* and *logogens* may be abstract (such as ‘hero’ or ‘amount’) or concrete (such as ‘desk’ or ‘pocket watch’). These aspects of language and image are processed separately and then output in non-verbal or verbal methods (Paivio, 1991, p. 327).

Allow me to provide you with an example: an individual hears or reads the word “tree” and this word evokes a very specific image in their mind that is encoded to match that particular set of letters and sounds. For one individual, the word tree may evoke an image of a live oak while for another person it might evoke a cypress tree. The tie between the word
and the image are based on individual experiences, culture and knowledge. It is an individual conception of the same word and the image and/or the word may hold different meanings for each of the individuals. The person who thought of the live oak may have remembered the tree house in the live oak in their back yard where they spent many happy afternoons playing. Whereas the individual who pictured the cypress in their mind may have been canoeing in a swamp and a snake dropped in the canoe from the tree and bit them. These experiences while radically different are evoked by the same word.

More specific phrases or words may have similar conceptualizations among individuals but it is dependent on how each individual experiences, perceives, and encodes the information. This returns to the research questions of how students and teachers conceptualize GIS in the world, instructional technology and GIS in schools. Each of these phrases may have a specific meaning for the individual subjects in this study. The similarities and differences among and between educators and students understandings may help instructional technology and GIS in education researchers understand how individuals perceive and conceptualize these ideas.

The ways in which individuals process these *imagens* and *logogens* may begin to define the way in which they understand the phenomena. Phenomenographic research is one approach which is “focused on ways of experiencing different phenomena, ways of seeing them, ways of knowing them and having skills related to them. The aim is, however, not to find the singular essence but the variation and the architecture of this variation in terms of the different aspects that define the phenomena” (Marton and Booth, 1997, p 117). While interview is the most common method used in phenomenographic research for data collection it may be coupled with other methods. Some phenomenographic researchers have asked
study participants to draw graphic representations of their understandings of a specific phenomenon (Marton, 1994, p. 4427). Through the combination of the interview and the drawings, the researcher is in essence comparing the *imagens* and *logogens* of the learner, which may lead to a clearer understanding of how different people categorize and understand a phenomenon. Key to phenomenographic research is to understand the “qualitatively different ways in which people experience and think about various phenomena” (Marton, 1986, p. 31). This research approach is dependent upon self-reflective responses of the conceptualization and understandings of a phenomenon by the individuals in the research. Thus it lends itself to a closer tie to the neural processes of categorizing and storing information among and between individuals about a phenomenon.

**Cognitive Neuroscience**

The functions of the brain in spatial cognition have emerged as a new avenue of study. Technological advancements have enabled scientists, psychologists, and neurologists to examine the brain in ways that have not previously been possible. These advancements from EECs (electroencephalography) to PET (Positron emission tomography) and fMRI (functional magnetic resonance imaging) have made investigations of the inner physiology connected with action, speech and thought more promising. Often studies have stemmed from persons who have suffered brain damage or lesions. Texts in spatial cognition in the past five years have begun to include information about the structure of the brain and the research that has arisen from this line of inquiry (Devlin, 2001).

Steven Kosslyn has emerged as a leader in spatial cognition research and neuropsychology. Kosslyn brings a combination of psychology and neurology to the table. His book *Wet Mind* provides an in-depth look at the processes that the brain must undertake
for the simplest of movements (Kosslyn & Koenig, 1992). An example of his work within this context is to think about what it takes to learn how to drive a manual transmission vehicle. He equates this struggle with similar processes that children must work through in order to learn how to write. Within the example of learning to drive, there are numerous factors that the new driver must consider — shifting, braking, staying between the lines, watching the vehicles ahead, behind and beside the vehicle. This process requires attention to space(s) as well as simple movements. After driving for a while, the driver becomes more comfortable; the movements come more easily so that the driver may focus attention on the surrounding space(s). Similarly, the repeated movements necessary to drive or to write must be encoded and stored in what Kosslyn refers to as ‘motor memory.’ It is remarkable to consider each and every one of the subconscious processes one enacts in a typical day. These movements are coordinated with visual stimuli for most people which means that the brain must interpret all of the signals and rank them as to which is more important and must be completed first (Kosslyn & Koenig, 1992).

Kosslyn’s (1994) work in *Image and the Brain* compared information processing within the brain to the information process of computers. This work focuses on the systems of the brain and the eyes in the interpretation of images and the environment. He includes in his discussion the newest imaging techniques with which to study the brain. EEGs (electroencephalography) were historically the way to measure brain responses to stimulus. With improvements in technology, PET (Positron emission tomography) and fMRI (functional magnetic resonance imaging) became the newest tools to scan and ‘map’ the processes of the brain. As these new technologies were harnessed for research, they permitted deeper insight into how the brain functions, including spatial cognition. Kosslyn’s
contributions to spatial cognition in the field of neuroscience are aiding in mapping and representing the systems and subsystems of the brain required to perform, as he says, “things the organism is able to do.”

**Spatial Representations**

By 1981, Lynn Liben proposed a typology of spatial representation that consists of three types and two contents. The three types discussed were spatial products, spatial thought, and spatial storage with two contents — specific and abstract (Liben, Patterson, & Newcombe, 1981). According to Liben (1981), “spatial products refer to the external products that represent space in some way” (p. 11). Spatial thought is often synonymous with spatial consciousness or spatial reflectivity. It refers to the way in which we think about spatial aspects of our lives. Spatial storage “refers to any information about space that is contained ‘in the head’ but is not accessed in a conscious or reflective manner” (Gattis, 2001, p.49; Liben et al., 1998 p. 13).

Liben’s descriptions concerning the content aspect of her typology refers to knowledge about specific places (sometimes referred to as environmental cognition) and abstract knowledge (also be referred to as spatial abstraction). When conducting research in spatial cognition it is important to consider what aspects of this typology will be investigated. The methodologies may differ depending on the content and/or the type of representation. There are a variety of methodologies employed to gather research about children and their spatial and representational understandings. Sketch maps and field experiences at home, in the community, and at camps seem to be the most popular locations for these studies (Devlin, 2001).
Vosniadou and Brewer (1992) investigated the conceptual understandings of children regarding the earth and issues of gravity through interviews and drawings. Vosniadou and Brewer were interested in the conceptual knowledge constructed by children about the earth and its location within space. They interviewed sixty children in first, third and fifth grades (20 in each grade). The researchers hypothesized that the younger students would conceptualize the world as flat due to their experiences on earth and limited educational exposure about the subject. The researchers did note that the concept of how and where the Earth is in space might have been discussed in participants’ homes (Vosniadou & Brewer, 1992). The 30-45 minute interviews conducted by Vosniadou and Brewer (1992) included requests for drawings of the earth, stars, sky and other pertinent representations. Of the 60 participants, twenty-six represented mental models of the Earth that were not spherical. This is interesting since, as Vosniadou and Brewer (1992) mention, many of the students are exposed to the idea that the Earth is a sphere yet they still insist on models that are flat or rectangular. The researchers contend that it is their environmental exposure to concepts like gravity that confuse the notion of the earth floating in space. Many of the students struggled with their own conceptions, which were in conflict with comments by teachers and parents and were attempting to reconcile those differences (Vosniadou & Brewer, 1992). This research demonstrates the interactions between Piagetian developmental stages and functionalist cognitive and/or constructivist principles at work as depicted in students’ spatial representations.

**Cognitive Mapping**

Downs and Stea (1977) described cognitive mapping as “an abstraction covering those cognitive or mental abilities that enable us to collect, organize, store, recall, and
manipulate information about the spatial environment” (p. 6). An individual’s cognitive map is his/her representation of the spatial environment used in interpreting, understanding and operating in space through integrated environmental perception. For instance, if asked to draw the significant areas of a building and its surroundings, the representations would differ for each individual. A wheelchair bound individual undertaking this task would denote the location of the wheelchair accessible areas as part of the representation. Whereas, the location of ramped entrances and elevators may or may or may not be considered significant features to another individual. Golledge (1997) categorizes cognitive mapping as a subset of spatial cognition (which he states is a subset of environmental cognition). He further states:

The process of cognitive mapping is a means of structuring, interpreting, and coping with complex sets of information that exist in different environments. These environments include not only the observable physical environment, but also memories of environments experienced in the past, and the many varied social, cultural, political, economic, and other environments that have impinged both on those past memories and on our current experiences. (1997, p.229)

There is often a temporal aspect to an individual’s cognitive map —much like a snapshot of a place in time. In the most simplified terms it is a “mental image,” a representation that is found in an individual’s brain. Downs and Stea (1977) state “The principal reason for attempting to understand cognitive mapping is that the world as we believe it to be serves as the basis for much of our everyday spatial behavior” (p. 12). They acknowledge the differences in individuals cognitive maps based on experiences and spatial ability.

Researchers have written about cognitive maps and their role in spatial cognition. Within spatial cognition, cognitive maps are concerned with where and how one stores and retrieves information about large-scale spaces (Downs & Siegel, 1981). Downs and Siegel (1981) use cartographic relativism to compare cognitive maps to cartographic maps. The
paradox, in my opinion is that a cognitive map is a representation just as is a cartographic map. Their comparisons are between two subjective representations.

Questions of cultural relevance or cross-cultural understanding of spatial representations are also pertinent to this discussion. For example, a Taiwanese student in a GIS course produced a map with the oceans in a green hue, which immediately struck her American classmates. The students from the U.S. held a cultural understanding that blue was the “accepted” color of water. While color differences are of significant interest the concept of spatial representations of the Earth surface is found across cultures. Stea, Blaut and Stephens (1996) examined the act of mapping as a cultural-ecological phenomenon. They note:

In human macro environmental behavior, it is necessary to visualize, analyze, describe and communicate the complex characteristics of the vast environment within which all humans live. Since this environment is too large and complex to be perceived from any single vantage point on the ground, in cognizing it or learning about it or describing it, humans need to map it. Cognitive mapping is thus ubiquitous. (Stea, Blaut & Stephens, 1996, 347)

Over time, humans have communicated through maps and diagrammatic schemata of their environment (Harley and Woodward, 1987). Stea, Blaut, and Stephens (1996) give credence to the cross-cultural play of children, which is rooted in cognitive mapping. These acts of “building” landscapes, worlds or replicas of their environment are part of the primary stages of spatial and cognitive mapping and thought. This play is the first step in the “ability to map, to express in material form the cognition of large scale-environments” (Stea, Blaut & Stephens, 1996, p. 356). If students begin to develop their cognitive maps prior to entering K-12 education the processes in school should further expand those maps.
Spatial Cognition, Mapping and Representation in Education

Students must navigate through space(s) every day. There is no explicit training in navigation through the hallways of buildings. When most students are very young, they are walked to the bus stop and met when they return home or are accompanied by an older sibling. In this situation the young student is being trained in the routes that are important to their environment according to Siegel and White (1975). The daily repetition of the walk to the bus stop is similar to the repetition that Kosslyn (1992) called motor memory. Slowly the environment becomes familiar. Spaces that were once unknown become known, and are stored as cognitive maps in the mind of the individual. As students grow and are allowed more freedoms, they expand upon the spaces with which they are familiar. Their ‘mental map’ becomes populated with images in memory of places, spaces, sights, sounds, smells and tactile stimuli.

Students maneuver through space and are engaged with it at a very young age (Alibrandi, 2003). Schools should help develop those spatial skills that humans have used through thousands of years of migration and exploration. Knowledge sets that are seen as valuable by a culture, such as mathematics or science, tend to receive higher value within the classrooms.

The subject of geography is most often associated with spatial thinking. Interestingly in the National Geographic-Roper 2002 Global Geographic Literacy Survey (2002), “Nearly nine in ten [U.S.] respondents (88%) said that map-reading is absolutely necessary or important. This ranks map reading on par with knowledge of personal computers (93%) and calculator use (90%)” (p. 10). Of the 495 U.S. respondents (aged 18-24), several factors that improved scores on the survey were geography education, international travel, multiple
language skills, and Internet usage. Map-reading is only one skill that is part of a larger spatial toolset. However, it is one of the most recognizable competencies. While most of the respondents to the National Geographic-Roper Survey suggested that map-reading was a necessary skill, almost half of them had not completed a geography course.

Curricular areas have potential spatial dimensions regardless of the grade level. Social studies, science and language arts have explicit locational and spatial components. World events, historical events, landforms and ecology, and settings in literature are all spatially tied to the curriculum of these subject areas. Health courses may examine spread of disease from location to location (or person to person). Drama and other arts courses examine locations of emerging techniques and styles of drama, dance and art as well as settings of plays and artistic works. Mathematical calculations, such as the representational fractions in scale, are necessary to represent the physical landscape on maps. These connections to spatial aspects of curricula can be introduced to students as parts of lessons. This would help to connect the environment outside of the classroom to the student inside of the classroom. These explicit understandings and representations of place and space for individual students may begin to connect the knowledge of school curriculum with his/her life experiences in the spaces, places, activities, and cultural understandings in their own culture.

**Cognitively-based educational theories**

Howard Gardner began to put space back in some facets of learning and the classroom. In his influential text, *Frames of Mind: The theory of multiple intelligences*, Gardner (1985) explains: “Central to spatial intelligence are the capacities to perceive the visual world accurately, to perform transformations and modifications upon one’s initial
perceptions, and to be able to re-create aspects of one’s visual experience, even in the absence of relevant stimuli” (p. 173). Educators may question how the spatial intelligence of Gardner’s theory is relevant to students who are blind or vision impaired. Through the use of tactile and mental imagery, students with vision impairments can participate alongside their sighted counterparts (Gardner, 1985).

The multiple intelligences are not the only entry point for spatial thinking and spatial activity in American education. Orienteering, a sport based on navigation and mapping, can be introduced in physical education courses. Social studies classes can undertake community projects outside of the classroom or assign semester/quarter-long scavenger hunts for community resources enabling students to experience the spatial relationships among their community agencies. In addition to previously mentioned mathematical applications, measurements often require spatial concepts, especially in geometry. There are numerous environmental science applications that have already incorporated spatial dimensions using GIS to correlate field studies (Baker, 2002; Audet & Ludwig, 2000; Alibrandi, 2003).

Important to this discussion is how technology and representational software fit within spatial cognition. There are numerous software packages that require the user to understand the meaning of representations. Geographic Information Systems are a natural fit for spatial explorations and analysis. Multimedia software and visualization software are also reliant on representational structures.

One of the most common navigational tools that students use without thinking of the nature of the technology is the World Wide Web. The Internet hyperlinks documents together using non-linear methods. Users often bounce from website to website without consideration of the route that they have taken until they must return. When designers plan the navigation
of non-linear multimedia they must consider the spatial aspects of how the information will be tied together and represented to the user (Chen, 2002; Fastrez, 2001). There are ‘navigation bars’ found on most Websites. These tools for navigating have roots in map making — most large websites have a “sitemap” that allows the user to find where they need to go within the site. These metaphors that draw from geography as Downs noted, serve as spatial representations of conceptually located information

**Developing Critical Lenses**

In addition to the spatial movement through technology we must encourage students to take a critical stance with respect to the representations of data with which they are presented. Edward R. Tufte (2003, 2001, 1997, 1990), offers several texts with many examples of representations and critical perspectives of representations. Tufte’s books also can be used in classrooms to begin a dialog about perspective within spatial contexts and representations. Interpretation of spatial data and symbology represent cultural understandings and constructs.

All maps are representations of the world. As representations they omit and exclude certain features in order to more fully examine others. The scale of a map determines to what level of detail the features are displayed. For example a community-based map of a watershed will provide details of creeks and streams. As the watershed is displayed on a state or national level the features become more generalized and may be omitted completely in order to produce a more understandable product. Cartographers make decisions in every map of what is important and what is excluded. A cartographer for a zoological society may create a map of the community watershed with the habitats of endangered species noted
whereas a tax assessor may exclude the endangered species and include the property lines and outlines of structures.

**Cognitive Mapping**

The topic of cognitive mapping is also important to educational settings. Every student has an individual cognitive map based on his/her experiences and the spaces in which she/he travels and lives. These individual differences may be primary to understanding the cognitive maps of others. For instance, in a language arts classroom, one would expect that students will be reading stories and novels. All literature is situated in a location, known as the setting. Students are expected to recognize and develop an understanding of the settings of books that they read. Reading comprehension is enhanced when mental imagery is present. “Places ‘come alive’ and we can see the world through the eyes of different characters” (Downs and Stea, 1977, p.25).

The position from which students see the world is also important from a developmental perspective. The cognitive map of an environment from an *egocentric* position is one where objects, spaces, and places are all relative to the individual. This world perceived and understood from the vantage point of the self is found among very young children. As children begin to move toward adolescence, their world and environment, according to Piaget and other cognitive psychologists, becomes *allocentric* in its position to the self. The position of objects and locations are relatively stationary and are seen as separate from the self. This does not mean that humans lose their egocentric positioning; they simply build upon it and are able to cognitively separate the self from the environment.
Concept Mapping

Concept mapping is one tool used on classrooms to help students organize their thoughts about a topic or idea. Buzan (1994) presents the idea that concept mapping allows another “to ‘get inside’ the mind of an individual and explore his or her ideas” (p. 85). The ability to view how an individual conceptualizes an idea through the use of images and words may help educators understand how a student not only understands a concept but also how it is connected to other aspects of the student’s prior knowledge, environment and experiences. Buzan (1994) stresses the importance of images, text and spatial awareness when creating a mind map. In this respect educators are able to observe the dual coding of conceptual knowledge for an individual. In addition, mind maps have spatial (and geographic) characteristics that can be evaluated: the main concepts or images; the branches of themes of the foremost idea; the hierarchy of the branches and sub branches; and the connections or nodes.

Novak and Gowin (1984) introduce concept mapping as a tool to aid students in learning about knowledge and how knowledge may be processed. “Meaning, to a person, is always a function of how he or she has experienced the combination of thinking, feeling, and acting throughout life experiences” (Novak, 1998, p. 35). Novak and Gowin (1984) focus on meaning making and shared meanings among students and between students and educators. One of the potential uses of a concept map is that it “can also provide a kind of visual road map showing some of the pathways we may take to connect meanings of concepts in propositions” (Novak and Gowin, 1984, p. 15). While these authors initially focused on how the representations created by students may aid teachers in the learning process, they also found concept mapping a helpful aid for researchers.
As previously discussed, Lynch (1960) categorized the features of the city to compare the mental image and the physical landscape. His examination of the nodes and interconnectedness of the locational information (landmarks, pathways, etc) could be similarly used in an examination of the mind maps or concept maps used in a classroom. The representation of the student’s unique connections between ideas, images and their relationships then allows the educators to examine the student’s personal understanding of a larger concept.

**Using Concept maps and Interviews: Phenomenography**

Novak and Gowin (1984) began to use student concept maps to structure interview questions when the “objective in an interview is to ascertain what the learner knows about a given body of knowledge” (p.122). These authors used sample concept maps to begin to develop interview protocols. One of the drawbacks to this method is “by applying as the major criterion for the student’s understanding the same concept map upon which the interview was designed, creative or unanticipated ways to view the same subject matter can be missed” (Novak and Gowin, 1984, 139).

Within my research, the concept maps are integrated into the interview process with individual students and educators. The research interest of my study is not only what may be common conceptualizations among the participants but also the variations in their perceptions and understandings of GIS, IT, and GIS in schools. Novak (1998) begins to contextualize meaning making of knowledge from an individualistic perspective. He discusses the differences in meaning between students and educators that need to be negotiated to increase understanding and knowledge. “It is important for teachers and administrators to remember that they live in a culture in some ways significantly different
from their students or subordinates. Therefore, the same word can have significantly different meanings for each person” (Novak, 1998, p. 38).

Mavers, Somekh and Restorick (2002) used the idea of concept mapping together with interviews to investigate student understanding of Information and Communication Technologies (ICT). The researchers selected the production of concept maps by participants as indicators to investigate students’ conceptions of technology. This seems appropriate given that new technologies “make extensive use of images and icons rather than conforming to tradition and privileging textual and numerical symbols” (2002, p. 189). In addition, the representations allowed the researchers to gain insight into the internal connections that students were making. This approach also begins with the perspective of the student rather than researcher assumptions. The representations are the external demonstrations of spatial and cognitive relationships. There are intriguing implications for further research in spatial cognition and K-12 education.

In my research, I will begin to examine the cognitive conceptualizations of students and educators with respect to GIS, IT, and GIS in schools. Through the use representational drawings by participants a deeper understanding of how the participants representing and making connections to prior knowledge will be examined. Subsequent interviews will provide a linguistic counterpart to the representation, thus approaching the concepts of interest through the two modalities of stored knowledge Paivio (1991) calls *imagens* and *logogens*. The insights and connections generated by the study participants may provide new perspectives of GIS and IT that have yet to be examined.
The Future of IT, GIS in Education and GIS within the Schools

GIS is used throughout the world. It is a powerful tool that enables the user to spatially represent and analyze data. It has been used in schools for 15 years and has a slow and gradual rate of adoption. GIS has been viewed in current research as a tool for a specific curriculum, such as a science tool or a social studies tool, whereas in the world it is a tool for everyone. If its position shifts to a more multidisciplinary location, such as in instructional technology, the adoption and decision-making process may be accelerated. Education based organizations will reach a decision point with GIS technology where they will: implement it, make/ask for changes to better their needs, or dismiss GIS technology.

While there is not a shortage of research in the field of instructional technology, the impact of computing technologies alone on K-12 schools has been investigated by numerous researchers, companies and organizations. The literature in instructional technology can help GIS researchers whose focus is education-based research. The concerns and issues schools, administrators, and educators have when integrating instructional technologies are a foundation for the consideration of GIS integration in K-12 education.

Through examination of instructional technology research questions and findings GIS in education, researchers must begin to examine questions such as: why is GIS important in K-12 education? What skills or knowledge do GIS technologies offer students and educators that other products and technologies do not? What are the best approaches to GIS integration in the curriculum? How do students learn with and about GIS in K-12 schools? While GIS applications are widespread in businesses and government agencies the research and discourse in GIS in education is in the early stages. This innovative technology could be poised for ubiquitous classroom use; however, the questions raised here must be addressed.
Instructional technology literature and research offers elements of a foundation on which GIS education research and literature may build their case for GIS in K-12 education.

These gaps in the research also include these questions: Can GIS be viewed as an interdisciplinary instructional technology rather than a subject area specific tool? Can teachers and students see GIS as a technology tool across disciplines? With the use of GIS in the classroom, can power and knowledge expertise paradigms shift to acknowledge and utilize student expertise status in K-12 settings? If the accepted roles in K-12 settings are altered, how does this affect student learning? Does GIS aid in spatial understanding among students regarding their own location and relationship to other spaces? To date there has not been a research study that investigates individual teacher and student perceptions of GIS. An examination of these points of view may aid GIS in education researchers, GIS software companies with an interest in education and GIS trainers by providing an understanding of the frameworks within which teachers and students place GIS.

There is currently a dearth of research on the implementation of GIS in individual classrooms. My research begins to take a step back and ask how the GIS-exposed educators and students conceptualize the technology. This study is a multi-case study using phenomenographical methods to investigate the perceptions of students and teachers, through the use of representational drawings and interviews. Their perceptions and conceptual representations are essential to understanding how GIS and IT might form a complementary relationship of perceived benefits of integrating GIS in K-12 settings. This study encompasses participants’ global perspectives on GIS, GIS in the schools, and instructional technology.
The participants’ perspectives on ITs, I believe are important for the following two reasons. First, many schools do not have a geography department or geography courses which are historically the “home” for GIS education. GIS consequently finds a home in science or social studies. The interdisciplinary nature of the technology is lost due to the perception that it is a tool for a specific curricular area. There are spatial connections across the curriculum goals and standards for all K-12 subject areas. GIS, a spatial tool, is the “missing link” between IT and the curriculum areas. GIS fills a need for tools that analyze and relate the spatial elements of curriculum and technology.

Second, if GIS is a ubiquitous yet invisible technology as postulated in chapter one, the findings in question four may be beneficial to stakeholders within the GIS in education field. If the participants have similar conceptions of GIS and of IT, as referred to in question 4, this may provide a foundation for future research and education in K-12 schools and for educators who are learning how to integrate GIS in the classroom. Conversely, if students and teachers do not have similar conceptions between GIS and instructional technology this can provide a starting point for GIS in education researchers and GIS software companies to begin to examine and create those connections in future research. This, of course, is predicated upon an assumption that there is a perceived need or desire to adopt the innovation. If there is neither a need nor a desire to move forward with GIS in educational settings as an innovation this discussion becomes moot.

Within the review of the literatures the diffusion of innovation theory helped to frame the discussion of how and where GIS and instructional technology adoption may fit as innovations within education. GIS in education adoption has been slower than IT. I suggest GIS in education is currently in initial stages of the organizational decision-making process:
agenda-setting and matching. There are a number of innovators and earlier adopters who have embraced GIS in educational settings. The decision point has not yet come for GIS in most educational settings, however it is soon approaching. The pedagogical considerations for GIS and IT integration in K-12 schools are vital. Technologies and other tools must be tied to the curriculum to enhance student learning. If technology, specific software, or approaches are not the best way to aid in student understanding, knowledge acquisition and higher order thinking they should not be the “tool” of choice.

The push by agents and software manufacturers toward Internet-based GIS rather than desktop GIS software may accelerate the diffusion curve to a quicker “uptake” or adoption by educators and/or educational institutions. IT on the other hand has surpassed the decision point and has moved into the implementation stages. The research and literature documenting this process in IT may be invaluable to GIS researchers and others with interests in seeing GIS in education.

One of the benefits of GIS integration in K-12 schools is a deeper understanding of the role of geography in other curricular areas. In addition, GIS can be used to augment student led inquiries, data collection, data analysis and representations of data. The spatial aspect of GIS can facilitate student understandings of the world around them. Spatial cognition research adds another dimension to this discussion and begins to frame the use of the representational drawings and concept maps found in the research methodology.

**Summary**

This chapter provided a review of the literature that supported and defined the research questions of this study. The conceptualizations of these earliest adopters, educators and students, of GIS, IT and GIS in schools are important in understanding the
process of diffusion of technologies as an innovation. The subsequent discussions of how these conceptualizations may inform processes of decision-making and implementation of IT and GIS in K-12 schools. The perspectives brought forth by the students and educators should reflect their experiences and understandings as expressed through the spatial and linguistic coding of these phenomena. In chapter 3, I elaborate on the methodology used to collect and interpret the understandings of the participants. This will specifically be framed by dual coding theory and phenomenographic research as brought forward in this literature review.
CHAPTER THREE

METHODOLOGY

In the literature review provided in Chapter 2, GIS and IT in schools were examined through the framework of the diffusion of innovations theory. From this discussion, the need for an understanding of how students and educators, stakeholders in the decision-making process, conceptualize these topics emerged. Through the use of dual coding theory based in spatial cognition research and phenomenographic research methodology, the research questions and methodology of this study developed.

In this chapter I will provide an overview of the methodology. This discussion begins with an overview of the qualitative methods selected. Background information regarding multi-case study, use of representational drawings, use of interviews, and phenomenography are provided. The selection of participants and overview of the decision-making process to determine those participants is provided. Additionally, the interview and informed consent protocols are discussed. This chapter ends with a discussion of the data collected, including how it was stored and how it was analyzed.

Overview of the Methodology Based in the Literature Reviewed

The research is a multiple case, or multi-case, study of six individuals who have demonstrated equivalent skills in GIS and are either educators or students in K-12 education. Studies of the use of Geographic Information Systems (GIS) and instructional technology (IT) in the U.S. classroom, as mentioned in the previous chapter, have generally focused on the skills students have learned and how the technology was taught. This study, however, will focus on the experiences, understandings, and ways of thinking about GIS, IT the relationship of GIS and IT to schools. The research questions scaffolding this study are
directed toward the questions of “how” these individuals conceptualize the phenomena of GIS in schools as compared with IT and GIS in the larger landscape. The methodology of this multi-case study draws on spatial cognition theories, prior research in the fields of geography and education and methods emerging from phenomenographical research. Through comparative analysis of the data (representational drawings, interview and observation) the understandings of these individuals will emerge. The findings may aid in the decision-making process of GIS integration in K-12 education by providing insights for GIS educators and instructional technologists in implementing this tool throughout the curriculum.

The qualitative research methodologies of case study, interview and phenomenography were selected based on the nature of the phenomena of this study. In order to understand how individuals conceptualize and make meaning about a given topic, a qualitative approach rather than a quantifiable approach lends context to the study. Bogdan and Biklen (1998) specify five features that are essential in the decision to use qualitative analysis rather than quantitative. These features include a concern for: 1) naturalistic settings, 2) descriptive data, 3) process rather than outcomes or products 4) inductive analysis 5) understanding meaning through participant perspectives (Bogdan & Biklen, 1998, p. 5-7).

The settings used in this study were decided upon by the participants [or their parent(s)/guardian(s)]. The ability to draw the representations and conduct the interviews in a location that was comfortable and natural for the participants was important to me. The reasoning for this was twofold. First, the individual’s ability to choose the setting would place them at ease. And secondly, the burden of travel was placed upon the researcher rather than the participant. The descriptive nature of qualitative data also accommodated my needs.
in the structure of data collection. The phenomenographic methodologies were decided upon to begin to analyze the products and outcomes but the conceptualizations were the focus of the research. Understanding how the lived experiences, knowledge acquisition and perceptions of educators and students influence how they understand and think about the larger topic of GIS in schools was also important to this study. Additionally, the belief that “most contemporary qualitative researchers nourish the belief that knowledge is constructed rather than discovered” is part of my personal subjective research lens (Stake, 1995, p. 99; Lincoln and Guba, 1985). These factors blended with my personal research lens led to the selection of this particular methodology for the study.

**Multiple Case Study**

The determination to use multiple case, or multi-case, study research rather than a single examination of one individual’s perceptions of GIS, IT, and GIS in schools is based on the assumption that each individual brings a unique perspective to the table that may help to paint a more detailed picture of the research question. Each of the six participants in the investigation represents a separate case. According to Stake (1995) a case “is one among others;” it may be a student, a teacher, a school, a program, or all of the schools of one country (p. 2).

According to Yin (2003), multiple-case design is often found in research surrounding school innovations. Both GIS and instructional technologies in schools, as described in the literature review, can be considered innovations in education today and are the focus of research. Stake (1995) refers to a multiple case study as a “collective case study” where: “balance and variety are important; opportunity to learn is of primary importance” (p. 5-6).

With the number of participants \( n \) equaling six, many quantitative researchers
might dismiss this methodology as non-representative of a population (or even a sample). While it is understood that the conclusions drawn in this study cannot be generalized beyond the sample of the six individual participants, the findings of their individual conceptualizations may begin to illuminate further landscapes of learning for future research. This is a qualitative-based research study that has replicable methods. Replicability of the findings, however, is dependent upon the individuals interviewed as this is an investigation of individual conceptions and thought processes about GIS, IT, and GIS in schools. The focus of this investigation is the greater understandings that emerge from “thick description.”

**Representational Drawings**

The decision to include representational drawings as a data collection point was based in prior research in geography and instructional technology. Lynch’s (1960) research in geography was seminal in the examination of how a phenomenon (a city) is perceived by the subjects of the study (in his case the inhabitants) and represented through drawings or sketch maps. Additionally, Lynch’s research was based on spatial perceptions and geographic locations, which have relevance to the study of GIS. This early research, using subject drawn perceptions, helped develop an understanding of the different ways in which individuals might experience and think about a similar location or phenomenon. This idea of externalized representations is not limited to geographic studies as it has been the focus of research for educational psychologists and instructional technology researchers as well.

Novak and Gowin (1984) provided the foundational research in concept mapping as a method to understand an individual’s cognitive maps. Novak and Gowin (1984) found “concept mapping is a technique for externalizing concepts and propositions” (p. 17). They began by evaluating concept maps quantitatively based on Ausubel’s (1963) cognitive
learning theory. Novak and Gowin developed scoring criteria for concepts maps. For example, one scoring technique, intended for educators to evaluate student work in the classroom, included the following categories: propositions, hierarchy, cross links and examples (1984, p. 36).

Research in the United Kingdom by Mavers, Somekh and Restorick (2002) and Somekh and Mavers in (2003) built upon the findings of Novak and Gowin (1984) and Novak (1998). Mavers, Somekh and Restorick’s (2002, 2003) phenomenographic research based on school children’s conceptualizations of Information and Communications Technologies (ICT) provides a foundation for this study. The researchers used concept maps or “mind maps” as the beginning point of the research. The student-produced representations were then used as the basis of the interviews conducted for further data collection. The categories of understanding of ICT emerged from the data collected. In the British research, the two categories that surfaced were “Spheres of Thinking (SoT) and Zones of Use (ZoU)” (Mavers et al., 2002; Somekh & Mavers, 2003). These researchers used a combination of quantitative and qualitative methods to identify the patterns from their phenomenographic and interview data.

My investigation, a multi-case study focusing only on six individuals, is methodologically structured based on the model provided by these British researchers. The data collection methods are similarly applied to the conceptual understandings of educators and students with respect to GIS as it exists in the world, instructional technology, and GIS in schools. The emergent categories from this study will be further discussed in the discussion of the data found in Chapter 4.
**Linguistic Understandings through Interviews**

*Dual Coding Theory.* Paivio’s (1991) dual coding theory, as discussed in Chapter 2, aids in framing the research methodology. His theory explains how individuals neurologically code experiences, concepts and phenomena. According to Paivio, individuals code their understandings and knowledge symbolically in linguistic and imagistic units. He labeled these *logogens and imagens* respectively. The integration of the logogens (words) and imagens (images) are unique to individuals and their conceptualizations of a phenomenon. The brain-based connections that develop surrounding a phenomenon are grounded in the individual’s understanding and experiences. Each individual begins to draw connections in their mind between prior knowledge and new knowledge both through linguistic and image based coding. Paivio’s research is complemented by the investigations of concept maps by Novak and Gowin (1984). Their research enables an investigation of cognitive understandings through externalized representations and spatial connections made between concepts and ideas. Based on Paivio’s theory, and Lynch’s and Novak & Gowin’s approach, the combination of representational drawings coupled with interviews will reveals the participant’s understandings of the research questions and related topics.

*Phenomenography.* In order to analyze the conceptualizations of the participants, this multi-case study will be assisted by the theory and methods of phenomenography. “The object of [phenomenographic] research is the qualitatively different ways in which people are aware of the world, experience, understand, apprehend and make sense of various phenomena and situations around us” (Marton & Fai, 1999, p. 10). At the core of phenomenographic method is the interview that may be supplemented by other data such as representations.
Phenomenography originated in Sweden in the 1970s. Original writings in this field began with Ference Marton in 1981. This qualitative approach is empirically based. Phenomenographic researchers seek to categorize the understandings of individual learners in order to better understand a phenomenon from a common grouping of individual’s understandings. These categories are often referred to as “categories of description.” Marton and Booth (1986) note, “It is a goal of phenomenography to discover the structural framework within which various categories of understanding exist. Such structures (a complex of categories of categories and description) should prove useful in understanding other people's understandings” (p. 34). In phenomenographic literature, this emergence of the categories of understanding (or description) from the data is a key characteristic of the analysis.

All of the material that has been collected forms a pool of meaning. It contains all that the researcher can hope to find, and the researcher’s task is simply to find it. This is achieved by applying the principle of focusing on one aspect of the object and seeking its dimension of variation while holding other aspects frozen. The pool contains two sorts of material: that pertaining to individuals and that pertaining to the collective. (Marton & Booth, 1997, p. 133)

Beyond the categorization of the ways of knowing, the relationships between the categories of description are also important to the researcher. Phenomenographic data are most often collected through semi-structured interviews but also may be collected from numerous other sources such as drawings, observed behaviors and products of an individual’s work (Dall'Alba, 1996; Marton, 1986).

**Participants**

As the understandings of both students and teachers regarding GIS, IT and GIS/IT in the classroom are the focus of this study, the participants involved represented both groups. The sampling of participants for this study was based on criterion sampling. The first
criterion for this study was geographic location of the participant. The study participants were geographically located in the central piedmont region of North Carolina. The geographic constraints were based on the researcher’s available time and travel. Students and educators were also selected based on three additional criteria: (1) prior GIS experience (2) representation of educators from multiple educational settings and curriculum areas and (3) availability and willingness to participate in the study.

Criteria for Selection

Prior GIS experience was determined by separate means for the students and the educators. The adult candidates for participation were determined by their previous enrollment in a GIS course with a K-12 educational focus at Atlantic Coast University.9 The student candidates for participation successfully completed two GIS courses in a local middle school. I had established rapport with four students and their parents. The students participated in student and teacher GIS training which I conducted. It was my intention to interview 4 students and 4 educators. This total number of participants was based on the number of students meeting the selection criteria.

There is an important point to note in the selection of the participants. All of the potential participants had similar GIS training and background. The GIS in Education course at Atlantic Coast University was based in constructivist principles. The educators enrolled in this course were taught the GIS technology as well as how to implement it for classroom use. While the interdisciplinary nature of the technology was shared throughout the course, educators were encouraged to create a project that fit the needs of their own classrooms. The

9 The name of the university was changed to protect the confidentiality of the study participants.
middle school students had completed at least two 18-week (semester) courses in GIS. The GIS skills acquired by these students were equivalent to those taught in the single semester college course for educators.\(^{10}\)

In addition, the students in the study were taught at least one course in GIS by a teacher who was enrolled in the first *GIS in Education* course. The teacher, Mrs. King, also became a part of the instructional team of the college-level course after completion of the course. The similarity in pedagogical philosophy and approaches used in both levels provided some consistency while attempting to understand the similarities and differences in the experiences of the participants at both levels.

Requests for participation were sent in letters of introduction to the study (see Appendix D). The initial introduction was followed up by email and telephone requests. Interviews were scheduled at the convenience of the participants (and parents of the students) and the researcher. Each participant was asked to participate in three semi-structured interviews.

*Student participants.* Those students who met the criteria of the study were limited to four Caucasian males. This severely limited the potential pool of student participants and also lent itself to a gender and ethnic imbalance. However, it was important to ensure that the skills of the educators and students were equivalent to establish a baseline of understanding of the technology. Of the small student population there were only two students who consented to participate. One parent of a student, who decided not to participate, when called as a follow-up to the introductory letter, expressed that she had not talked to her son about

\(^{10}\) Semester long courses at this university were 15-weeks in duration for Spring Courses and met for 3-hours once a week. Summer courses met for 3 1/2-hours twice a week and were 5-weeks in length.
participating. She had assumed that the time that had passed since his completion of the course would not be beneficial to my research. I assured her that the time lapse would be informative to the knowledge that her son would bring to the study. She commented that she would then bring this request to his attention and inquire of his interest to participate. A week later the consent request was denied, the mother cited her son’s already filled extracurricular calendar as a reason for non-participation.

*Educator participants.* Educators in the study were selected based on their successful completion of the *GIS in Education* course at the university. The selection of the educator participants was based on 1) access to the individuals, 2) an attempt to represent multiple curriculum areas and educational positions; and 3) gender balance. In order to represent multiple curriculum areas, an initial overview of subject areas taught were gleaned from a compilation of the student rolls. It was decided that varied representation should be based on curricular areas, educational settings and teaching experience:

- **Curricular considerations**
  - The “hard” sciences (such as science or mathematics)
  - The social sciences (such as social studies or language arts)
  - Other curriculum support areas (such as an instructional technologist or curriculum specialist)
- **Educational setting**
  - Traditional public school
  - Non-traditional public school
  - Private school
- **Teaching/Educational Experience**
  - Beginning (in an educational role 3 years or less)
  - Novice (in an educational role less than 5 years)
  - Experienced (in an educational role 5 years or more)

Many of the educators who completed the course no longer attend the university and the instructors had not maintained contact with them. Therefore the next criterion was the ability to access the individual and their willingness to participate. Of the four individuals originally
contacted all agreed to participate. However, one of the original four individuals withdrew from the study once she reevaluated her schedule for the study time period and found that participation was not possible. At that time another individual was requested to participate who most closely fit the decision criteria. The only impact on the research of this final participant’s consent was a time delay of data collection.

**Role of the Researcher**

The researcher in qualitative research may found on a continuum of participation. At one end of the spectrum the researcher may be only an observer, with no interference or participation, of the phenomena being studied. Moving along the continuum, Glesne (1999) refers to the next point along the continuum as the “observer as participant” where “the researcher remains primarily an observer but has some interaction with study participants (p. 44). Next on the continuum one might find a “participant as observer” with more participation in that which is being studied than potentially observing. While this allows the researcher a deeper understanding of the phenomena, Glesne (1999) warns of the risk involved in this role: “The more you function as a member of the everyday world of the researched, the more you risk losing the eye of the uninvolved outsider; yet, the more you participate, the greater your opportunity to learn” (p. 44). The opposite end of the continuum from the observer is the participant. The full participant is a person seen as a member of the community while also being seen as the researcher. Within the context of this research my role would be participant as observer.

**Researcher Subjectivity**

It is important to note at this time my role in this study. As a student and an instructor in the college-level course entitled *GIS in Education* over a four-year period I have had
access to the pool of possible educator participants. I have had personal contact with all of the participants as an instructor and/or a fellow student in GIS and instructional technology courses. I either served as a co-instructor of the course or a fellow student in the course taken by the educators. And I served as a co-teacher and community partner to the middle school students. While there were other co-instructors present in all courses this potential bias should be illuminated.

This could impact the results of the study in several ways. First, as a participant observer my influence on the educator’s own personal knowledge of GIS is based on the initial instruction I received myself or that I was a part of co-constructing. The middle school students received direct instruction from me on numerous occasions within their second and third levels of GIS course work. This role as teacher, mentor, and/or community partner may have influenced the participant’s understandings. This potential bias should not discount the other prior and subsequent experiences, knowledge and understandings that participants bring to the study.

Additionally, my prior contact with the individuals in the study could influence the study in the answers I received. The role of teacher, mentor or outside expert is one that often exists with an established expectation of behavior and responses by students. While it was explicitly stated to each participant that I was interested in their knowledge and understanding of the topics of the research it is possible that I received answers that were what the participant thought I might want to see or hear rather than what they really thought. This might have been alleviated by the use of an intermediary interviewer. However, the existing rapport with the participants enabled me to build upon prior observations and establish trust more quickly for interviews. In addition, the use of phenomenographic
methods used to analyze the data collected is based on a secondary perspective of the researcher. The researcher, though a participant and observer in the data collection, distances herself in the data analysis. As a researcher it is important to acknowledge the lens with which I view the study, the data and the participants.

**Researcher Frame of Reference**

My experiences as an educator at Colonial Williamsburg were influential on my research and my teaching. I worked in many different settings within the largest living history museum in the world. The diversity of the visitors was always challenging and could parallel any US classroom. The work at Colonial Williamsburg led to a strong belief in constructivist principles of learning, the value of real experiences and how place or location influences learning.

The challenge of engaging individuals in history was made easier by the location of my “classroom.” We were standing on a property that stretches roughly one mile from east to west and includes 81 original 18th century structures. Another 150 buildings reproduced on the original site locations accompanied the original structures. How do we know where those building were in colonial Williamsburg? *The Frenchman's Map*, a map created by an unknown person who labeled the map in French when it was created in the 1780s, gave us the blueprint for the Williamsburg we can experience today. Maps surround us and are valuable to find one’s way or to determine a route or to analyze spatial relationships.

As I began work on my Master’s degree in social studies education, the immersion in computer technologies and introduction to Geographic Information Systems (GIS) intrigued me. The power to visualize and represent data in ways I had not ever imagined made me wonder how this technology could impact learning.
Throughout my doctoral work in instructional technology, it became apparent that there were numerous pedagogical approaches using computer-based technologies, as reflected in the literature review in chapter 2. The choices educators, schools and legislators make regarding use and adoption of computer-based technology are commonly discussed topics. Often, I felt, the educator and student voices were not included in the literature. Their roles and perceptions of the importance of particular technologies are relevant to adoption and implementation of computer-based technologies. How students and educators conceptualize these technologies may differ based on their roles in schools. The educator is often situated within a curriculum area and does not necessarily seek ties to other curriculum areas. The student meanwhile travels through 6-8 classes a day attempting to make connections between and among these disciplines. Both educators and students desire relevance--relevance to the curriculum and to their personal lives.

Additionally, as reflected in the introduction, one of the strengths of GIS software is the ability to visually represent data. Through a study of the literature surrounding spatial cognition and the way individuals cognitively code and store information in visual forms the methodological use of drawings and representations seemed appropriate. Paivio’s dual coding theory supplemented the spatial cognition with linguistic cognition. The request for representational drawings and semi-structured interviews began the investigation of how educators and students conceptualize computer-based technologies. It was within this framework of the literature and my personal understandings the following research questions emerged.
Research Questions

As noted in the literature review, there is a need for research regarding teacher and student conceptualizations of GIS and IT. From this research I would like to better understand the relationship of GIS, IT and education through the perspectives and experiences of the participants in the study. The perspectives of both students and teachers are significant to discerning any dissonance, as well as common understandings, of the experiences and perceptions of GIS, IT and their role in the classroom.

The questions guiding this study, as described in Chapter 1, are:

1) How do students and educators conceptualize GIS?
2) How do students and educators conceptualize Instructional Technology?
3) How do students and educators conceptualize GIS in schools?
4) What similarities or differences exist between how students and educators perceive these three ideas?
5) How may educator and student conceptualizations of GIS and instructional technology inform future GIS implementation in K-12 schools? Pre-service teacher education? Professional development for educators?

The findings were generated from the data collected and the phenomenographic categories of description emerged as the study progressed. Identification of the similarities and differences among participants in their experience and conceptualizations of these areas of research is one of the goals of this research. In addition, analysis of the data collected in this study provides a frame for future pedagogical approaches to integration of GIS in the classroom. Marton and Booth (1997) suggest that phenomenographic research is foundationally situated in the “how” and the “what” of learning. In this study I hope to share the participants understanding of how GIS, IT and GIS/IT in education are conceptualized, as well as what the students and teachers understand that relationship to be.
Data Collection

Each student and educator in this investigation represents an individual case from which an understanding of the participant’s collective conceptualizations of GIS, IT, and GIS will be derived. The information collected from each individual was in the form of three participant-drawn representations. Each individual participated in a series of three interviews focusing on one aspect of the research: a) Interview one focused on GIS, b) Interview two focused on IT, and c) Interview three focused on GIS in schools. This third area of research ‘GIS in schools’ was selected rather than ‘GIS in education’ so as not to be confused with the educator participants understanding of the GIS in Education course. Each meeting with a study participant began with the participant drawing an external representation of their understanding of the relevant research area. This was then followed by an interview used to elucidate further understandings from the participants.

Representational Data

The representational drawings were requested in a format consistent with concept mapping. Concept mapping (also referred to as mind mapping) as noted by Novak and Gowin (1984) and Buzan (1993) can be viewed as external representations of the objects, experiences, understandings, and relationships relating to a given subject. These representations may help researchers better understand the spatial and cognitive connections that the participants have regarding their experiences and understandings.

The participants were given approximately 30 minutes to draw and label their representations. The first 30 minutes the participants were prompted to draw their concept representations. The first 30 minutes the participants were prompted to draw their concept representations.

11 This choice of terminology could potentially influence the findings of GIS in non-instructional yet school related GIS use, such as operations and transportation.
maps followed by 5 minutes to label or index the drawing. This protocol is similar to that of the ImpaCT2 and Project REPRESENTATION research (Mavers et al., 2002; Somekh & Mavers, 2003). The researchers in these projects found that asking students to label their concept maps or list the components of the maps on a separate sheet was beneficial in the data analysis stage of the research. Thirty minutes was designated as the time limit so as not to rush the participants in their representations yet to also be conscious of their personal time.

Participants were provided pencils and black pens. The choice to exclude colored pens or pencils was based in two reasons. First, some colors would not reproduce well on a photocopy machine. Photocopies of the original concept maps were used during data analysis. This enabled the researcher to code the concept maps without harming or changing the original representations. Second, multiple pens and pencils may detract from the task at hand. The content, rather than artistic ability or multi-colored drawings, is more relevant to the research. The paper provided for each concept map was 11 by 17 inches in size. This allowed the participants to map or draw their understanding on a larger sheet of paper than normal. This sized paper allowed the user to extend any thoughts out on a larger sheet of paper aiding in the analysis of the drawings. In addition, paper of this size could still be photocopied and shrunk to fit in published works. Banner paper or butcher paper was originally considered for this part of the study however it was less manageable for data analysis and storage purposes and was therefore rejected. Eighteen representations (3 each from six participants; four adults and two middle school students) were collected from the participants over the period of the study. The analysis of these images will be further discussed in the following chapter.
Interviews

The focal point of each of the subsequent interviews was the representational drawing and the participant understands of the topic. Phenomenographic methods necessitate the researcher assume a second-order perspective.\textsuperscript{12}

It means taking the place of the respondent, trying to see the phenomenon and the situation through her eyes, and living her experiences vicariously. At every stage of the phenomenographic project the researcher has to step back consciously from her own experience of the phenomenon and use it to illuminate the ways in which others are talking of it, handling it, experiencing it, and understanding it. (Marton & Booth, 1997, p. 121)

The participant drove the interviews with only a few open-ended questions from the researcher (Dall'Alba, 1996; Marton, 1981; Marton & Booth, 1997; Mavers et al., 2002). An interview protocol (see Appendix E) was used, however the use of semi-structured interviews allowed me to further build upon the comments and concepts from participants through the development of relevant questions during the interview.

As previously noted, the representational drawing was used as the introductory data collection to each interview. The exception was the first interview. The first interview began with an overview of the research project process and general background questions for each interviewee. The background questions (See Appendix E) include subjects such as name, age, and hobbies for all participants. Students were asked about their grade-level, how they would describe themselves as students, content subject-areas of interest, extra-curricular activity participation. Educators were asked to describe their roles in education, what grade(s)/age group(s) they work with and whether they have a subject-area of concentration.

\textsuperscript{12} For a more detailed description of first-order and second-order perspectives see Marton and Booth (1997, p. 117-121)
The background questions were used to create brief biographies of the participants found in Chapter 4.

Interviews were videotaped and audio taped with the permission of the participants (and their parents in the case of the minors). The digital videotape was used to analyze any gestures, movements or actions during the interview that may be relevant to the study, such as pointing to a specific portion of a drawing. Audiotapes were used as the basis of transcription of the interview. In addition, the videotape served as a back up in the case of tape recorder malfunction. I also recorded field observations during the interviews.

Interview questions were drawn from the representational drawing of the interviewee. The use of semi-structured, open-ended questions of the interview allowed the participants to share their experiences and understandings. In the phenomenographic approach, the interview has focus, however it is not driven by the researcher’s understandings or preconceived notions. “Questions from the interviewer are intended to get interviewees to reflect on what they have expressed, to explain their understanding more fully and to reveal their way of understanding the phenomenon” (Bowden, 1986). After the interviewees completed the representation, they were asked to further explain what they had drawn. They were asked to describe the process in which they created the representational drawing or concept map. As necessary, the participants were guided to consider the topic of the interview (GIS, IT or GIS in schools) from the perspective of their individual experiences and understandings (See Appendix E for the complete interview protocol).

The Interview Guide and Drawing Prompts for each interview may be found in Appendix E.
The interviews took place over a six-week period (see Appendix F). Each interview consisted of the approximately 30 minute concept mapping activity followed by the interview. The time allocated for participant meetings was anticipated to be different for students and educators. I expected student interviews to be no longer than an hour. This was based on interviews conducted with middle school students in a previous study that typically lasted 8 to 20 minutes. Mavers, et al (2002) found that their interviews lasted between five and fifteen minutes. One hour was requested for student meetings although several interviews extended over one hour. The meeting locations were negotiated between the researcher, participants, and parent(s). All student interviews took place in their homes.

One and one half hour was requested for meetings with educators. Based on previous interviews with adults I found they tend to be more open and willing to talk than students. The meeting location was negotiated with the participants depending on scheduling and distance of travel. Meetings with the adult participants varied in location from classrooms, offices within their educational institution, university meeting rooms, and participant’s homes.

**Data Storage**

Each meeting with each participant, 18 total, included a representational drawing, a digital videotape recording, and a cassette tape recording. These were stored in a safe location to ensure the privacy of the participants. The video recordings were transferred from the videotape to a digital format (CD or DVD) for analysis purposes. This protected the original data on the tape from suffering damage from overuse during playback. In addition, the cassette tapes were transcribed for analysis purposes. Multiple photocopies of each
representation were made to preserve the originals. This allowed for the drawings to be written upon during the analysis phase of the study.

Participant confidentiality is protected in this study through the use of pseudonyms for participants who are under the age of 18. Adult participants were given a choice of whether or not use of a pseudonym, however I have chosen to protect the identities of the participants through the use of pseudonyms. In addition, it was requested of the participants that I be able to maintain and use copies of the research data for future use in publication, presentations and further research. Those individuals who did not consent to this request were given all audio- and video- cassettes upon completion of this study. During the study all materials were maintained in a secure location.

Data Analysis

In qualitative studies the data undergoes content analysis to create common themes in the data. In phenomenographic research the data is analyzed to find common understandings or ways of knowing. These understandings are grouped into categories of description.

The original finding of the categories of description is a form of discovery, and discoveries do not have to be replicable. On the other hand, once the categories have been found, it must be possible to reach a high degree of intersubjective agreement concerning their presence or absence if other researchers are to be able to use them. (Marton, 1986, p. 35)

The first content to be analyzed was the representational drawings. The interview transcripts were then examined for similarities and differences in order to categorize the data. Categories were initially established through hand coding the representations and the transcripts. Categories and sub-categories of understanding were evaluated and condensed when possible. Phenomenographers believe that “there will be four or five kinds of awareness of a phenomenon among a group of individuals” (Somekh & Mavers, 2003, p.
Through the data analysis the types of understanding would then emerge. The concept maps were analyzed for content as well as structure. The factors for consideration in the structural analysis of the concept maps included: use of icons, use of symbols, and image versus text usage.

**Triangulation**

Triangulation is a common approach to issues of validity in qualitative research. Stake (1995) offers several typologies of triangulation including: data source triangulation, investigator triangulation, theory triangulation and methodological triangulation. In this study I employed two of the four methods: theory and methodological triangulation.

In order to establish reliability of the categorizations that emerge in phenomenographic research, inter-rater reliability is encouraged through comparison of the data to the grouping. “Interjudge reliability requires that one or more researchers (co-judges) read the same data as the original researcher, but with reference to the categories of description that have been identified by the original researcher”(Sandberg, 1996). The inter-rater examined the representational drawing and the transcribed interview data for reliability. This approach addressed issues of objectivity and subjectivity surrounding the interpretation of the collected data and the meanings extrapolated from those interpretations. The use of methodological triangulation helped to better understand the data through constant comparison of representations, interviews and observations.

**Chapter Summary**

The methodology and frameworks that are presented in this chapter begin to explain the data offered in the following chapter. Representations and concept maps as a means to
externalize spatial understandings and knowledge were used as a data collection point based on dual coding theory. This representational data coupled with the transcribed interview data were used to determine the linguistic understandings of the participants. Through the combination of linguistic and spatial data, categories of description of common understandings of the participants emerged. The multiple case study structure of this investigation facilitates a broader understanding of the research questions surrounding student and educator conceptualizations. Multiple perspectives and experiences brought forth through the methods used to collect the data.

In the Chapter 4, the data collected through the methodology are examined in detail. The presentation of the data begins with an overview of the general findings. Individual participants are introduced in brief biographies. The data is discussed with respect to the original research questions guiding the study. The findings are compared between individual participants as well as through the examination of each individual’s thoughts and understandings from the first interview to the third interview. The data illuminates the conceptualizations of GIS, IT, and GIS in schools of these early innovators in GIS in education.
CHAPTER 4
THE DATA: GLOBAL VIEWS, VISUAL WALKS AND CONFLUENCES OF UNDERSTANDING

Introduction to the Chapter

In the last chapter I provided an overview of the methods used for the research data to be discussed in this chapter. The research for this multi-case study was based on an analysis of representational drawings and interview data collected from four educators and two students. The research began with the following five questions: (a) how do educators and students conceptualize GIS; (b) how do educators and students conceptualize instructional technology (IT); (c) how do educators and students conceptualize GIS in schools; (d) how are these representations similar and different; (e) how may these conceptualizations inform GIS integration in K-12 education?

Using Paivio’s (1984) dual coding theory, phenomenographic analysis was based on the representational images and the subsequent interviews. Phenomenographic methods were used to help categorize common descriptions and understandings of the participants.

In this chapter I introduce the reader to the six participants in the study. The selection criteria of individual participants are explained as well as an overview of the relationship of the researcher to the participants. Following this introduction of the participants, an overview of the data is provided.

Next I begin to address the first three research questions through the data collected. The nature of qualitative research is to immerse the reader in the experiences and understandings of the study participants. Each question is organized based on the emergent categories of description and is contextualized by the common frames of reference among the
participants. The inclusion of “thick description” based on the interview data, field notes and representational data provides a robust understanding of the educators and students conceptualizations. In addition to the thick description participant representational drawings are embedded within the discussion.

The results from the fourth question, a comparison of the similarities and differences of students and educators, draw convergence from discussion of the understandings of GIS, IT, and GIS in schools. An overview of those findings follows discussions of the first three questions. The chapter concludes with a summary and a brief discussion of how chapter 5 will address the final research question and other implications of this study.

Overview of the Data

Data collected for this study were grounded in the participants’ learning, experiences and conceptions as they responded to the research questions. The purpose of the three distinct participant interviews was to investigate the concepts of GIS, IT, and GIS in schools independently. The first question, “How do students and educators conceptualize GIS?,” was researched through a representational drawing based on the topic of GIS in the world. The second interview topic was the participants’ understanding of instructional technology. This was driven by the second research question: how do students and educators conceptualize IT? The third research question of this study, investigated within the final interview, focused on the participants’ understanding of GIS in schools. “How do educators and students conceptualize GIS in schools?” was the question. An analysis of the findings in the representational drawings and the subsequent interviews led to exploration of the fourth research question: What similarities or differences exist between how students and educators perceive these three ideas (GIS, IT and GIS in schools)?
Each participant was visited by the researcher on three occasions. On each occasion, a representation was drawn by the participant, and this became the basis of the ensuing interview. Paivio’s (1969, 1991) dual coding theory, described in the review of the literature, grounds the methodology for this study. Paivio theorized that humans cognitively store and process information and experiences in both linguistic and image-based forms. He believed that humans code experiences in each modality. The data within this research demonstrate distinct individual preferences for externalizing either image based (*imagen*) or word based (*logogen*) understandings. By utilizing both representational drawings and verbal responses from interviews, a greater clarity begins to emerge from the student and educator conceptualizations.

*The Role of Phenomenographic Methods*

The methodology for this study is based in multi-case study and phenomenography. The qualitative methods of collecting the representational and interview data are based in prior phenomenographic studies. According to Marton (1986) the four features of phenomenography; the relational, experiential, contextual, and qualitative are also features of traditional phenomenological research. The differences in the approaches, as explained by Marton, between phenomenography and phenomenology are:

- investigator perspective based on how things appear to the subject (phenomenography) rather than the researcher conceived understandings (phenomenology);
- examination of the commonalities of the variant forms of experience (phenomenography) rather than that variation itself (phenomenology);
- emphasis on the relationships between experience and “conceptual thought” (phenomenography) rather than the distinction between the two and more emphasis on examination of the experience (phenomenology).
Once the data are collected, the researcher using phenomenographic methods begins to examine the conceptualizations that emerge in the interview transcriptions. “Conceptions are typically presented in the form of categories of description,” according to Sandberg in D’Alba and Hasselgren (1996, p. 130). The categories of description are developed through an examination of the data pool. These categories of description are therefore not preconceived or pre-established by the researcher. The categorization of concepts emerge after the data collection and during the analysis stage much like grounded theory research.14

The first step of my analysis was to organize the data by the individual research question addressed. The analysis was simplified by the structure of the data collection methods -- the three interviews were organized individually around the three topics to be analyzed, GIS, IT and GIS in schools. Copies of the representational drawings were used to code the categories and subcategories of meaning that emerged. In addition, the interview transcripts were coded into categories and subcategories. Many of the smaller subcategories were enveloped by larger categories throughout the coding process. From what Marton (1986) refers to as the “pool of meanings,” the categories of description developed. After reviewing all of the representational and interview data for each question, the “categories of description” emerged. The following discussion of the data and thus the educator and student conceptualizations will be addressed through the categories of description for each topic.

14 See Glaser and Strauss (1967) for a more detailed description of Grounded Theory Research.
**Representational Data**

The initial components from each question were the representational drawings. Each of the participants’ three interviews began with a topic and guiding questions that were used as prompts for each representational drawing. Each participant drew a representation that could include text and images to represent the main ideas relating to the prompt. They were asked to make connections or links between ideas they felt were connected. The drawings could be in any form and could be drawn in any order they wanted.

Each participant was given 30 minutes to produce his or her drawing. Most of the participants used the full time for their drawings, though times varied based on individual and topic. Once the representation was complete, the participants were asked to index or create a list of what they had drawn. The prompts for the representations can be found in Appendix E along with the interview guide. The 18 individual drawings have been reduced from their original size (11 inches by 17 inches) to 8 1/2 inches by 11 inches (see Appendixes G-X). The interview portion of each meeting with individuals supplemented the representational data.

**Continuum of Representations**

Through a preliminary analysis of the 18 drawings, a continuum of the representations emerged. There were two very distinct types of representations: textual and abstract graphical. The textual representations were solely based in text or had no more than one image. There were four drawings that I categorized at this end of the continuum. The abstract graphical end of the continuum had image-based representations containing little or no text. There were 3 representations of this type of representation.

Most of the representations fell in the middle of this continuum, including both text and images, with varying levels of both. The text-based representations were typically more
easily interpreted upon first glance. The image-based drawings, on the other hand, were more
dependent upon the interview responses and participant created index (or descriptive list) for
interpretation.\textsuperscript{15} All representations can be found in Appendixes G through X.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{continuum.png}
\caption{Continuum of Representational Drawings} This continuum represents the
range of representations collected in this study. Figures 13-15 are examples of
representations of participants’ understandings of GIS.
\end{figure}

The differences of individual representations that emerged along this continuum of
representations in the research offer a simple, yet fundamental, pathway to understanding
how individuals might approach a technology. If individuals process their experiences both
as images and as linguistics, as Paivio suggests, representational drawings provide a useful
way to begin to understand learners’ preconceptions about a topic. How individuals make
connections between their experiences and knowledge can be explored through concept
mapping or representational drawings before beginning to explore new knowledge, skills
and/or technologies. The potential of this methodological approach within other contexts
such as teaching and learning with instructional technology, professional development and
pre-service education are explored in chapter 5.

\textsuperscript{15} Figures 13 and 14 exemplify contrasting approaches; the word or \textit{logogen}-based (13) and
the \textit{imagen}-based type of representation (14).
Interview Data

Semi-structured interviews were conducted with each individual following their drawing of the representations. This approach supports phenomenographic interview methods where,

the phenomenographic interview has a focus, the way in which interviewees understand the chosen concept, an this focus is maintained throughout the interview. Interviewees are encouraged to express their qualitative understanding of the phenomenon under investigation (Bowden in Dall’Allba & Hasselgren, 1996, p. 59).

The 18 interviews lasted between 30-90 minutes. They were structured around the drawing the individual produced at the start of the each meeting. The participants were requested to retrace their thinking and process of drawing. The interviews were also used to ask the participants to elaborate on points they had drawn in their representations.

Frames of reference: allocentric and egocentric

The experiences shared throughout the representations and the subsequent interviews illuminated the frame of reference from which the participants viewed GIS, IT, and GIS in schools. The participants described their understandings from allocentric and egocentric positions within their cognitive maps. Cognitive maps, as explained in chapter 2, are the internal representations of spatial and conceptual environments. All human activities take place within geographic locations and thus have spatial attributes. An allocentric perspective is focused on the external object rather than its relationship, or relevance, to the individual. The physical environment may be the focal point of an allocentric perspective. An egocentric position is centered on the self. The reference point for an egocentric position is the individual’s body or self. While these frames of reference are often correlated to very specific coordinate and locational references in geographic literature, I intend to use the expressions in the broader terms of spatial cognition, thinking and learning.
Allocentric understandings by participants were discussed with a distance placed between the individual and the concept. Individuals might have “seen” or described a concept in the world or in a school, however they used terms that position it in the physical environment as observed and away from them. In this study, the allocentric understandings emerged in the interviews where the imaged-based data provided the primary insights into the student and educator conceptualizations.

Egocentric positions revealed little or no separation between the individual and his or her understanding of the concept. Individual participants were able to describe their understandings embedded within the context of their person or the spaces around them. The egocentric understandings, in this study, often emerged from the representational drawings but were described more fully in the linguistically based interview data.

The interviews were used to extend the researcher’s understanding of how individuals framed the concepts, made connections and processed the conceptual landscape in their minds. The experiential relationships to physical locations, such as a classroom, a business, or a pond, are similar to Lynch’s (1960) findings in his study of shared perceptions and mental images in various cities as discussed in the review of the literature. The physical landscapes are tied cognitively to the individual’s experiences and understandings.

The location of the individual, allocentric or egocentric, reflects how the individual positions him or herself within the context of the concept. Throughout the discussion of the research questions that follow, the student and educator representations and interview data provide a map of how the study participants “located” themselves within the topics of GIS, IT and GIS in schools. This relationship between the understanding of GIS, IT and GIS in schools is tied to the spatial identities of the spatial concepts themselves. As humans navigate through their experiences they think and store spatial information. The cognitive
and spatial relationships can shed light on where individuals in educational settings do and do not “see” GIS and IT.

**Participant Selection**

In order to understand how students and educators conceptualize GIS, IT and GIS in schools it was important to include participants representing both groups in this study. The adult participants were selected based on their successful completion of the *GIS in Education* course offered through Atlantic Coast University. The course was first offered in 2000 and has been offered at least once a year since. There was an attempt to include educators from across different semesters rather than all educators from common semesters. Four educators were selected based on the 40 course participants using several criteria. Accessibility and individual willingness to participate were key factors. The instructors of the course, of which I was one from 2001-2004, had not kept in touch with all 40 individuals from various iterations of the course after course completion (see Appendix A for *GIS in Education* participant overview) thus limiting the pool of potential participants. Other selection criteria considered included diversity of curriculum areas, positions held within educational institutions, gender balance and grade level of students served. Initial letters of invitation were sent and four willing participants were found.

The adolescent participants in the study were selected based on their successful completion of at least two GIS courses in their middle school. The student participants had also served as teaching assistants with the researcher for an after school GIS training for teachers. The GIS skills sets learned, assignments and projects completed in these two electives were equivalent or exceeded the GIS skills learned by the educators in the *GIS in Education* course at the university. Only four students had completed a minimum of two
levels of GIS electives in their middle school; all were white males. Of the four requested to take part in the study, two of the students and their parents agreed to participate.

Another factor considered among the selection criteria for this study was the teaching approach with which the teachers and students were taught GIS. Although changes were made in the GIS in Education course from semester to semester, based on student and instructor reflections, the underlying pedagogy and objectives remained the same. The course was pedagogically based in constructivist principles with the objectives of: (1) GIS skills acquisition and (2) integration of that knowledge into a final project based in the individual educator’s curriculum and needs. GIS integration within the course included modeling and requiring community partnerships, discussions of ethical implementation of the technology, and modeling interdisciplinary approaches in K-12 education using GIS. Further information regarding the university course can be found in Appendix B.

The student participants in the study were taught in their second level GIS elective by a co-instructor of the GIS in Education course at the university level. As noted previously, similar approaches and pedagogical philosophy were used in both the middle school classroom and the university classroom. I attended class meetings, as a community resource, in the second level middle school GIS class once, sometimes twice, a week to help facilitate the group project these students were investigating through GIS analysis. In addition, I was an instructor in the third level GIS elective, an independent study, in the middle school. The students in the study also participated as teacher assistants in GIS in-service trainings for educators conducted by myself and others. It is important to note this involvement in both the university and middle school classroom; my presence and perspectives in their classes may influence the conceptualizations and responses in this study. The previously established rapport with the participants did aid, in my opinion, in creating a “safe and trusting”
environment in which they were able to share their understandings of the topics. This participant-observer role, however, also has potential for researcher bias and the influence of my own role as a GIS educator with the participants was considered in the selection of the methodologies used, as noted in Chapter 3. The decision to use phenomenographic methodologies for the analysis and data collection was based upon the potential bias that was inherent to the research based upon my previous roles. Through the use of phenomenographic methods, the understandings are grounded in the unique and individual experiences of the participants rather than the researcher’s understandings or preconceptions.

Student participants

The School

The student participants in this study were eighth grade students at Maple Middle School. Maple Middle, a Gifted and Talented (GT) Magnet school, is located in a large, county wide school district. The Oak County School District consists of 135 schools, twenty-eight of which are middle schools. Maple Middle School has a total population of almost 1000 students in grades 6, 7 and 8. Participant confidentiality is protected in this study through the use of pseudonyms.

Ernest Milton

Ernest Milton was a very soft-spoken, introspective and respectful young man. He was “almost 14” years old at the time of the study. Ernest described himself as a “straight A student” with “pretty good conduct,” to which his dad rolled his eyes, as I conducted the interview in their home. I suspected he had excellent conduct. His teachers have nominated him for awards related to character, such as leadership and integrity awards. At the time of the study, Ernest was involved in chorus, technical theatre (study of the elements of theatrical productions such as lighting, sound, publications, set construction, etc), and
“Battle of the Books” at school. Outside of school, he enjoyed computer games and participated in church youth groups. He described himself as quiet at home and school and “tend[ed] to keep to himself.” He has a “tight knit group of friends at school” with whom he joked around and had similar reading interests. He liked to read science fiction, fantasy and historical novels. His “good friends at school” do not live near one another so they often chatted and played games on the computer when they were away from school.

Ernest described his family as “involved.” According to Ernest, the Miltons are involved in community, scouts and church. Ernest lives with his mother, father, younger sister, a cat and a very friendly black lab named Dixie. I would add to Ernest’s statement that his parents are very involved in their children’s schooling and extra curricular activities. This is also a very technology literate family. When we were scheduling each of the interviews his mother and I consulted our PDAs and his father consulted the family schedule on the laptop in the kitchen of their home. Ernest has used technology since he was young. He commented during one interview “when I was 5 my dad taught me to type.” He noted educational software, such as “Magic School Bus,” and games as his early uses of computers.

**CJ Grebb**

CJ Grebb was also an eighth grader at Maple Middle. Fourteen and a lively, outgoing, inquisitive, young man; CJ was living at home with his mom, a dog and a cat. His mother is a former science teacher and has recently returned to school for a media specialist degree. She currently works in that position in the elementary school CJ attended. His father passed away in 1999 from brain cancer. CJ states that he is very close to his older brother, a 20-year old computer/electrical engineering major at the nearby university. He described himself as hardworking and a leader. “I sometimes overwork. I like to learn stuff.
Any chance I get to learn something, I generally do.” He thought his friends would describe him as “humorous” and “always calm and collected.”

Math and social studies are CJ’s favorite core classes but he was excited to tell me more about the electives he has taken. The eight period days at Maple Middle allowed students to explore electives like solar race cars, guitar, strategic games (like chess) and technical theatre. Outside of school, CJ played basketball, card or board games, he liked to cook and watch action, historic and scary movies. He worked on the computer and played games online by himself or with friends or his brother. Like Ernest, CJ also commented on computer use early in his life he remembers Elmo’s Magic Squares as a game on one of the first family computers. “My dad worked at IBM so he was able to get some computers….Eventually my brother, he was really big into computers as he got into computer engineering. And by the time I was probably in fifth grade, he made me a computer.” In his household, CJ and his mother each have computers and CJ also included the two his brother had at his apartment as part of the household technology.

**Educator Participants**

It was important to attempt to understand the conceptualizations of GIS, IT and GIS in schools from multiple perspectives. The population of educator participants in this part of the study was based on those educators that successfully completed the *GIS in Education* course at Atlantic Coast University from 2000-2004. Kathleen completed the course in 2000. Natalie completed the course the following year. Ben completed the course in 2003 and Charles completed the course in 2004. As mentioned earlier in this chapter, the educators were selected based on several additional factors including: gender balance; availability; curricular area; grade level(s) worked with; and role or position in the school.
The educators in this study represent private and public K-12 settings. They worked in magnet schools and traditional schools. Positions represented include: a social studies teacher, a science and math teacher, a curriculum integration specialist and a distance education specialist. Two of the educators worked in middle schools and two worked in high schools. Their teaching experience varies from two years of experience in education to over twenty years of experience. Of the four educators two are female, two are male and all are Caucasian. The GIS in Education course over its four years had the following demographic distribution of students: 13 males; 27 females, 36 Caucasian students, 3 African American students, and 1 Asian student. All instructors of this course were white females. Participant confidentiality is protected in this study through the use of pseudonyms and all school names have also been changed.

**Kathleen S.**

Kathleen S. was a very thoughtful and innovative educator. She had worked as a computer programmer and a classroom teacher in two different states. A married mother of a teenager, Kathleen described her interests in outdoor activities, such as biking and running, as well as cooking and reading. At the time of the study Kathleen was an outreach specialist with the distance-learning department of a state supported science and mathematics magnet high school.

Kathleen described the school as a residential facility for 11th and 12th grade students from every county in the state. The student population had an equal balance of males and females and attention was given to ethnic diversity in the admissions process. The residential program was one part of a dual mission in the school. The second mission is the distance-learning program, which supported students in schools that were not able to offer advanced math and science classes or other subject areas such as art. This may be due to lack of
funding or the small number of students enrolled in a course to support a full time teacher. Kathleen explained that her “clients in distance learning are students in regular public high schools across the state.” Students enrolled in the distance education classes offered over the information superhighway are generally “self-directed, independent learners” according to Kathleen. While she mainly worked with the distance education portion of the school, Kathleen also worked with the students and teachers in the residential program. She enrolled in the initial GIS in Education course while working on her Master’s degree in Liberal Studies and had previously taken an introductory GIS course at the university.

**Natalie H.**

Natalie H. was a very creative, friendly and lively educator. A married mother of two, Natalie was working on her Ph.D. in instructional technology. Natalie had taught in a number of states over the past 15 years. While participating in the study Natalie was a Curriculum Integration Coordinator (CIC) at a traditional middle school in the Oak County Public School District. The school is a newer school in the system and has between 900 and 1000 students. In her position she had a myriad of responsibilities. The CIC was part of career and technical education the position with responsibilities, according to the district, “to support the school-to-career connection and facilitate business alliance activities.” Her position was definitely not limited to that description. During our first interview Natalie was called upon because the server was not working. She explained that the technology support person is only at her school once a week if that often, so her technology expertise is called upon quite often. In addition, she visited classroom teachers with technology integration. Natalie enrolled in the GIS in Education course to fulfill an elective requirement of her instructional technology degree upon recommendation of her advising professor.
Ben H.

Ben, a caring and enthusiastic young educator, at the time of the study was in his second year teacher of teaching. He was a social studies teacher in a high school in Oak County Public School District. In his free time Ben enjoyed playing tennis and spending time with his friends, whom, he notes, are mostly teachers.

Ben knew he wanted to teach in high school and had worked with children in previous jobs, such as lifeguard and tutoring Hispanic individuals through his church. Ben worked with an autistic student throughout his college career and he continued to work with the student during his summers once he began teaching. He described American High, as a school with “diverse demographics,” with “caring teachers” and above average academics and discipline issues. The high school has a “traditional curriculum” with almost 1800 students in grades 9-12. Ben was teaching one World History and two Civics and Economics classes on a four period block schedule. His students ranged in age from 13 to 20 years old. Ben enrolled in the GIS in Education course to fulfill a general education requirement for graduation in his pre-service teacher education.

Charles V.

Charles V., a native of Buenos Aires, Argentina at the time of the study was teaching algebra and science at a private middle school. Charles attended a university in Washington, DC where he obtained his undergraduate degree in biology. He pursued a Master’s degree in marine biology and marine environmental science at State University New York – Stony Brook. After completing his thesis Charles worked with students at a summer camp, which led him to return to SUNY-Stony Brook to complete teacher licensure in science education. Charles has worked primarily in private schools.
The school where Charles worked during the study was a fairly new private college preparatory school that opened in 1997. With middle and upper schools, about 300 students attend the middle school. Charles noted the availability of computer resources in the school, as there is a networked, Internet enabled computer for every two students in the school. He described the institution as one that is rigorous for students and “promotes a lot of innovation and wonderful opportunities for faculty to grow professionally.” Charles taught 2 sections of an eighth grade Algebra 1 course and two sections of science. The science course, Charles described as an “interdisciplinary course” which includes “some physics, some biology and some earth science.”

Charles’ personal interests often overlap with his involvement in the school. He described working with model airplanes and photography, both of which he has integrated into his work with the aviation club and in his science classroom. His interests in ecology, environmental science, the impact of human contact with the earth and conservation efforts are closely tied to his interest in outdoor activities, such as hiking, biking, kayaking, and snorkeling. Charles also expressed an interest in “various nationalities and international cultures.” He suggests this is due to his personal experiences growing up outside of the U.S. and his marriage to his wife who is from Columbia. He commented that he always has had “one foot in each culture, in Latin America and in the States.” Charles’ personal interests led to his desire to take a course in GIS. After taking a one-week GIS institute, he enrolled in the GIS in Education course, on recommendation by another department at the university.

**Summary of Participants**

The experiences and interests of the individual students and educators are important to contextualize the data that follows. Each participant was interested in enrolling in a GIS course for different reasons. Both middle school students noted the brief demonstration of the
software by their academically gifted (AG) math teacher as what piqued their interest in the first GIS elective course. Once they completed the first level of GIS instruction, each felt they wanted to learn more about the technology and they enrolled in a second level elective.

The educators enrolled in the GIS course based upon either personal interests, previous instruction in GIS technology and for fulfillment of degree requirements. The four educators in this study represent a number of different educational settings: private and public, traditional and magnet, and middle and high schools. They are all teaching, geographically, within a 20-mile radius of the university in which they enrolled in the GIS in Education course. The consistency of instructional methods and pedagogical frameworks between the middle school courses and the university level course help provide baseline understandings of GIS and GIS in schools. The personal experiences, opinions and understandings of the topics of this study provide richer description of the conceptualizations of students and educators in GIS.

**Addressing the Research Questions through the Data**

In the previous section I provided an overview of the primary data collected and introduced the individual participants in this multi-case study. The following discussion is focused on the data in response to the first three research questions. Each of the three interviews was each based upon a specific research question. I will discuss the student and educator conceptualizations as expressed through these interviews and participant created representations. Embedded within each of these discussions will be a further investigation of the similarities and differences that emerge between and among the educators and students, thus beginning to examine research question four.

The structure of the presentation of the data is two-fold. First, each discussion of the data relevant to a research question is presented within the allocentric or egocentric frame of
Both the allocentric position (where individuals locate the concept in the environment--without referring to their own position) and the egocentric (where individuals locate the concept as related to themselves) are based in experience, knowledge, and spatial relationships. The frames of reference of GIS, IT and GIS in schools were pivotal to the understanding of common landscapes among individual cases in the study.

The participants’ conceptualizations of GIS are discussed from allocentric locations or positions. Participant’s understandings of IT are located in egocentric frames of reference. Whereas, GIS in schools represented a confluence of the allocentric and egocentric locations of the common understandings. The final discussion regarding research data includes observed perspectives based on individual roles in the school and relevant questions posed by the study participants.

I describe for each question the emergent collective “categories of description” based on phenomenographic analysis of the data. This discussion of participant conceptualizations was categorized by investigating the collective understandings of the concepts from a “pool of meanings.” Examples from individual participants’ understandings are provided to elucidate the larger categories of description.

Research Question One: How Do Students and Educators Conceptualize Geographic Information Systems?

Throughout the following discussion of research question one: ‘How do students and educators conceptualize GIS,’ the conceptualizations of GIS in interview one demonstrated how the participants located GIS in allocentric terms. An understanding of the allocentric frame of reference was established through the analysis of the representational and interview data. In their representations and interviews, the participants distanced themselves from the technology. They described it existing in places “out there” in the world away from
themselves, although each of them had individual experiences with the technology and with others who used the technology. According to Dewey (1938), “as an individual passes from one situation to another, his world, his environment, expands or contracts. He does not find himself living in another world but in a different part or aspect of one and the same world” (p. 42). The analysis elucidates the relationship between the spatial relationships of GIS in the world and the categories of description that emerged from the study participants’ understandings.

When asked to represent their understandings of geographic information systems (GIS), participants’ drawings represented six different categories of description: (a) personal experiences with the technology, (b) jobs and individuals who may use GIS in the workplace, (c) examples of software and hardware needed to use GIS, (d) GIS internet applications (e) GIS as a global tool, and (f) Global Positioning Satellite (GPS) technology and applications. The representations produced from the first interview can be found in Appendixes G through L. These categories of description are discussed within the context of the allocentric frame of reference.

Allocentric Views of GIS in the World

The student and educator conceptualizations of GIS demonstrated an allocentric positioning. The shared understandings, found in the data, locate GIS away from the individual and in the world. The participants described GIS as something found in the world, used in the world, and as a tool to study the world. This shared allocentric positioning of the study participants within the physical landscapes of their individual experiences begins to locate this spatial tool within the spatial understandings of their environment and world.
**GIS is Found in the World**

*Global Perspective.* The geographic extent of the understandings of the physical location of GIS ranged from global to local with representations of U.S. states, counties, communities and within vehicles. Students and educator participants understood GIS as a global tool, not only to study the world but also found within different parts of the world. At the core of Ernest’s concept map of GIS is a circle entitled “GIS in the world” that is connected to many sub-topics of his representation (see Figure 13). His classmate CJ began his representation with a circle with the word “Global” in the center. He stated at the start of the interview: “Well, I started at global because GIS can be used to display pretty much anything, anywhere.”

![Ernest's Representation of GIS](image)

*Figure 13. Ernest's Representation of GIS.* Ernest’s drawing provides an example of a text based representation of knowledge. He described the interconnected nature of the GIS software, its uses, the users and workplace applications: “Well, everything is pretty much connected.” See Appendix G to view the full-page document of the representation.

The educators also represented the global aspects of GIS in their representations. Ben applied his understanding of GIS to his World History course in his representation by identifying
locations in Greece and Egypt that might be enhanced by GIS use (see Figure 14). This common understanding of the potential of mapping, exploring and analyzing worldwide data is an important concept that was shared by both educators and students.

![Figure 14. Ben's Representation of GIS](image)

*Figure 14. Ben's Representation of GIS.* An example of an image based representation. Ben states, “GIS seems to me, that it’s about making a connection between one place and another.” See Appendix I to view full-page document of this representation.

Kathleen framed her representation within a world outline with satellites outside of the world. In the interview Kathleen explained,

Well, the first concept that I was trying to communicate was that there had to be information. And I started doing a map of the United States and I realized, no, it would have to be worldwide, of course, and in space that we collect all manner of data.

Her comment regarding the global nature of the data and information found in and used by a GIS is an important point. This illuminates the relationship between the spatial nature of the
Many of the participants suggested the potential for GIS use worldwide. Charles’ representation (see Figure 15) includes a globe with stars to represent locations on earth where he felt GIS might be found. His index of this representation included a comment that “GIS is found in most countries around the world. More so in affluent nations that have access to technology.” Kathleen echoed Charles’ global view of GIS, in her discussion of where in the world GIS was and was not found:

Kathleen: Well I think all countries. It’s used on the land to gather information, it’s used in the oceans, it’s used in research on polar extremes. And I think weather information is probably the biggest utilizer of GIS. And then—industrialized nations, it’s used in collecting and manipulating information for economic decisions. It’s used by public health increasingly. And then in the distribution of care or how to maximize the use of your resources, it’s not used enough.

Interviewer: Why do you say that?

Kathleen: Well because technology hasn’t penetrated in all areas and then you have to have an educated population to use it. You have to have money associated with issues in order for anybody to care about and collect data and you know often times the poor places in the world don’t get the attention and therefore don’t have access to information because it’s not collected.

The participants also recognized how limited resources would impact GIS implementation. The need for resources, knowledgeable users and relevant data are described further in the next chapter.
Figure 15. Charles’ Representation of GIS. Representation of GIS. This is an example of a representation that would be found in the middle of the continuum of representations, it contains both images and text. In his interview Charles suggests that as GIS users become more comfortable with the technology they “start asking questions and using it for, what I perceive the real beauty of it -- which is, making connections between spatially arranged quantities and spatially arranged things.” The full-page document of this representation can be found in Appendix H.

Natalie drew an image of a globe on a stand and wrote within that image “Global—where found—everywhere!” While describing this part of her drawing Natalie noted her personal understanding of the idea that GIS is ubiquitous yet her personal knowledge of GIS as limited by her experiences. “It’s all over the world. It’s being used right now. And obviously, I don’t know all of the things its being used for…” she continues this thought with multiple examples of international, national, business and individual uses of GIS in the world. Both Natalie and Kathleen’s representations, Figures 17 and 18 respectively, are found in the discussion of GIS used in the world. The implications of this understanding that
GIS is ever present in our world but not often recognized will be further discussed within chapter 5.

**GIS is Used in the World**

Personal experiences with GIS technology led to a number of individual internalizations of the diversity of GIS uses in the world. From the interview and representations participants’ experiences such as: personally collected data and contacts with professionals or professional uses of GIS emerged. These personal experiences and connections were stored and related to the individual’s understandings of GIS in the world. Many of the experiences that follow are unique and personal to the individual participants, however the data were represented as distanced from the individual and allocentric in nature. In addition, the use of Internet-Based GIS also emerged in the data is an understanding of how GIS is used in the world.

**Student connections to the GIS community: juvenile crime project and job shadowing.**

One example of the personal experiences that emerged in the understandings of GIS in the world by students was their experience with a juvenile crime project. In their second level elective course, both student participants completed a group project examining one year’s worth of city and town juvenile (10-15 year olds) arrest data, geocoded by crime. Each of the young men represented a part of this project within his concept map of GIS in the world.

One of the central ideas found on Ernest’s concept map was “Many jobs use GIS to help make decisions” (see Figure 13). Ernest connected “police stations” and “crime investigation” to this idea. Ernest recalled the class project when discussing this part of his drawing. “And then police stations, because I remembered the crime investigation type thing that we did last year and how they can use that to put a new police station or more people.”
CJ drew a representation on his map of “hot spots where things are happening” (see Figure 16). During the interview he referred to this part of his drawing and stated: “I’ve got hot spots because it was reminding me of when we did our juvenile crime project. Where certain crimes happened and where there was less crime. So, we looked to see if there were bunches so you can look back.” By ‘bunches,’ CJ means data clustered in certain locations, which was one of the findings in the juvenile crime project. These experiences with real world data and problem solving remained in these student’s memories over a year after their experience with it.

Figure 16. CJ’s Representation of GIS. “I kind of went from global and then I went more into the ‘how it’s used’ or what’s needed for it --that had the data. Then I went kind of more local with CGIA [Center for Geographic Information and Analysis]. They only do North Carolina stuff.” The full-page document of this representation can be found in Appendix J.
CJ also drew about his experiences ‘job shadowing’ at the state level Center for Geographic Information and Analysis (CGIA), as displayed in (see Figure 16). His job shadow took place within a week of the first interview. He was able to shadow a GIS professional his mother located through a co-worker. In his discussion of how CGIA used GIS he explained,

And then there’s CGIA-people I went to…people that use it. That’s their job. And then there’s one project they did--they studied the Tar River and its flood plains and the bridges that cross the Tar River and the average height of the water when it floods. To see if the flood had damaged any of the bridges or if any of the bridges needed to be changed.

They also created [www.nconemap.com](http://www.nconemap.com). It’s still sort of a project but it’s a great example of GIS because you can see a lot of stuff in it. You can view satellite images. You can measure from point to point getting directions. You can see elevation. If you look at elevation then you can look at a profile of it. You just go from one dot to another dot and it will show you the up and down lines, profile. And also CGIA sometimes will answer questions of businesses on where something should be done, where it needs to be built.

The job shadow experience takes place annually at Maple Middle on Ground Hog day every year. This part of the career exploration for 8th graders is coordinated by the CIC at that school. CJ’s prior knowledge and personal interest in GIS were relevant to and expanded by his job shadow experience. Dewey noted, “it is also essential that the new objects or events be related intellectually to those of earlier experiences…which by stimulating new ways of observation and judgment will expand the area of further experience” (1938, p. 90). These “real” experiences in the workplace and with guest speakers in the classroom are connections to GIS that are key to the students understanding of GIS outside of the school. This is the “actual” part of what Alibrandi (2003) calls the four-fold approach to teaching with GIS: actual experience, virtual GIS applications, critical perspectives on the technology and ethical use of GIS.
Ernest’s representation also included jobs he thought used GIS for decision-making, including park rangers, utility companies and construction companies. Ernest connected GIS day to the users and of GIS. This event is an international celebration of GIS held annually in the middle of Geography Awareness week in November. At Maple Middle school, GIS Day was used to educate the student body and their teachers about GIS in the world.

*Educator GIS experiences and community.* Kathleen, Charles and Natalie expressed similar experiences with real world data in their understandings of how others use GIS. Natalie included uses of GIS in military, business and industry, infrastructure, weather, recreation, and education in her understandings of the uses (see Figure 17). In her interview, she commented on her knowledge of these uses from reading about technology as well as organizing events for students, which included GIS professionals as guest speakers and visitors to the school. At another school Natalie brought in guest speakers as part of her role as a CIC. She coordinated career fairs for the eighth graders and “take a child to work” day for the seventh graders and the sixth grade had a truck fair. They invited companies who worked with different types of trucks to come and show how their truck and equipment were important to their jobs.

When I was over at Belk [middle school], we had a fair, a truck fair for the sixth graders and that was my most recent using of it. We had a gentleman come and he would show the kids how to use GIS and he had a truck and it was the whole setup he had…He would show the kids what they use GIS for and how it’s used in everyday life and how they use it in government.
Figure 17. Natalie's Representation of GIS. “Where is it used? Everywhere, it’s used. It’s all over the world. It’s being used right now. The full-page document of this representation can be found in Appendix L.

Kathleen’s representation of GIS in the world included a number of users in different settings as seen in Figure 18. She represented census taking as houses and an individual outdoors, collection of data about trees, survey information and streetlight inventories. She spoke about the collection of streetlight data from a personal experience with a guest speaker.

I had this guy come in and talk from a company that he worked for one time where they were counting streetlights. And they actually went out and they had to look at each street light and take its GPS reading and then go to the next streetlight when they were doing surveys and inventories of, I guess streetlights in Charlotte.

This personal connection with an individual was stored in Kathleen’s memory and then applied to her understandings of other applications of GIS. Kathleen expressed how she learned about all of the components in her representation from classes, books, contact with others and applying the knowledge to her own maps.
Charles’ representation of the users of GIS, as seen in Figure 15, demonstrates his understanding of multiple realms of GIS use. In his representation he portrays various groups of people who use GIS. These include a “town planner, children of all ages in school, a naturalist and/or scientist who study environmental topics, such as a marine biologist.” The thought clouds expressed in the drawings of these individuals express a metacognitive understanding of the tool and how others might think about using GIS. In addition, the representation of the marine biologist may have drawn upon his study of marine biology in graduate school.

Contact with individuals in the community who use GIS or to request data further expands the conceptual knowledge of how GIS is used in the world for individuals. These
experiences are stored and recalled when students and educators are asked to think about what GIS is, where it is found and how it might be used. The connection with GIS community users is also tied to how the individuals think about what is necessary for GIS to work.

*Internet-based mapping used in the world.* As discussed in the literature review, GIS is not a “plug and play” software. The relative difficulty of the software, the prerequisite technological knowledge and the time required to learn and use GIS could affect the rate of adoption of this technology in schools. This idea was expressed by Ben:

> I think as time goes on and, I think, as more people become more technology literate, I think, it [GIS] will be more accepted. I’m not saying it’s not accepted now, but I don’t think it gets the notoriety that it should get.

As suggested in the literature review, a shift from stand-alone GIS software in schools toward Internet based GIS and mapping may reduce the adoption curve to a swifter “uptake.”

In Charles’ representation of GIS, the cable connecting the computer to the Internet, as seen in Figure 15, is indicative of the connections the educators and students make between GIS and the uses of Internet based maps and Internet based GIS data. CJ described his understanding of the services provided by online mapping from his observations in his job shadow. He connected CGIA and NCOneMap within his representation as seen at the top of Figure 16. He further drew maps that could be extracted from the online data (www.nconemap.com), that provides online GIS mapping services for statewide data.

Then I went kind of more local with CGIA. They only do North Carolina stuff, but NC OneMap--they want every state to have that and there to be a US OneMap type deal where every state has counties that supply information because that’s what’s behind NC OneMap. They have cities and counties that participate and send information to NC OneMap and NC OneMap has all this free data and so it’s just on the fly when you want something you can type in an address and it will instantly go to its server and search for stuff. And so they want that for each state that will search for stuff and supply the big map.
Ernest expressed an understanding of the connection between the Internet and GIS as a resource for research as well as to collect different types of data. “We’d go to the internet a lot to look at, to find locations of stuff or even finds maps or downloadable GIS... ready GIS layers from their website.” The Internet provides access to data and maps that many GIS users would not have had otherwise.

Charles described a world of resources opening up with GIS through the connection of the cable to the computer. He did not distinguish between obtaining data and exploring data online, but his excitement over the possibilities of worldwide access was evident from his comments. While the students delved more into the data that could be found in Internet based mapping, the educators’ comments were more focused on access to the technology and the ubiquitous nature of GIS in different forms.

When Kathleen was asked if she would add or change anything to her initial drawing of GIS, she reflected about online mapping as an easy entry point for users of GIS.

Well I guess if I could draw just a teenager using MapQuest--that you don’t have to be a professional at one of these tables--that there are easily accessible, various tools, that the unsophisticated user, that the novice user, can use and does use.

Kathleen’s comment regarding the accessibility issues of GIS to a general user is also reflected in Natalie’s description of a GIS user:

I guess it would be someone that would have to be trained to understand what GIS is all about or if it’s embedded in something that they’re using and they don’t really realize they’re using GIS in any one of its forms.

This concept of GIS as an embedded and ubiquitous yet unrecognized technology is an important part of the discussion of adoption and diffusion of the technology. Alibrandi (2003) comments that GIS surrounds us every day but that most people see it but do not know what it is. GIS outputs are the weather maps on television and maps in newspaper and articles but they are not described or labeled as GIS maps. Awareness of the technology is
the beginning of understanding why it might be important to learn where and how it might fit into individuals’ lives in the future. Why is this important? Individuals who can critically examine and question the representational maps produced by a GIS will not blindly accept these that surround them daily. This concept of making visible the ubiquity of this still ‘hidden’ technology as well as the need for developing critical consumers of GIS maps and data are further discussed in chapter 5.

The interconnected understandings of the nature of how GIS is used in the world and descriptions of Internet-based mapping by participants are an interesting commonality. Their contact with GIS professionals and users of GIS influence these connections. Online GIS was viewed as a tool to study the world.

**GIS as a Tool to Study the World**

As the participants clarified their understandings of GIS as a tool they described the requirements of GIS technology, such as: hardware, software, data, and training. The participants also connected geospatial technologies such as Global Positioning Systems (GPS) and other geospatial data such as satellite and aerial imagery to GIS. The relationship between GIS, GPS and the geospatial data illuminates the participants understanding of GIS as a spatial tool to study the world.

GIS technology, as stated in Chapter 1, is a system of hardware [computer(s) and the necessary peripheral components], software, data, people, training, and sound methods for geographic analysis. When asked how she knew about all of the different parts of GIS that she had drawn in this first interview, Kathleen stated: “One of the questions in both my classes was ‘what does GIS stand for?’ I can’t remember it verbatim but it was store, manipulate, input data using software, hardware and people.” Later she stressed the equal importance of all of these components:
It all depends on this total interplay of the information, how it’s collected, how it’s analyzed and communicated back to those people who use it. So it’s, nothing is more important than any other piece I don’t think. The hardware, the software, the people.

The necessary components for GIS such as hardware, software, data and training were also included in the representational and interview data for all participants. Yet how they represented or discussed these components begins to shed light on the small differences in the conceptual understandings of each participant.

Perhaps the most prominent common understanding for all participants was GIS as a computer-based technology. Within that understanding there was a broader spectrum of detail the individuals expressed in their understanding of software, hardware and data needs. First, I will explore the understandings of the hardware and software followed by a discussion of data with respect to GIS.

Hardware requirements. Of the six participants, four explicitly included hardware and software. However it is important to note that the computer was not seen as a singular entity. Each participant that drew a computer tied it to another component, like data, software, the Internet and or people. This intertwined understanding of the component parts of GIS were not limited to the representational drawings. The two educators that did not include the hardware or software in their drawings described the importance of these components within their interviews.

Ben’s abstract representation did not include a computer or software but within the interview he indicated that certain resources would be necessary to use GIS, which included a computer and the software. Natalie’s drawing also did not include the hardware or the software, though her understandings of GIS as a computer-based technology with specific software needs were more explicit in the interview.
Software requirement and resources. All of the participants drew or commented on the need for GIS software in order to use GIS technology. Charles’ drawing includes a computer in the center of the drawing. He explained during his interview that he began with the computer because the software is tied to the computer technology. As he explained the spatial relationship of his representation he stated,

Here I guess I thought of like…have you ever seen those pictures of the electromagnetic spectrum? They have…it flares out. So here in the screen you could actually be seeing any of these [he points to the text describing ESRI software products] and then a smaller part dedicated to this [he points to the notation of “others” above the computer on the drawing] because I’m not as familiar with this. A magnified view or branching out, if you were, of the possibilities you’d have on the screen over in the PC.

This description of the software as represented similarly to images of the electromagnetic spectrum provided insights into how Charles was cognitively connecting GIS software to computer technology and his prior knowledge and understandings of other subjects.

Charles’ notation of the ESRI software products is not unique. Natalie mentioned the approved software for Oak County Public School District are the ESRI GIS software products, ArcVoyager, ArcView and ArcGIS. This is important to note as CJ and Ernest are students within this district. Ernest described software packages used in his GIS classes:

Well the two that we used at school, ArcVoyager and ArcView were both GIS. ArcVoyager was simpler. I remember it was kind of a tutorial, building up into finally ArcView. The software… I know we used [Microsoft] Excel to make our spreadsheets and data sheets to put into the software and we’d go onto the Internet a lot to look at, find locations of stuff or even find maps or downloadable GIS…already GIS layers from their website.

CJ’s representation included the software as well. As he described that part of his representation he stated, “Over here [he points to the images and text of ArcView represented by a magnifying glass and ArcCatalog represented by a file cabinet] is two programs, ArcView and ArcCatalog. Because there are other ways of GIS – those are both ESRI programs I think. Ones I’ve used.” In the representational drawings, these images are the
common icons on buttons used to evoke specific applications with in the ESRI GIS software. CJ has represented them by the commercial names. CJ’s use of ArcCatalog, a feature of ESRI’s ArcGIS 8.x and 9.x, occurred during his job shadow with the North Carolina CGIA whereas ArcView 3.x was the main software used in his classes at Maple Middle School.

Kathleen also remarked on the ever-changing nature of the software that Charles mentioned. “It’s frustrating that the software’s changed also. Our GIS, I can’t get anybody to pay for it. And it’s $500 so I feel badly even asking.” Kathleen and her school have ESRI’s ArcView 3.x product. At her school Natalie notes “We got the $50.00 one where you can keep it on for a year and then decide if you want to do the full-blown or not. So we’re coming up to that time.” She was referring to the ESRI Press book, *Mapping Our World: GIS Lessons for Educators*, that included a 1-year ArcView license.

The limited awareness of “other” GIS software may be due to a number of reasons including training and education in GIS, marketing by GIS companies, and economic factors in school software purchases. The software issues raise implications of adoption and implementation in Rogers’ diffusion of innovation theory. I will expand upon this discussion in the implications found in chapter 5.

*Training.* Ernest wrote, “GIS is a unique bit of software” as one of the main subtopics of his representation (see Figure 13). From this point he drew connections to the ideas that “It is very adaptable to many different needs” and “Many different other softwares can be integrated into GIS to make it better or more unique and specific to a certain area.”

Within his description of the GIS software Ernest alluded to the need for training. He stated,

And you need to know the software. You would have had to use the software before. And you can’t. I don’t think you can just jump in it and say it’s GIS and I can use this and not have any experience with it at all. You have to gradually go into it and then start exploring your area of interest and integrate them together.

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He continued to describe the characteristics and knowledge a GIS user would need in order to use GIS to its maximum capability:

You have to really know all of the different short cuts and different things you can do with it. And they would probably be very knowledgeable about GIS and software and how to use it. And different places that they could use it and that it is used and how it could be made better. They would notice things about it, maybe, that could be improved upon. Or after they’ve used it for a while, you have to go through a series of things to get to a certain place and you could just think about a shortcut to do that or just to make it better and they’d probably be very observant of their surroundings. And how it could be used for everyday life.

The common understanding of the need for training and GIS knowledge was also found in the comments made by the novice teacher, Ben. When asked to elaborate on what was needed to use GIS, he stated: “The GIS program. Computers. The knowledge to be able to run the GIS program is probably the most important. Time. Energy. Enthusiasm. A projector. And content knowledge.” I asked him to expand on each of these points and note which ones he thought he had. He answered:

Honestly? I’ve got the computer, I’ve got the projector. I’m comfortable on content knowledge. I’m comfortable. I wouldn’t say I’m anywhere, where a teacher teaching for twenty years could be at but I think content knowledge is reasonable. The energy right now and enthusiasm and especially time, and as well as the grasp of the knowledge of GIS, I feel inadequate… I see time and knowledge are the two most things that hinder GIS in the classroom. Time and knowledge.

Ben was very focused on his role as an educator in his response to the query: How do you conceptualize and understand GIS. This perspective will be further explored by all participants in the discussion of research question 3, which focuses on GIS in school.

Data. Kathleen’s drawing expanded on the data collection and data storage more so than any other participant. Her experiences in computer programming and her hobbies are reflected in her focus on the data and data collection part of GIS.

I’ve loved maps for a long time and just…and worked as a programmer for a while so I’m not afraid of computers. And I really enjoyed…I like the information. I like
the whole idea of presenting information in a graphical context so it can be analyzed and looked at. I guess I forgot to say I like art and that’s one of my hobbies, going to museums. So images are important to me and it just seems like a rich area for learning and a different way of problem solving is to look at a graphical representation instead of just columns of numbers. And I should say, yes these reports are not just reports, they’re maps. They’re things that you can look at.

Kathleen drew connections, literally and figuratively, between the data storage and collection within her representation. Connections between the GIS data and the people were also fundamental to Kathleen’s representation of how GIS works. She included workers, data collectors, policy makers, surveyors and other individuals explicitly labeled as the users. Not only did the educators observe the importance of data to the GIS, the students commented on this aspect as well. CJ stated, “I drew a little computer because it’s a kind of computer based thing. But behind the computer you’ve got to have data.”

**Global Position Systems (GPS), satellite and aerial imagery.** Another important commonality of the conceptualizations among the educators and students was that of Global Positioning Systems (GPS) as it related to Geographic Information System(s) or GIS. In many conversations with GIS professionals I have heard a frustrated tone when they are explaining the difference between GIS and GPS. A GPS uses satellites to determine locations on Earth. GPS coordinate data collected with a GPS can be imported and mapped into a GIS.

Kathleen and Natalie both included GPS in their representations of GIS. Kathleen’s representation includes GPS to collect data to be stored. She explicitly labeled three GPS users in her representation. The first was a user on a bike with a GPS unit. As mentioned, this particular understanding of GPS was based on her experiences with a GPS user who was a guest speaker. Another use of GPS as seen in Figure 17, Kathleen’s representation, is that of GPS on a delivery van. She explains “Or in your own office, asking for reports that will
tell the UPS guy where to go to deliver stuff. You’re always tracking where he is with the GPS unit on his truck…” She also includes GPS in her drawing of the census collection as seen in the small houses and the individual recording data. This GPS image is connected to drawings of two satellites further illustrating her understanding of how GPS works.

Interestingly, Natalie’s representation displays combined uses of GIS and GPS as seen in Figure 18. She described her drawing process as “linear.” She began with her earliest memory about geospatial technologies, which is represented by a car in the parking lot. She had locked her keys in her car and with the OnStar™ system she was able to have the car remotely unlocked for her by a simple phone call. Interestingly, on the right side of her representation she drew another smaller car and she included recreational uses where she notes map and travel. Many cars equipped with the OnStar™ system also have digital map displays, an integrated GIS system. These representations demonstrate the combined applications of GIS and GPS.

Within the interview Natalie commented on her personal discomfort with what she had drawn. “Like I said, I don’t know the ins and outs of GIS and probably have some of this misrepresented.” She continues, “I do know it’s a satellite thing and connecting to it. And that’s why you can’t get it to pinpoint right away because you have to wait until the clouds clear to get a good shot of the satellite.” Natalie was able to describe how GPS worked but often mixed her references between GIS and GPS. She remembered GPS from the GIS in Education course where it had been introduced.

In the U.S., recreational GPS units are available in sporting goods stores and mega-stores such as Wal-Mart or K-Mart. in the U.S. As noted by Natalie, GPS services are used in automobiles, such as the OnStar™ system, and in cellular phones for emergency tracking. Linguistically, it is understandable that GIS and GPS are confused as they both are
commonly referred to by their initials rather than their full names and they have similar referents. This confusion could serve as an opportunity to help individuals understand what GIS is and how GPS works with it. The implications of how educators understand GPS and GIS may be a potential line of investigation for later research, particularly regarding the visibility of GIS.

**Summary of Research Question One**

Both students and educators described GIS as it is *found* in the world, GIS as it is *used* in the world and GIS as a tool to *study* the world. They were able to “see” and represent a world populated by geospatial technologies and data. The participants were able to connect spatial information and users together through the use of GIS technology. They had common understandings of the necessary requirements of GIS, such as hardware, data, software, resources, and training. Internet-based data and GIS software applications were another a common understanding.

The common understandings of GIS as explored in this section begin to unveil not only how students and educators conceptualize this technology outside of the walls of the school or classroom, but also how they position GIS as allocentric to themselves. There are common categories of description between all of the participants. They include: personal experiences with the technology, jobs and individuals who may use GIS in the workplace, examples of software and hardware needed to use GIS, internet based GIS, GIS as a global tool, and to a lesser extent Global Positioning Satellite (GPS) technology and applications. The differences among the participants are found not only in how they represented their understandings of GIS but also in the individual connections that they made with it.

The interview data surrounding this question focused simply on describing the elements of the representational drawing with little or no elaboration. Most of the
participants were not able to expand upon their understandings beyond the images (*imagens*). The interview data paralleled the images but tended not to diverge from the understandings represented within the drawings. Their representations alluded to experiences, knowledge, and physical locations about GIS but the participants were physically removed from concepts thus positioning themselves allocentrically. In the next section, I will discuss the data related to research question two: How do students and educators conceptualize instructional technologies?

**Research Question Two: How Do Students and Educators Conceptualize Instructional Technology?**

The conceptualizations of instructional technology (IT) discussed in this section are derived from responses to the research question that demonstrated the participants’ position frame of reference was egocentric. An egocentric relationship to IT was established through examination of the representation and interview data. Both students and educators represented IT in terms of classroom settings and locations inside and outside of the school. However, emergent understandings what IT was and how IT fit into the learning process focused far more on the internal reflections of the individuals. The representational data served as a starting point for understanding the participant’s conceptualizations. The interview data from this particular research question was more enlightening to the researcher. Through the interviews, the egocentric frame of reference emerged to provide a deeper linguistic understanding of the concept of instructional technology. The interview data for this particular topic was lengthier than in other meetings with the participants and revealed that the participants’ understanding of instructional technology seems to be tied more to what Paivio referred to as the *logogens*. The egocentric frame of reference of the data is used to structure the discussion of the categories of description.
Using phenomenographic methods to analyze the data from interview two, which focused on IT, six categories of description emerged. The categories of description of the common concepts of instructional technology among study participants included: (a) setting, (b) hardware, (c) software, (d) users, (e) subject/curriculum areas, and (f) pedagogy. This section of the chapter will focus on the data that best represents these common understandings. The representations produced from interview two can be found in Appendixes M through R. Relevant examples are provided and referred to throughout the discussion of research question two: How do students and educators conceptualize IT?

**The Egocentric Positional Relationship to IT**

The egocentric position was very firmly constructed in the individual participants’ roles in their K-12 institutions. The two classroom teachers located all of the technology within their own classroom use of technology. They were so established within their classroom environment that they were not clear about IT connections beyond their classroom and curricula. Most participants did not express their knowledge of individual software or hardware, rather they expressed the awareness of what hardware or software was available, used or even potentially useful for learning. This awareness was coupled with the frame of reference of instructional technology as it applied to their experiences and role within their school and therefore their egocentric positioning was the perspective from which they formed their responses to questions 2.

As discussed in Chapter 2, the expected role of the classroom teacher is that of a specialist in pedagogy and in content area knowledge. While elementary teachers in the early grades are generalists, the two classroom teachers in this study taught in middle and high school settings where understanding of (or even comfort with) other content areas are not necessarily expected. In addition, Charles and Ben were able to locate and describe the
pedagogical approaches they used in their own classrooms. As educators often work in isolation, they are not frequently afforded the opportunities to observe the pedagogical approaches used in other content areas or even other classrooms in the school.

The two educators in support roles, on the other hand, were conceptually able to locate IT across numerous curriculum areas and provide uses of IT in various contexts. In Natalie and Kathleen’s roles, each supported teachers from different content areas and different educational settings. The ability to describe different pedagogical approaches they have observed was centered in their understanding of IT with respect to their own egocentric positions. The experiences and expectations of the participants in support roles allowed them to negotiate across and through the invisible barriers that are perceived to exist for many classroom teachers in regard to other curricular areas.

The students’ frames of reference for IT were similar to those of the support persons. They too observed and experienced many different applications of IT throughout the content areas and were able to draw connections of IT use across the curriculum. Students navigate daily through a number of content areas and pedagogical approaches. With every bell or class change they encounter an environment that is different from the last. These experiences moving across the curriculum and throughout numerous classrooms located the students egocentrically in a multidisciplinary position from which to reflect.

Both educational support staff and students have the benefit of very fluid movements that enable a broader environment of IT over those of the classroom teacher. Yet classroom teachers Charles and Ben also grounded their understandings from egocentric perspectives. The implications of the egocentric position location of the classroom teacher, the educational support staff and the students will be further discussed in chapter 5.
Framing the Discussion: Pedagogical Considerations

As the participants described IT there was a common understanding of the variation in methods and materials used when teaching with and teaching how to use technology. This discussion of the learning processes surrounding IT is not limited to teachers teaching students, it also incorporates how educators learn and use instructional technology. I have featured Natalie’s representation of instructional technology (see Figure 19) as it provides context for the conceptual locations and understandings all of the participants shared. The category of description, pedagogical approach, was the least explicit common understanding among the participants. The relationship between pedagogy and the other categories of description (location/setting, hardware, software, users, subject/curriculum area) are explained through Natalie’s conceptual location of IT. It is important to note that I would consider Natalie’s conceptual understanding of instructional technology to be more in-depth than the other participants because she is not only part of the educational support staff in a middle school but she is a doctoral student with a research focus in instructional technology.
Figure 19 Natalie's Representation of Instructional Technology. It includes IT found in her school, IT as a tool and two approaches to technology divided by a river and the goals of education. A full-page image of this figure may be found in Appendix M.

A visual walk. Natalie began with a brainstorm of the types of technology used in schools, found in the top left corner of the representation. In the next image, she took a “visual walk through her school” found below her brainstorm in the top left corner of the representation. She continued by drawing a hammer and nails to represent technology as a tool. The main part of her drawing represents the two approaches she had observed educators using when teaching with Instructional Technology—traditional and non-traditional.

The two pedagogical approaches are separated by a river and meet at the star. This part of the drawing, the river, she intended to be “a deep ravine” but she was not happy with the lack of depth. Natalie had begun to draw bridges across the ravine and added boats as she shifted her idea to “a deep river.” These areas between the two sides of the river Natalie
describes as paths towards a shift in pedagogy whether it is a short trip to look around or shift to the other side. Representing teachers’ pedagogical choices, she states,

Even though we [support staff, IT specialists, and others providing professional development in IT] offer them a ferry across and docks, and we offer them even a bridge -- where they can find out they don’t want to. They’re too bogged down with the End of Grades\textsuperscript{16} and testing and “this is the way I teach” and “this is my classroom.” No matter how many opportunities we give them, unless we change the way they think, they are not going to use it. And all of the boats are on this side [she points to the “traditional” side of the river] because they don’t want to get across to find out, even though we’ve given them all the access roads.

On each side of the river, non-traditional and traditional, Natalie included at least three components. The first is a layout of a typical room that fits the structure of the pedagogical approach represented. She associated these diagrams on classroom layouts she has observed within her school and and previous schools. Second is an image of a building that she used to represent how IT is “structured” within a particular pedagogical perspective. Third is a list of the cognitive skills that she identified with each approach, based on Bloom’s taxonomy.

The goals of education, according to Natalie, are found in the top right corner of the drawing located between the two approaches around the star. “They’re all [the students are] ending up in the same place,” she states, “so it just depends on where you are going to end up. And when you go out on your own and you reach for the stars, that really changes your reach I think.” She elaborated on each of the parts of the star:

EOG’s and testing are the big thing. But, you know, when you’re talking about this [she points to the image of the star], they are both leading to the same thing. Kids are going to have a career; they’re going to have higher education; they are going to have to deal with life; character; and good citizenship. Those kinds of things. Skills.

\textsuperscript{16}“End of Grades” or “EOGs” are the vernacular terms used in North Carolina for end of course and end of grade standardized accountability tests.
I will elaborate on the elements of Natalie’s representation as they relate to the categories of description. Examples will be provided from the representational and interview data of the study participants.

First I describe the hardware and the location and setting, as these are where Natalie began and they represent two of the most common participant understandings. Next, I describe the users within the landscapes of Natalie’s drawing. Finally, I discuss the category of subject/curriculum areas that includes a discussion of common goals, the methods and materials used. The final category of description is software which will be discussed within the context of materials used in subject/curriculum areas.

**Locating The Hardware**

Natalie began with a methodical process of brainstorming the instructional technology that she then framed within the structure of a school. She described this process as taking a “visual walk” through her school. She was making connections between the words, or *logogens*, from her brainstorm and the images, *imagens*, located within her school. The *logogens* at the forefront in Natalie’s mind were hardware associated with IT. Natalie’s initial cognitive process is representative of the two most prevalent categories of description that emerged from the Question two data: hardware and location/setting. All of the participants included hardware in their representations. The location, or setting, of instructional technology was distinguished in several representations but was described by all participants. Participants situated the hardware within the school setting and in settings outside of the school.

*The computer and the peripherals.* The study participants immediately conceptualized the computer and often included many of the peripherals within their representations. The computer was noted as the first item drawn by two of the educators and
one of the two students. I will describe those items most commonly suggested by the participants, which could be categorized as hardware and peripherals of computer-based technology. This will be followed by other technologies that the participants recognized as instructional technologies.

Personal experience with a variety of technologies influenced what was included as IT in the representations by the students and educators. CJ pointed out, the “first thing I thought of was computers, that’s just the major thing…and my favorite form of technology anyway. It’s got a lot of programs on it that teach.” Ben remarked, “I couldn’t survive without my computer.” The two types of computers that emerged from the representations and the interview transcripts were laptop computers and desktop computers. Laptops were associated as hardware specifically among educators whereas both students and educators represented desktop computers. Only Natalie referred to “laptop carts,” a mobile cart with a classroom set of laptop computers that can be checked out by a teacher, to use with students in classrooms with a limited number of desktop computers.

Across the representations, the computer may be distinguished as a distinct object. In addition, the participants drew and described many of the computer-based peripheral items. Charles’ representation locates the computer at the center with connections to various peripherals and settings (see Figure 20). He described the many tools that are enabled by the computer including probes (sound and pH), digital cameras, video cameras, GPS units, data projectors, and graphing calculators. Additional peripherals suggested by the participants were scanners, SmartBoards, headphones, mice, keyboards, and Personal Digital Assistants (also called PDAs or Handhelds). The depiction of objects in the representations can represent personal experiences or awareness of the phenomena related to IT. For example, Kathleen included PDAs in her conceptual drawing however she explained in the interview
that she had not “actually seen a kid using PDAs but I’ve been to presentation where a middle school teacher did this whole presentation about how he uses them in his language arts class.”

![Diagram](image)

**Figure 20.** Charles' Representation of Instructional Technology. He stated, “I would say instructional technology is, to me…it would be a manmade tool that helps in conveying a concept among students… to grasp and learn a concept.” The full page image of this figure can be found in Appendix N.

Calculators and graphing calculators were referred to by numerous participants. Graphing calculators can visually represent the data as graphs and tables. Today’s calculators can connect to probeware for collection of data, computers for analysis of data stored on the calculator, and between users to share information. Charles commented that the students also discovered the ability to load additional software, tutorials and games on the
calculators. At Kathleen’s residential magnet high school, students are required to purchase a calculator:

I guess the only thing we require is we require all kids who come to this school to purchase a calculator and that’s the only thing you’re required to purchase. And actually, public schools a lot of times, they’ll have a classroom set of calculators but they won’t let the kids take them home at night. And that’s a real hassle because they don’t have the time to do their homework with the calculator.

This issue of access, raised by Kathleen, is significant to implementation considerations during the decision-making process.

All of the students and educators described limited access to certain IT hardware and peripherals by potential users. Access to many of the peripheral items may be limited to specific users by content area or by physical location. Kathleen describes the accessibility of equipment to students at her institution:

There are lots of computers all over the school for public access.... And they also have access to printers. Though they’ve got an account and this can’t exceed a certain amount unless they have to start paying for it. And with the exception of video cameras, which we never seem to have enough of when kids want to do projects, they are provided with the equipment that they need to use.

When asked if she thought this was typical of schools Kathleen replied “No. Absolutely. Not. We are very fortunate.” Inequities exist in the available IT resources at different schools and even in different classrooms within one school.

Other technologies. Instructional technology is not limited to computer-based technologies as defined in the introduction of this study. Larry Cuban (1986) defined instructional technology as “any device available to teachers for use in instructing students in a more efficient and stimulating manner than the sole use of the teachers voice. Hardware and software, the tool itself; and the information the tool conveys define the technology.” The computer was the central focal point for almost all of the participants however, they also mentioned other technologies they have observed and used in the classroom. These included
overhead projectors, DVD and VCR players, televisions, laminators, devices used in science labs (circuit boards and electronic balances), devices used in vocational education (saws), chalkboards/whiteboards and SmartBoards.

Access to, and the use of, instructional technology is often dependent upon where the hardware is located. The location and settings of instructional technology was an emergent category of description in the data. Participants included objects in the representational drawings and described explicitly in the interviews the locations of IT inside school walls (as in Figure 19) and outside of the walls. From the common understandings of the physical settings of IT, the following issues emerged: infrastructure considerations of IT implementation, influence of school and classroom layout and use on IT integration, and equity issues inside and out of school.

IT within the school. The most common physical location of IT, described by the participants, was within the confines of the school. Both students and educators represented objects found in classrooms and computer labs in the schools that implied setting, such as: pull-down maps, a SmartBoard, a chalkboard and/or white erase board and overhead projectors. Ben’s representation of IT was limited to his daily use of technology within his classroom and teaching (see Figure 21).
Figure 21. Ben's Representation of Instructional Technology. He states, “I looked at the technology which I use daily.” The technologies in this image are: (1) an overhead projector (2) a chalkboard or whiteboard (3) a laptop (4) a television (5) a VCR or DVD player (6) the Internet. The full-page document of this representation can be found in Appendix O.

There was variation of settings described across educational institutions. Charles’ second interview, focusing on IT, was conducted in his classroom. He described how he began to conceptual computer technology within the context of his school:

As you see here, this is quite a typical classroom. You haven’t been in the others, but there’s roughly one computer for every two children, every two students. And so, I definitely think of the interior of this school. Here we are actually really fortunate. In the private middle school in which Charles works, there are no computer labs. Charles felt that his school tended to select individual teachers who were willing “to explore a lot of different technologies.” Purposeful decision-making regarding the infrastructure necessary for IT implementation, such as the one at Charles’ school, can influence: pedagogical approaches engaged by educators, IT integration in the curriculum, and the diffusion of IT as
an innovation. Further discussion of the impact of these concepts will be explored in chapter 5.

The private school setting is contrasted by the understandings of the student participants. Ernest states, “I think there’s like one class per team that has computers to use. Other classes will have at least one computer in them, but that is for the teachers to keep up with grades or to print out tests.” The designated use of a computer by one individual or a group within the school is a concept that will be explored within the discussion of the users of IT, another category of description in the data.

CJ notes, “Well generally, we don’t work too much on the computers in the classroom. It’s generally in the computer lab because there is not enough computers.” Every school setting is different. Natalie, who is at a newer middle school within the same district, describes the setting in her school:

We have labs that are open for everybody to use. We have classrooms that have at least 2-5 desktops and one laptop. We have printers, TVs VCRs – every room is equipped exactly the same. In support areas, we have desktops, scanners, printers, you name it.

Computer labs, locations specifically designated for instructional purposes that are technology enabled and contain multiple computers, are not unusual accommodations in the increased implementation of instructional technology. As discussed within the context of the diffusion of innovations model, part of the adoption and implementation process for an innovation includes redefining and restructuring the organization. Within the context of a discussion of IT in education as an innovation, the inclusion of facilities adaptations within educational setting is necessary. All of the participants from public institutions described numerous labs within their schools.
The descriptions of the settings inside of the school found in the data substantiates my suggestion that IT as an innovation is well into Rogers’ implementation stage. The decision to not incorporate computer labs in the private school setting, and subsequent inclusion of computers in each classroom, locates Charles’ school on the non-traditional side of the ‘river’ and further along the innovation curve. The implications of this pedagogical location of the hardware associated with IT on pedagogy and IT integration will be further explored in chapter 5.

Many schools provide spaces and access to the instructional technology for students. However the students often have limited time and/or permission to use or enter these spaces. During the interview Ernest described other areas of access to IT for students, such as the media center at Maple Middle. He observed,

Generally if you want to use a computer you’ve got to go to the lab or the library in the morning before class. And you get a pass from the front desk in the library to use the computer and then log into the network to use it. And then you have to get back to class before the bell rings. Computer use is pretty much limited to in-class time -- using it for research.

This concept of the school providing space yet not necessarily time for students to access the technology is a pivotal issue surrounding implementation. This example of spaces but not places provided, in the school structures for access to the technology, typifies the lack of routinization of IT in K-12 settings as it relates to Rogers’ (2003) diffusion of innovation theory. Routinizing, the final stage of the diffusion theory as explained in the literature review, is vital to long term sustainability and increased adoption of an innovation such as IT.

The distribution of the hardware in classrooms and schools is one facet of the setting or location of IT. Funding resources are generally at the core of any discussion of the number and quality of computers, or other technologies, located within schools. More
importantly the impact of IT on learning in schools is tied more directly to how the existing hardware is used. The impact of classroom layout on learning and teaching with IT is another characteristic that is demonstrated in the original representation framing this discussion.

IT in the classroom. The first images Natalie included when representing non-traditional and traditional approaches to IT were classroom floor plans (See Figure 19). Natalie constructed a layout of the space she considered representative of the non-traditional classroom. As she recalled the layout of the classroom of a specific teacher that she felt used non-traditional methods, she noted:

We have a language arts teacher that is very strict --seems very traditional when you talk to him --until you get into his classroom. He has four computers along the back and those are the kids sitting there. He has an area where kids can go and read quietly as a station. He has an area where the kids can get together as a team. He has...seats around instead of traditional [rows]. And that does integrate technology because it gives them [students] a more responsibility to learn.

In Natalie’s drawing of this classroom, she uses dots in circles to represent the seats around table, two boxes and four dots representing the tables and chairs where the computers are located. The teacher is in the corner and is labeled “Teacher Facilitator.” Yet the layout of the room represented by Natalie facilitates numerous ways of learning. The IT is integrated as a part of the classroom structure even though it is limited by four computers and is located on the periphery of the room.

The other classroom layout represented was referred to by Natalie as a traditional classroom. In her discussion of traditional approaches to teaching she described the layout of the traditional classroom:

Those people are on this side of my little map here, they use traditional classrooms. Here their computers are sitting idle, doing nothing. Teachers are in the front teaching off the blackboard and whiteboard, now it is called. And students are sitting
in their regular rows and they are teaching their tradition [content area] and they’re using it [technology] as an “add-on.”

In this part of the representation, although there are computers present in the classroom, the spatial layout of the room does not facilitate the use or integration of the technology into the teaching that takes place in that space. In such a setting, which Natalie describes as traditional, she depicts IT as an “add-on.” The concept of IT as an “add-on” will be further discussed with respect to the methods used in teaching.

Participants in the study described the spaces and settings for IT in schools. They illustrated the use of IT in settings such as computer labs, media centers and classrooms. Decision-making surrounding the physical location of IT in schools, such as in labs and with individual components like laptops, influences user access and can define how the technologies will be used. The implications of school based decisions about access and location on implementation innovations, such as IT and GIS, will be further discussed in chapter 5.

IT outside of the school. Study participants did not limit the location/setting of IT to the confines of the school. Instructional technology for many of the participants was discussed within experiences and settings outside of the school. As Kathleen described her representation of IT, she acknowledged this idea of instructional technology not being bound by the school building or the classroom (see Figure 30). “I wanted to emphasize that it’s not just in school, it’s at home, so I moved over to here and it was not just in school but outside also.” She pointed out that IT could be located in numerous outside settings. She provided an example of a biology class going to a lake with probes to collect water samples and data.
Figure 22. Kathleen's Representation of Instructional Technology. She begins by stating, “Instructional technology in the schools are basically different items that abound. The computer being the main one and there are all kinds of different applications.” The full-page document of this representation can be found in Appendix P.

Charles also described instructional technology use outside of the classroom but still within the surrounding area of the school. His school had recently acquired a pond on a piece of property adjacent to the school. His representation includes a drawing of the pond with a use similar to Kathleen’s example. “We went to the pond and [the previous owner] let us go in there and take our…collect our data.” Charles’ students used probes to collect data from the pond. Charles’ ability to move his students to other environments on the school property provided an opportunity to use and connect the instructional technology, in what he considered a “meaningful” experience, in the world outside of the classroom.

The students and educators commented on the potential of applying and using IT in the context of home. Participants provided examples of uses, such as student research and
educator preparation of instructional lessons and materials. Kathleen provided an example of student home use of IT: “Students using computers at home, if they’re doing an online course. They might be doing it at school or they might be doing it at home, so instructional technology is being used.” This does however open the discussion to issues of equity and, what is commonly referred to as, “the digital divide.” Both the educators and students recognized that not every student has the capability to own the necessary instructional technology. Equity issues will be discussed in the context of the participant’s understandings of the users of IT.

**Instructional Technology Users**

The descriptions of hardware distinguished as a component of IT and the locations/settings where they are found begins to illuminate the next category of description: the users. Both educators and students viewed the users of IT as teachers, students, and others in the school setting (such as administrators and media specialists). Conceptualization of the users of instructional technology provides further insights into the perceived roles of teachers and learners in schools, digital equity issues, and access to IT.

*Teachers and IT.* All of the participants acknowledged the teacher as a primary user of instructional technology. Student and educator perceptions of the type of teachers who use instructional technology were wide-ranging. The students observed numerous teachers using technology and had difficulty describing the commonalities among them. Ernest noted, “It varies. A lot of our teachers use all sorts of different programs and technology so you can’t, I don’t think you can really put a specific character trait or anything with them because everybody uses it.” The educators, however, had not observed such uniformity of use. Nor had they observed the widespread use of instructional technology described by the students.
Educators described common characteristics of teachers who successfully used IT, and those resistant to IT use.

The educators were able to describe teachers they felt used IT but their individual depictions differed. When describing a teacher using IT, Kathleen stated that s/he is:

Someone who is comfortable with the equipment. No one uses technology they’re not comfortable with because they don’t want to appear foolish in front of their kids. So in that definition it, it’s really hard to say. It’s not necessarily an old teacher or a young teacher. Because there is not a stereotype.

While Ben agreed with Kathleen regarding the need for comfort and past experience with technology, his understandings included a generalized definition of a teacher who uses IT. Ben’s characterization of teachers using IT was that they were, “younger, always younger, most of the time, I would say 95-99%.” Natalie, on the other hand, believed older teachers were more willing to try technology. She attributed this to the established procedures “seasoned teachers” (with 7 or more years of experience according to Natalie) have in place in their classroom.

If the teachers that have been teaching a long time have set up or know what they’re doing in their classes…they can step out of the box a little more. But you have a new teacher coming in that’s 22 years only, has no idea what they are doing; especially a lateral entry teacher, and you don’t have the structure behind you. So, you can’t just go wild and say, “Gee, today we’re going to do this—we’re going to try it.” Because every day, for them, is something new.

Even though the educators differed in their conception of the “typical teacher using IT” they agreed on characteristics that parallel those of adopters of new innovations in the early stages of the diffusion process. As described in chapter 2, the Innovators, Early Adopters and Early Majority are the first 50% of individuals who adopt an innovation (see Figure 8.). The Innovators and Early Adopters are more willing to take risks when a new innovation is introduced. The Early Majority adopters tend to be more deliberate. Natalie described herself in terms of an innovator or early adopter who often recruits other teachers to try new
technology. Teachers that feel comfortable with technology are the users who may be open to the new ideas presented to them.

The latter two categories of adopters, according to Rogers (2003), are the Late Majority and the Laggards. These individuals are often resistant to new innovations. Charles stated that when trying to integrate new technologies into the curriculum in this other school, I would say it was sort of a passive resistance – “Well, we are just going to do it our way.” And when I would have a meeting, they would say…they would sort of nod their heads and listen but then when it actually came time to doing it, it wouldn’t happen.

Kathleen provided a number of reasons she felt many educators were resistant to IT:

They have had bad experiences. They don’t have good support. They have no opportunity to learn. They don’t have time. They don’t have good equipment so it’s too risky to use it because it might break or not work. And they don’t have any support. And, I guess, partly there is a fear that the kids know how to do everything and you don’t wan to appear unskilled in front of your students.

Ben juxtaposed his ideas of young teachers as the early adopters with the idea that those teachers who do not use technology as “older, less experienced with technology or they tend to be afraid of the technology.”

The perceived lack of knowledge and fear of technology among teachers was pointed out by both educators and students. Also mentioned was that some teachers find student knowledge about technology unnerving. As Ernest explained his understanding of teacher workshops about IT, he provided an example of one of the causes of teacher anxiety with IT. He described the student reaction when teachers revealed what they were learning, “a lot of times, some students will start laughing because sometimes it’s stuff that they learned a couple of years ago, but the teachers haven’t learned yet because they were kind of used to their teaching style.” This observation of teachers resisting technology due to their choice of pedagogical approach is important.
Natalie’s representation of the role of the teacher is “teacher as facilitator” in the non-traditional, or constructivist, classroom; the so-called “guide on the side.” This contrasts with the teacher using the approach Natalie identified as “traditional methods;” The so-called “sage on the stage.” The pedagogical approach, chosen and employed by teachers impacts student learning outcomes and the methods and materials utilized in the classroom.

Natalie’s “traditional approach” is paralleled in instructional technology literature as the objectivist approach and that was described in the review of literature. As I stated in chapter 2, this approach tends to focus on a hierarchical diffusion of knowledge. The teacher, through direct instruction imparts knowledge to the students. Ben is a study participant whom I would locate on the traditional side of Natalie’s river (see Figure 19).

Ben described his pedagogical approach as primarily lecture based with the overhead to help provide structure for his students. He explained that he uses overheads and the blackboard, rather than presentation software, so as not to distract the students. “They’re going to be too occupied with what the computer is doing as opposed to what’s on the screen. That is what I have found.” The overhead projector is central to his understanding of IT and its use in the classroom.

Both students and educators described the overhead projector, though their opinions diverged. CJ noted that the overheads “are used by the teachers and you take notes.” He categorized the overhead along with pull-down maps, books to read and lecture as non-hands-on activities in the classroom unlike the computer-based technologies. This distinction is significant from the student perspective, though may be indistinct from the teacher’s perspective. As seen in Figure 21, Ben’s initial representation was an overhead projector; followed by his laptop and the Internet, the DVD/VCR and television in his classroom. The technologies used by Ben and the methods he described are rooted in objectivist models.
Charles’ understanding of IT, like Ben’s, was also based in his classroom and teaching methods. He included many different representations of the potential hardware and uses of IT inside and out of school. While Charles recognized the need for lecture at times, the descriptions of activities he employed in the classroom were anchored in constructivist principles. Non-traditional classrooms changed the educator’s role to facilitator allowing for student controlled learning through conventions such as stations, inquiry, co-teaching with technology and projects, core concepts in constructivist-based principles. Charles offered an instructional perspective regarding the limitations of the school structure on his desired pedagogical approach:

Sometimes you need to pre-bake, so to speak, some of the steps. And that’s going to be a compromise. They’re not going to get as much out of it compared to if they have to do A through Z. So, I would say, just time they’re allowed to grapple with the question, grapple with the equipment. Grapple may be too strong of a word. To handle the equipment, to …not play but investigate with the equipment and then to get the data and think about it, what it means in the big picture. … That’s what I would say makes something meaningful.

Charles’ thoughts demonstrate the choices teachers make daily as they select instructional modes and media. The personal teaching philosophy of the teacher has implications for the students’ cognitive understanding of a subject area, the selection of materials and the methods used in the classroom. Next I will discuss the students as users of IT. Within this discussion, equity issues and the cognitive skills students use based on pedagogical approach will be discussed.

Kathleen described the shift in the role of the teacher and students when moving from the traditional classroom to the non-traditional classroom with IT. According to Kathleen, “It’s not teacher directed but that these are, sort of…the emphasis is the technology really is to support inquiry based learning. Where kids are working in groups on projects and not just
the teacher at the blackboard directing everything.” The role of the educator in the non-traditional, or constructivist classroom facilitates student learning in a different way.

Students and IT. Another subcategory of IT users prevalent in the data were the students. Ernest suggests a range of student users based on their skills, “Students…there are students that know shortcuts and backdoors to different programs and then there are students that are learning how to use the programs.” As Ernest pointed out, there are various levels of users among students. Both students and teachers articulated many of the cultural and socioeconomic issues that surround technology use and proficiency among students in K-12 settings. When asked whether or not he felt students would enjoy using technology or not, CJ replied, 

I don’t think there’s very many people that don’t enjoy the computer. Not many people have access to the computer as much as I do. Some people have big limits: they have one computer for two kids, you’ve got to split time; some people can’t afford a computer. But at school, I think everybody enjoys working on the computer. I mean it’s something you do. You don’t just sit there.”

While CJ did acknowledge that some students would like to simply read a book he immediately followed that up with a statement that students who like to read can do so on the Internet. Ernest, when asked if any students did not want or like to use IT, echoed the equity issues described by CJ:

I hate to say it this way, but generally, at this day and time the students that don’t like to use the computer are students that don’t -- maybe haven’t had as much experience as other people because they can’t afford a computer. Or they don’t have time to really experiment with it. They have other responsibilities at home that maybe some other students don’t have. Such as, maybe: they’ve lost a parent so they have to take care of the younger kids; wash the dishes; take care of the house because the other parent probably works. So they’re probably going to be home alone or without siblings... They might not have a lot of time to use it so they’re not comfortable with it. And what people aren’t comfortable with they generally don’t like to use it.
This idea of discomfort due to infrequent use reiterates the same idea pointed out by Kathleen when discussing teacher resistance. Kathleen expanded upon the equity issues the students identified through her personal experiences in distance education. She provided an example of how the “digital divide” impacts student users in schools:

In the distance-learning department, we teach a course, we teach C++ or with the videoconferencing, we’d have to expect that kids can’t have access to work on their homework, their programming homework outside of class. It’s limited. And we’ve also collected data that we know not all kids have computers at home and not all kids have Internet at home and not all schools will provide time in the day for kids to use the computers. They have to go at lunchtime. They can’t stay after school necessarily.

As computer use becomes more ubiquitous in the future, this divide between those who do and do not use or have access to computers may lessen. Until that time, if there ever is a time in which there is no divide, the discomfort and access, among students and educators, must be addressed.

Natalie suggested that there should be a shift in the way in which educators view the role of students when using technology:

In the ideal situation, they’d be almost a partner in the instructional technology. Maybe not a partner -- maybe half and half, maybe 25/75 or something. I learn a lot from the kids and the kids know a lot about technology that they can give back to the teacher. That’s why I say we don’t need to start with the teacher knowing everything about it because they’ve got a classroom full of kids that grew up on computers. And if they’re in trouble there’s probably one child in there that can help you.

This tactic requires a pedagogical crossing to the non-traditional, constructivist, side of the river. Educators do not have to make a total move but can take small excursions and test out the landscape through the use of the students’ prior knowledge. As Charles discussed student users, he described how “the students really became teachers to their peers and colleagues and…not colleagues, but peers with their teachers as well.” This is representative of a
relocation of pedagogy completely to the non-traditional side of the river. As Charles reflected on his statement, he began to think about the students in his school:

I don’t think we’ve reached that point because the students are so busy with stuff and we don’t have a lot of free time to do the stuff that…I think they’re just basically scrambling and getting what they need. But maybe they need more time to be able to develop that and to be able to express it.

The educator often shapes the learning experiences of the students within the school. The level at which students are engaged cognitively with IT is dependent upon which side of the landscape their activities and assignments are located

Other individuals. There are a number of persons who emerged as users of instructional technology who were not teachers or students. Charles’ representation (see Figure 20) includes a an individual, who he explains, “could be a student, a teacher or anyone involved…in an instructional role in an institution.” These individuals could include support staff, such as Natalie and Kathleen, as well as media specialists.

And the media specialist in the library. Usually teaching kids how to do research: What are the big search engines? What are the ethics involved? How do you identify a good website and a bad website? How do you locate materials that are not on the web --but books?

Charles described the role of the librarian, with regard to IT, as the person who presents potential resources, such as subscriptions the school hold. In addition the librarian provides helpful tips for conducting research and also addresses issues such as copyright.

Other individuals in the school setting that the participants associated with instructional technology included the administrators. CJ states:

In the schools there’s actually administration – first, I was thinking that there’s the principal and vice principal. They always have beginning of the year, middle of the year, and end of the year--three times—like a this is “I am the boss,” this is what’s going to happen if you do something wrong,” like a behavior thing. And they’ll generally have a PowerPoint and a speaker.
This administrative use of a computer-based software is an example of the misunderstandings between instructional technology and educational technology as described in the introduction of this study. As CJ began to describe his representation at the start of the interview he admitted he did not necessarily know what instructional technology was. “Technically, I think that some of the stuff I put in there is not technology. But at the same time, I guess it depends on what instructional technology is.”

This is not simply a student’s impression of instructional technology; many educators also include administrative uses of technology, such as record keeping, that do not necessarily have a direct impact on student understanding of content area knowledge as an instructional technology. Kathleen included administrative uses of technology, such as data driven decision-making, in her description of IT: “Administrators are always seeking to collect data about: who is doing what, and where are the problems, and how can you solve it by making changes to your program?” The use and location of a technology in a school does not necessarily mean that it is used for instructional purposes.

Decisions regarding the adoption and use of instructional technology are perceived to be at an administrative level. In her description of her representation (see Figure 22), Kathleen mentioned the role of the administrator as an individual who influences decision-making and purchases of IT. Ben’s understanding of the decision making process regarding IT was within the context of the district level rather than school administration. He stated, “I know it is not done at the school level. It’s got to be done at the administrative level. That’s a big government decision, but it is somebody in central office.” Each school in Oak County School District has a technology committee that includes individuals from different curriculum areas, parents, support staff, and an administrator. Natalie participated as a member in her school’s technology committee. She described the role of the committee as
one that evaluates current IT in the school, recommends purchases of future hardware and software for the school to the administrator (based on district guidelines), and can seek external funding for projects and other IT needs. She admitted that the role and participation of stakeholders in committee decisions varies depending on the school.

The inclusion of technological hardware and individuals who use the hardware in K-12 educational settings should not imply instructional use. Use of computer technology in teaching and learning distinguishes educational technology from instructional technology. The final discussion of IT focuses on the instructional uses of technology. I begin with educator choice of methods and materials in the context of curriculum/subject area use of IT.

**Methods, Materials, and Common Goals: Curriculum Areas and Software**

The methods and materials used by educators are the distinguishing features between the two sides of the river in Natalie’s drawing (see Figure 19) and thus the two pedagogical landscapes. Teachers have the ability to move between both landscapes as signified by the bridges and boats in the representation. However, as Natalie pointed out during her interview “all the boats are on this [the traditional] side because they don’t want to get across to find out.” The hardware and the software of IT were commonly perceived within the constructs of one curriculum area rather than across multiple disciplines.

**Curriculum areas.** From the data, the subject areas referred to as locations of IT were: Mathematics, Language arts and English, Science (including specific references to biology and physics), Social Studies and geography, Business education courses, Vocational education, Fine arts (music and theatre) and Special needs. These curriculum areas listed are in order of shared reference and understanding of IT use. The educators often limited the description of the use of technology to specific curriculum areas. The student representations also located software within specific subject areas but were able to make connections
between the subject areas and the uses of technology. Ernest’s complex representation, as shown in Figure 23, provides links and connections between the technologies used and the subject areas.

Figure 23. Ernest's Representation of Instructional Technology. When asked about the courses in which he used technology he responded “Well, we use it in just about every class now.” His representation connects the users, the uses, and the curriculum areas that he sees as instructional technology. A full-page version of this figure can be found in Appendix Q.

Materials. Educators use many different materials when teaching. After Natalie located the hardware in the school setting she drew a hammer and nails. The hammer states “IT as a Tool.” The nails are examples of IT, such as “word processor, spread sheet, pictures, downloads.” Teaching tools that are used in the classroom, such as IT, are often shared among the disciplines. The conception among the participants, as expressed in the data, is that teachers view software, hardware, and IT use as curriculum specific.
Participants often categorized a software or software use within a particular curriculum area. Spreadsheets were seen as a math or science tool to the exclusion of other core areas such as language arts and social studies. The use of instructional videos was most often described in the context of social studies classrooms. The most ubiquitous use of IT was through the Internet, according to the participants.

Ben signified the Internet in his representation by a large mass of spaghetti-like lines that he described as a depiction of the interconnectedness of websites across the world (see Figure 21). Charles commented on the usefulness of the Internet for supplementing concepts presented in the text. “Because our textbooks, it’s just amazing, you can’t get a textbook that has everything you want in it.” He uses the Internet to find examples, and check facts. The two students and several educators referenced other uses of the Internet such as: checking E-mail, instant messaging and gaming. The most commonly described use for the Internet, as an IT, was research.

Student research using the Internet was most commonly turned in as a paper or a presentation using the appropriate software. Ernest and CJ also commented on the use of presentation software by their teachers to present material. CJ was able to recall vividly a presentation from the previous year on the effects of landmines in South East Asia in his social studies class. The teacher had accompanied the facts and statistics with numerous images.

Uses of word processing software included research papers, essays and letter writing. Natalie also provided an example of a classroom experience where a teacher had students using word processors for note taking. Kathleen described spreadsheets use, “for analyzing data in math and science classes.” Ernest provided the example of spreadsheets used for “sound plots and cue sheets” in technical theatre classes. Fine arts courses often are
overlooked as spaces for technology. Both Kathleen and Charles expressed knowledge of the use of music composition software in their schools.

Figure 24. CJ's Representation of Instructional Technology. He asserts, “I think everybody enjoys working on the computer. I mean it’s something to do. You don’t just sit there.” CJ divided his representation into hands-on (items on the left) and non-hands (images in the center and to the right) instruction. See Appendix R for to examine a full-page document of this image.

It is important to note that the software referenced throughout the study was often was by brand or name. The most ubiquitous software product was the Microsoft suite of
productivity tools. Geometers Sketchpad®, a mathematical exploration software, was a software that was referenced by both students and educators. This software allows the user to visualize, measure and analyze geometric figures and can be used in courses such as geometry, algebra and calculus. Both students were introduced to this product within the school year of this study. The Environmental Systems Research Institute (ESRI) GIS products were commonly referred to within the instructional technology data. ESRI software products referred to by the participants from most frequent to least frequent included: ArcVoyager, ArcView, ArcGIS, ArcCatalog, ArcExplorer (referred to by CJ as ArcExpress).

Other software acknowledged by the participants included those used for testing, practice or tutorial, and gaming. Natalie’s school was a pilot location new testing software. The students also referred to the use of computer based technology for testing and evaluation. CJ described software that evaluated reading comprehension and SAT preparation software that he used in the middle school. One of the evaluation tools was described by CJ as “pretty dull, just question and answer.” Charles referenced students’ exploration of “practicing software” which he described, “has a sort of game element to it.”

Gaming was a use of technology the students mentioned as part of their use of computer-based technology outside of class. Often they were able to make connections between the games they play and the courses they are taking in school. Ernest described one of the games he enjoys in his time outside of school:

17 The following Microsoft software products are, in order of most commonly referenced by participants: (a) Word, word processing software; (b) Excel, spreadsheet software; (c) PowerPoint, presentation software; (d) Publisher, publishing and marketing software; and (e) Access, database software.
18 The ESRI products are approved GIS software for the Oak County Public School District and were owned by every participant’s school. ArcVoyager and ArcView 3.x were the software’s used in the GIS in Education course and the middle school electives.
My friend recently got me into Age of Empires, which, kind of, could be used to teach history. For each of the campaigns that you do, they’ll have historical background of what actually happened. And then you get to go through the same thing that the great historical figure did in that empire. How they conquered. Like the Romans how they conquered Europe. You get to learn and experience virtually how they did it.

Many early IT tutorials had a game like quality to them. The expansion of the gaming industry and decline in prohibitive cost of some technology has increased the market for games. This is one area of IT that has potential growth if games were more instructionally sound and less entertainment based.

**Methods.** In Natalie’s representation, how implement the materials is at the core of IT pedagogy. Natalie represented the two methods of implementation as buildings in her representation (see Figure 19). In the traditional landscape Natalie drew a building with an addition. The traditional building structure represents IT that is viewed as an “add-on” to the current methods of teaching. In the non-traditional landscape there is only one building. Natalie wrote within the building, “IT part of the structure of learning.” Both of these structural approaches to IT were described by students and educators.

CJ described in his representation the “non-hands on” method used by many of his teachers. He represented this teaching method with the chalkboard/white board, the overhead projector, the pull-down maps and an individual lecturing at a podium. As he described these features of his representation he mentioned:

> You have overheads which can be pretty boring...Those are used by teachers and you take notes. Then there’s the book that you read. Then there’s just the pull down map. You just kind of look at it. You don’t really do one [create a map] your self. And then there’s the lecture. The teacher just tells you. So none of those were really hands on.

Ernest observed the differences when using IT in the classroom, of “peer help” versus the traditional methods employed by his teacher:
They [his classmates] were more comfortable than if a was teacher standing over their shoulder and being like…barking out orders-- “ok click here, click here.” -- “You need to do this, this, this and this.” And they’re not learning anything because they’re just following the instructions of the teacher.

This approach of “clicking” through the steps toward a more significant understanding of a software or concept using technology leads only to knowledge about how to do the steps not necessarily how to apply those in a broader understanding of a concept or how a technology may be used in different contexts. When asked who used the Smart Board in his representation CJ stated, mostly teachers. The following account was his only experience with it:

She allowed us to use it. That was pretty cool. You just kind of went up and answered stuff on it. Basically we didn’t do anything creative on it. It wasn’t really your own thing. She would basically tell you what to do on it.

Ben, when talking about his personal philosophy toward IT in his classroom, articulated this concept of IT as an “add-on.” When asked to explain how technology is used in schools Ben’s response was “Supplemental learning. Strategy. Which it is, if you think about it, none of this technology is critical to the learning process. It’s more supplemental.”

IT used as an “add-on” to the existing structure of learning is viewed by Natalie as promoting lower level thinking skills.

Natalie framed the levels of engagement of the user within the context of Bloom’s taxonomy. The skills Natalie associates with the traditional approach are the lower level skills within Bloom’s taxonomy. The three lower levels of Bloom’s Taxonomy (1956) typically are referred to as knowledge, understanding and application.¹⁹ These three fall into the levels of knowledge and comprehension in Bloom’s taxonomy, consistent with the

¹⁹ The skills Natalie represented were name, knowledge and identify.
examples provided by the participants. Application and learning how to use a software does not require higher level thinking skills such as evaluation or synthesis of a topic.

Charles pointed out that there were limiting factors in the shift from the traditional to the non-traditional uses of IT. He pointed out the limits of the 40-minute class period with regard to digital camera use: “you can get some quick snapshots but to really make a good data collection or something more than a tourist experience, I think you need three or four periods at least.” Charles recognized the potential of the use of digital cameras to provide meaningful learning but the limitations of the structure of the school day intervened. This concept of lack of time, for both educators and students, is one that is often prescribed by the traditional school schedule.

In the landscape of the non-traditional, constructivist, methods, IT is integrated into the structure of learning. Natalie’s building representing the implementation of IT from the perspective of non-traditional classroom teachers is that they “see it…technology, instructional technology as part of the structure with minor changes.”

Often the educator allows the students to discover their own understandings and create their own knowledge. An example of IT integration in a geometry classroom was provided by CJ. The first time the students were introduced to Geometers Sketchpad the teacher provided them with simple guidance and then,

She basically just let us sit down and discover ourselves. She gave us one little tutoring worksheet basically... She’ll tell you the shortcuts later but first you’ve got to figure out what’s exactly going on. So she took us there and let us draw triangles…and we could see relationships. She never told us at first what the actual theorems were, we had to find as many as we could. So it, kind of, stuck better if we found them ourselves.

When asked if he had encountered a similar approach with other teachers he replied: “No.”

Kathleen found that student often were more willing to begin to explore from the start with new technology. “I’ve seen kids sit down at our computers and just start pulling down
menus and making things happen. But, you know, they quickly get, kind of frustrated if there’s no guidance.” The exploratory or discovery based learning experience does not mean that there is no scaffolding or context. In CJ’s class the students were allowed to investigate how the program worked and apply prior knowledge, in this case knowledge of geometric concepts, in order to use higher level thinking skills with IT.

On the non-traditional side of the river Natalie included “Higher level skills” including “analyzing, synthesizing, and transforming.” These “higher level skills” Natalie referred to are the corresponding stages of Bloom’s taxonomy: analysis, synthesis and evaluation. At these levels the student has internalized the basic knowledge and concepts and is building upon it in more cognitively complex ways.

The recognition of prior knowledge and experiences is also important to co-constructing new understandings. These understandings might be learned in the classroom, in workshops, from peers and family, and other experiences. Both students and educators commented on the importance of peers when learning new technology. When discussing peer teaching Ernest remarked:

I think it helped them because it was more on a personal level, student-to-student kind of thing. ...And when you get the chance to talk to another student who’s finished it and done. And they know, possibly, what they’re struggling with because they might have experienced it themselves but got over it. It just helps to have somebody your age, your similar experience level.

Charles began to practice with the graphing calculator with one of his fellow Algebra teachers. “My colleague…she taught me basically most of the stuff I know on the calculator –how to graph. And I have learned bits and pieces from students as well.” The idea that teachers can learn from students is fundamental to constructivist theory and practice. In addition, the shared knowledge among peers and among students and teachers is also important in diffusion of innovations theory. The adoption of innovations is often due to the
influence of peers and individuals who are respected within a community considering an innovation.

The divide Natalie portrays between IT as an “add-on” and IT as fully integrated in the curriculum is not simply a divide between how students are taught; it can also be applied to how educators are taught about IT. When educators are taught about/with instructional technologies the experiences often do not provide the opportunities for educators begin to evaluate or apply how they would use the technology in their classroom or curriculum.

Natalie noted:

That transition from using it at home to using it in the classroom as something other than a tool is a really methodical kind of thing. And what we do is, we take them [teachers] in and teach them “how to.” Ok, this is how you use the computer. This is step by step by step by step. And we’re doing this to them, name, knowledge, identify… We are not giving them the leap... And there has to be a connection to what they teach specifically and how they are going to use the computer…They have to be able to see how the content can be taught more efficiently and better. If it’s not, they’ll always stay there [she points to the traditional classroom].

All of the educators expressed time as a limiting factor in IT training as well as IT implementation. Time is a two-fold issue for educators. Time is scarce and heavily prescribed when it does exist. In his interview about IT Ben’s frustration with how he was expected to spend his time:

Training is ridiculous. We’re not trained. We’re told how to do it once… I mean, number one they’ll send you to training but then training is always after school or at lunch time or your planning period and you’re trying to get so much other stuff done. …By the end of the day, I’m tired. I don’t want to have to sit an hour or two hours while someone explains to me how to use something. I don’t pay attention.

Ben’s exasperation with technology training typifies many of those educators on the traditional side of the river.

The final destination in Natalie’s representation, the star, represents the common goals shared across curriculum areas and pedagogical approaches. Each path along the river is moving toward the goals of success for students beyond the K-12 experience. Instructional
technology is not the only tool, nor is it the only means of conveying, analyzing and displaying information. Educators and students must critically examine the purposes of the tools they select. If it can be done, faster, better, or more meaningfully without technology then technology should not be the first choice. The important decisions are what cognitive skills do teachers want students to be equipped with to traverse the landscape and how will they be implemented with IT.

**Summary of Research Question 2**

The emergent understandings of the participants’ conceptualizations of IT were based on both the representational and interview data. The students’ and educators’ frame of reference when discussing IT was from an egocentric position. The participants related their understanding of IT more easily in *logogens* than in the *imagens*. The imagens expressed in the representational drawings provided an entry point for the discussion of IT. However I was more reliant on the linguistic understandings than the images to clarify the categories of description to fully answer this research question: How do students and educators conceptualize instructional technology?

The egocentric landscape of IT extends both inside and out of schools. Participants’ common understandings of IT included the: users, hardware, software, subject or curriculum area, and pedagogical approaches. Within an organization, the latter stages of diffusion adoption are redefining/restructuring, clarifying, and routinizing of an innovation (Rogers, 2003; see Figure 10). The data from these particular cases illustrates the first two stages of implementation. The redefining/restructuring stage in how IT has influenced the school structure aligned with participant descriptions of: spending, individuals using technology, and for what purposes the IT is being used. Issues such as digital equity and resource availability are not resolved according to the participants. These observed problems must be
addressed before the final stage, routinization, could be reached. Clarification of how IT should or could be used in learning environments is still developing, but these participants had observed a shift in teaching with IT. They provided examples of how IT improved learning in subject or content areas.

Some participants were able to provide examples of constructivist practices involving both teachers and students in the learning process with IT, while others provided examples of resistance to the implementation of IT in the classroom. Resistance does not mean that the innovation will not be adopted. And resistance by individual teachers and students may not ever be overcome completely. Rogers (2003) notes that the implementation stage can be lengthy and there can be active and passive rejection of the innovation. Those adopters who are in the later adopter categories are more likely to discontinue the use or adoption of the innovation.

The discontinuance of an innovation is one indication that the new idea may not have been fully routinized into the ongoing operations of the adopter at the implementation stage of the innovation-decision process. Such sustainability is less likely (and discontinuance more frequent) when the innovation is less compatible with the individual’s beliefs and experiences (Rogers, 2003, p. 191).

The educators gave prior bad experiences as a reason for teacher resistance to IT implementation. The students suggested that some teachers did not use IT because it didn’t fit their “teaching style.” According to the findings of this study, other considerations of resistance include limited resources and the lack of understanding of IT as a tool among many teaching methods and materials. These are important considerations and the implications of this resistance will be discussed further in chapter 5.

By the final stage of innovation adoption, routinization, there should be a seamless use of the innovation within the organization. IT would at this stage become part of the regular classroom and teaching experience. The data from this research indicates movement
toward it, however, this multi-case study includes only 6 participants and a larger study may yield different findings.

**Research Question Three: How Do Students and Educators Conceptualize Geographic Information Systems in Schools?**

Within the context of the third research question: “How do students and educators conceptualize GIS in schools?” the data revealed a confluence of many of the ideas that had emerged from the broader discussion of GIS in the world and of instructional technology, IT. The categories of description that emerged in response to this idea were fewer than in previous questions and were less discrete. The context of one category often overlapped with another. The categories of description that emerged from the data in interview three were: a) GIS technology, b) users of GIS in schools, c) classes and curriculum areas, d) uses of GIS in schools, and e) uncertainty, questions and raising awareness

**Confluence of Allocentric and Egocentric Positions: A Framework for GIS in Schools**

In *Experience and Education*, Dewey (1938) cautioned of the disassociated learning that may take place if experience and content area knowledge are separated. He warned that if knowledge:

…was segregated when it was acquired and hence is so disconnected from the rest of experience that it is not available under the actual conditions of life. It is contrary to the laws of experience that learning of this kind, no matter how thoroughly engrained at the time, should give genuine preparation (p.49).

The conceptualizations of GIS in the school often referred to real world problem solving and application.

The representational drawings and interview data were a confluence of several frames of reference. From the representations, generated in response to research question one, focused on GIS, an allocentric position was described by and drawn by participants. The images, or imagens, found in the representational data, that provided the primary source of
the understandings of GIS were drawn without the participants located within them. Participants described GIS as a phenomenon: found in the world; used in the world; and as a tool used to study the world. These descriptions revealed a distanced viewpoint between GIS in the world and the individuals. The experiences of the individual with real world uses were most influential in the conceptualizations of GIS. In the data form research question two, the conceptualizations of IT were also based on the participants understandings and experiences, but the connections between the ideas in the representations and interviews were more personal and were located very closely with each individuals’ personal vantage point. This egocentric position of IT was tied more to the linguistic, or logogen, based data than the conceptualization of GIS.

The conceptualizations of GIS in schools for the participants seemed to be at a confluence of theses two previous frames of reference. GIS was observed from an allocentric position in the schools. This frame of reference located GIS in schools in the U.S. and the world with many different users and uses. But in addition, participants were also conceptually able to position GIS in schools egocentrically. This frame of reference located GIS within their school and their curriculum and their understanding of the technology. The connections the participants made (or were not able to make) between GIS and schools were based in their experience and their observations. The participants themselves raised questions about the use of GIS in K-12 schools in their responses, in both the drawings and in the interviews, which had not occurred in previous interviews.

**Confluence of GIS Technology and Users**

*GIS technology.* The first common understanding that emerged for all of the participants was that of GIS as a technology. They mentioned and/or drew the hardware or software necessary to implement the tool. CJ began by drawing a map and a computer (see
Figure 25). His computer also included the keyboard, monitor, and mouse. That drawing was followed by a long row of computers on a table to represent a computer lab. During CJ’s second level GIS elective, the teacher had four desktop computers and a laptop in her room. CJ later mentioned in the interview the fact that the software was loaded on the server and that he was able to use it in the elective class.

Natalie drew the distribution network of the technology in her representation (See Figure 26). Framed within the “Server room” of her image is a laptop with access to numerous software icons, one of which is the GIS icon. She reflects,

To me GIS is just an icon. However, once you click on that icon, it opens up a whole world. Where most of our teachers won’t go that far, I can almost guarantee you that over 50% of our teachers (a) probably don’t know it’s out there and (b) have never attempted to click on it.

Natalie had made an effort in the two schools she had most recently worked to have GIS software provided for teachers. The ESRI product line is approved by the county and can be loaded by the technicians on the school servers. She showed the principal of her current school the Mapping Our World: GIS Lessons for Educators text to her principal and requested that the accompanying ESRI ArcView software be loaded on the server. She explained that the one year licensed version of the software was one of the reasons she has GIS at her school and expressed concern about a school purchase of a full version once it expired.

Ernest, the student who had text based representations throughout the three interviews drew one image of a computer screen on this final representation (See Figure 27). He mentioned at the start of the interview that he “couldn’t come up with a whole lot to say.” He provided an overview of who used and in what curriculum areas GIS could be found. When describing “What does it look like?” (one of the sub-questions of the prompt provided to assist participants who weren’t sure where to start) he connected the words and images.
He points out, “Well the only place that I’ve really seen it is computer software – ArcView and ArcVoyager. And I drew a picture of what ArcView looked like.” The central logogen in this part of Ernest’s drawing was “computer software” which was connected to two of the ESRI products, ArcView and ArcVoyager. He then connected his image of the ArcView screen:

I just drew a random image of the software screen and it’s not very detailed but we have the title bar and then different buttons, the different tools, shortcuts. And then you have the table of contents and the different layers. And then the map. There’s, like, data tables within that by clicking on the certain things on the map. But I just didn’t show that. It’s the link to everything else. Kind of like the common point.

Figure 25. CJ's Representation of GIS in Schools When asked how would he sum up the future of GIS in schools, CJ stated “Everywhere.” A full-page version of this representation can be found in Appendix S.
Figure 26. Natalie's Representation of GIS in Schools. She began with the superstructure of the school and named it GUHMS – GIS Used Here Middle School. She explained, “GIS in this particular case would be within...this is the access we have within our walls.” A full-page version of this figure can be found in Appendix S.

Figure 27. Ernest's Representation of GIS in Schools (the only drawing of Ernest’s to include an image.) When explaining the appeal of GIS to another student he notes, “Well, I’d probably say ‘once you start using it, it’s fun, because even if you may not be interested in GIS itself, you could use it in whatever career you are looking at. You can use it in your other classes. And it’s fun.’” A full-page version of this figure can be found in Appendix U.
During the interview, Ernest pointed out the ability to use the software in different places, careers and subjects. The depth and complexity of the software he felt was important. However he would suggest to the software manufacturers to improve the computer resources necessary to use it. “It takes so long to load the software because it is so in-depth and so complex. That’s not something that should be changed because trying to make it take less time, you could lose some of the features of it.” The computers at Maple Middle were running on an older operating system and barely met the minimum requirements for the software. This combined with the distribution of the software over the school’s network often frustrated students and teachers using the GIS software.

This point echoes the reasons Baker (2005) suggests Internet-based mapping as an alternative to desktop GIS software. The limitations of the hardware that Ernest mentioned could be minimized in Internet-based maps services and data. The software manufacturers have also begun to address this issue with the release of limited software packages such as ArcExplorer Java Edition for Educators (AEJEE) by ESRI. This shift reflects Rogers’ ‘negotiation of the innovation process’ not only by K-12 organizations but also by the GIS change agents—the manufacturers and marketplace stakeholders. This is further discussed in Chapter 5.

GIS users in schools. Ben used various icons to represent the users of GIS in schools (see Figure 29). A locker represents students, a podium represents teachers, and a desktop nameplate represents administrators. These icons also signify his understanding of the roles and locations in which these persons would be found in the school – in a hallway, behind a podium, behind a desk respectively. Other participants also included workers that would be on the school grounds or involved in the work of the school. A brief discussion of students, teachers and school personnel as users of GIS follows.
Students. The students as users of GIS in schools were commonly referred to by the participants. This is not to say that all students were seen as GIS users. “There would probably be some students who wouldn’t like to use it because they don’t like computers…I know some students would probably enjoy using it because it is something new and it’s not just sitting in a class taking notes, it’s doing something.” Student users were included in all of the representational drawings and the interviews.

Learning style and personal interests of the students were explored as reasons for students to use GIS. Ernest mentioned the potential use of GIS in students’ free time. Ben observed that it would be “a good tool for visual learners and students with interest in computers and technology.” Ernest explained to me that he had heard somewhere that students’ minds were like sponges, they just absorb everything.” Ernest observed, “The students, it’s easier for students to learn how to use the software because ... students aren’t certain of a career path, so they’re just interested in taking different classes and they’re…it could easily spark the interest in someone to take more of a class, get more interest in it.”

Student interest was a point that Kathleen addressed illuminating also the gender imbalance in some of the GIS classes described within the study. Kathleen offered a seminar in GIS at her school. Seminars are short courses for credit but are above and beyond the regular curriculum at the residential magnet school. Only two male students signed up when she first offered it. Subsequently, she designed a mini-term course that attracted more of mix of males and females. The mini-term course was taught by a community partner and nationally recognized GIS expert.

The students at Maple Middle School also observed a gender imbalance in the student enrollment in the GIS electives. Ernest and CJ described their first GIS elective as having
between 20 and 30 students, with more males than females enrolled. Both noted that their second GIS class had 4 males only. Ernest commented,

I don’t know why. Part of it could be because the girls were drawn to more of the Home Ec classes and the guys are kind of drawn into technology and computer classes. So this was just another class that was based around computers and software.

A discussion of gender issues and implications is found in chapter 5.

Both students and educators commented on the grade level of the students who could use GIS. Overwhelmingly, there was a hesitancy regarding the use of GIS in the lower grades. Ernest also felt that GIS might be overwhelming for the younger students and Natalie echoed CJ’s thought that it could be used with the upper elementary students, if at all. CJ pointed out,

I don’t think it could be used for any grades that aren’t introduced to computers yet. Less than third grade probably couldn’t handle it. I think fourth and fifth would be good grades to be introduced to it. Get to understand it and know the tools” He continued by later stating, “I think you’d have to start GIS with third graders, fourth graders, fifth graders – students in elementary school --learning what GIS is. And in middle school wanting to continue it – learning more about it.

The students stressed the importance of introducing GIS in later elementary grades and continuing to build skills through middle school and into high school. As these eighth graders were investigating different high school choices for the next school year, they had not heard of any high school using GIS. GIS was most often observed as a tool for students at a middle school or high school level by both students and most of the educators. Natalie wrote in her representation that in the middle school, “Teachers [are given] a chance to w[or]k outside of the box as partners with students.” Teachers were also seen as users in the understandings of GIS.

Teachers. The observations and experiences of the participants in this study influenced their thoughts on the teachers as users of GIS. While all of the participants had a
common understanding of the teacher as a user, they had very different observations about the characteristics of teachers who use GIS, the role of the teacher when using GIS and how teachers learn GIS. One of the important discussions in the GIS in education literature that has not been examined that was brought up by several of the participants is: what happens when the teacher who uses and knows GIS leaves the school?

Charles, when describing his representation, remarked that the teacher in his picture “is facilitating the learning of the software.” Charles continued to describe the wetland area on his picture that led to his personal feelings about his role as a teacher using GIS:

I was thinking, a little bit selfishly, about myself because I don’t feel like I like to be…tied to the desk. Not that I teach from a desk because everyone walks around a lot but just this whole paper/pencil -- and that is important – but I think it would be good, healthy for us all to be able to get out more.

His ideal, as a teacher, would be a combination of what he considers to be virtual and real experiences.

Contemplating his experiences in the GIS in Education course Charles commented on the importance of seeing other uses of GIS in other curriculum areas. He reflected:

It was important for me to see that because I can offer that to a colleague or I can broaden my own thinking a little bit…Sometimes, I think one of our defects and one of my defects is to become too much of a specialist. You have to be well rounded.

The school curriculum and the subject area is an entrance point for GIS. This idea will be further discussed in the category of description that discusses content area and curriculum areas.

Many of the participants noted that the teachers using GIS are isolated teachers in their schools. Kathleen’s representation included two teachers: one a middle school teacher and one a high school teacher, she describes them as an individual teacher and an individual project-centered teacher respectively. She felt that she did not know of too many teachers who use GIS. She mentioned three individual teachers during our interview. One was a
middle school teacher from another county who had made a presentation along with her
students about using GIS in a water quality project. Another was a high school teacher in
Kathleen’s county who came to a presentation at her school. Third was a teacher in
Kathleen’s school of whom Kathleen was unaware until a student mentioned her use of GIS
in a class. She remarked, “I guess we’re all in our own cubby holes and we only focus on
what we’re doing right here. You do have to get out and walk the halls or go to conferences
to meet people.”

Both students in the study had assisted in an after-school teacher workshop on GIS
and had aided teachers using GIS in the computer lab using with their students. They shared
their observations during the interviews about how they felt teachers learned GIS. CJ
observed that one of the differences between teachers and students was more student
willingness to explore the software.

They [the teachers] seem to be a lot more careful before they start trying to figure out
what things do. And some of the teachers there didn’t seem like they really wanted to
be there. It was like you have to do one of the workshops a year so it was like the
only workshop we could do. Whereas the kids, most of them seemed pretty excited
about it.

CJ had assisted in a teacher workshop that was required workshop for a group of initially
licensed teachers (ILT’s) in another middle school. CJ felt that teachers had to be willing to
teach GIS. He felt many of his current teachers were not willing to do so. He reflected,

I think it’s more of a new subject. And old teachers, like some of my teachers,
haven’t been to college for a while and computers are not real new and GIS is a
newer computer program. I think newer teachers would be more inclined and
more...have it exposed to them sooner. Like, by the time you’re some of my
teachers’ age...if whatever you’re doing is working fine --the way it is -- you don’t
feel like you need to change it.

The concept of new teachers being exposed to GIS and computer technologies while in their
pre-service program is a point that has been raised in the GIS in education literature. There
have been no formal studies regarding the inclusion or the benefits of GIS in pre-service
teacher education. Kathleen pointed out “It’s not something that’s a part of the regular pre-service training for teachers.” Ben, who took the GIS in Education course during his pre-service program, felt it would help to include GIS experiences in pre-service teacher education. However, when asked how he felt it should be included he was unsure. He suggested it possibly as an elective and he wasn’t sure how it might be integrated in his college level experiences.

Natalie felt that modeling was an important part of the process for teachers.

It’s amazing to me how modeling does change the way you teach. And certainly if you are watching a teacher, your mentor teacher never goes near the computer, there’s not incentive to get to the computer. But if your mentor is easygoing and goes to the computer and enjoys going to the computer and is willing to take a risk then chances are you are too. Especially, if there’s positive reinforcement coming from that person.

Due to heavy teacher attrition in this state, mentors are used in student teaching as well as in the initial years of teaching. The more new teachers are exposed to GIS or any instructional technology during their college experiences, their practica, and their first year’s teaching the more they may use IT in the classroom (Bull, 2003).

Peers can also be pivotal in teaching one another GIS. Charles provided a brief overview of GIS to his colleagues during a faculty meeting. Once he completed the GIS in Education course, Charles followed-up by offering a two-hour beginning workshop for his colleagues. In the private school where Charles worked, faculty training or in-service weeks were offered between trimesters. At the end of each trimester the students are given two weeks off and the faculty do not teach during this time. The first week is typically used for planning, training, and meetings and the second is for faculty vacation. Charles invited his peers in the middle school to participate first. He noted,

I kept the size down because I knew from experience, with you [in the GIS in Education course] and just intuitively it was going to need a lot of one-on-one
interaction and help. I kept it down to five teachers and of that four of them showed up. It was three middle school teachers and one upper school teacher.

He felt that all of the teachers were very enthusiastic about GIS but that they probably hadn’t implemented it in their classroom. He was planning to follow up formally and informally. He will formally provide another introductory session or may build upon what they learned in the first meeting. Informally, if his peers ask for help or a refresher he would be willing to help them out. Charles is an ‘early adopter’ in his school. From his personal contacts with peers, GIS use has the potential to move a step forward toward more widespread implementation. His peers are, in Rogers’ terms, the Early Majority, but they must reach an innovation-decision whether to continue using GIS in his school before moving forward.

This is where the “rubber meets the road” and is crucial in developing positive and simplistic ways to match an innovation with new users.

Charles had picked up a GIS demonstration software package at a conference and tried to teach himself how to use it. He then found a weeklong GIS workshop offered by a local university. According to Charles, “the workshop was very valuable in showing us applications and just opening up our minds, exposing us to all these possibilities.” Charles explained that there had been numerous guest speakers from local organizations and from Brazil discussing various uses of GIS. He felt that the contacts he made through the workshop were invaluable. However, time was one limitation Charles noted; there was little GIS practice in the three-hour a day weeklong workshop. Another limitation of the workshop, he felt was in how he was taught the software,

we got to do an exercise in the workshop but there was a lot of intervention, coaching on the part of the folks running the workshop. So, you would say how do I do this and they would walk you through the steps. That was the only way they could do it in that short amount of time. But I think what we wanted, eventually, was to learn it for ourselves so we could be more self-sufficient.
Charles described the workshop experiences as a “survey of GIS” while the semester long GIS in Education course as a “deeper” experience. He felt that the semester long course offered more exploration into personal curriculum interests and a better understanding of the software and an exploration of some of the issues of fairness and equity that arise in discussions of GIS data collection, representation and use.

If these opportunities are hurried or are not seen as valuable to educators, the adoption process and innovation decision process may not proceed. Ernest suggested the following about teachers and GIS:

I think some teachers don’t use it because they aren’t interested in using it. Or maybe they don’t see how it could be used because they haven’t worked with it a lot because they specialize in whatever subject they’re teaching. Well, they’re focusing on the next day’s lesson so they’re not thinking about other ways to teach their lesson. A lot of teachers stick with just conventional note taking out of the book, or watching a video about the subject, and research projects using the Internet. But we don’t really use… we just don’t use it. They don’t see it as something they can use.

This was not only an observation by students. Ben also commented on the lack of willingness of many teachers to change how they are teaching. Ben pointed out, “Teachers…they need a different way to present the information other than lecture, packets and the notes.” Ernest observed, “I think it’s probably harder for teachers because they’re kind of rushed into it in a class or workshop.” Ben was uncertain of how teachers would learn GIS. He commented, “I just don’t see how people or teachers would become familiar with the program. I don’t see it unless it is renewal credits. But it’s going to have to be an ongoing process. It can’t be ‘Okay, go to this workshop and you’ll be set.’ That is not the way it’s going to work.” The experiences of the educators in the classrooms and schools must be meaningful, supported, and sustained.

School Personnel. Only two of the participants, Kathleen and Charles, noted other personnel in the school using GIS in schools, Kathleen included administrators in her
representation. She included resource planning in both her vision of current and future GIS use. She suggested uses such as site location for new schools, bus route assignments, school redistricting “to satisfy particular ethnic and socio-economic requirements,” and for locating and recruiting teachers. Kathleen’s view of administrative users included superintendents, principals and contracted services to schools.

Charles drew several outdoor areas on his representation (see Figure 28). He noted “I also drew a soccer field here because I see GIS as a natural for helping plan facilities and maintain facilities.” He described a faculty enrichment grant he proposed to create a campus map for his school. He projected,

I envision this as being a tool being used by the grounds staff and the landscapers to say, ‘Okay, we have these trees.’ And we could have data tables associated with each of the locations of the trees…Since GIS allows you to have the map and the tabular data, you could really store all kinds of information about the tree and the soil and fertilization rate – how they fertilizes the soil and what they use as mulch or whatever.

This practical approach to using GIS would provide layers of information to multiple users. Another potential use of the campus map Charles suggests is for the community as a whole – the students, the teachers and the parents, whom he also connected in his drawing. He sees the potential of this as a project that could include and benefit many individuals in the school.

Community partners. Charles’ project to map his school could involve school personnel, students and teachers. The historical documentation of his school from its opening in the 1990s to now and into the future could benefit the parents and the school community. He proposed a grant to a larger corporation to have his students work in the local parks to collect environmental data. His desire was that “the parks will benefit and the community at large will benefit from the GIS work that was done by the teacher and the student.” He referenced that information transfer from the school to the parks in his representation
Figure 28. Charles' representation of GIS in Schools. He provides one of his motivations in the use of GIS. “These for me, as a teacher, are intimately linked – the computer experience with the outdoors…My kids are so…comfortable with the virtual that I want them to see what the virtual represents. It’s to smell, touch and feel…” A full-page version of this figure can be found in Appendix V.

The idea of the community as a partner in GIS in schools was suggested in many of the educators’ and students’ interviews. Natalie suggested the potential use of guest speakers in the classroom. The community of GIS professionals locally, nationally, and internationally can offer introductions to GIS in their field or demonstrate potential uses of

20 Community partnership was required in all but the initial GIS in Education courses.
GIS. Kathleen described the importance of one part of the visit to her school from a noted national GIS professional:

We did these presentations when [he] was here where he just talked about what GIS was. And I think that that is part of his mission to just get the word out there so he showed examples of where it’s used and how it’s used. He gave it a name, which is what I think, is partly what the problem is. People can’t understand it unless they know that there is this body of software and technology. Oh, yes, you’ve used MapQuest --you’ve used GIS. So they can kind of understand that it’s a discipline that is distinct.

In addition community partners may provide resources such as hardware or data, aid in problem solving and help teach using GIS. Natalie had negotiated a plotter\textsuperscript{21} donation by the local GIS office. CJ mentioned my role in the GIS elective class. As described earlier in the methodology, my role in the student’s classroom was that of a resource person. I taught some of the skills the students needed or wanted, attending their class once or twice a week to answer questions about the software or about their projects. In addition, I helped the students locate data necessary to complete their juvenile crime-mapping project. CJ understood me to be a friend of the teacher. He wasn’t sure what my role was but he stated that the students “just accepted” me.

Ernest included “GIS Day” as an important part of GIS in schools. GIS Day in Maple Middle School was celebrated for two years school-wide and one year on a 7\textsuperscript{th} grade team. Ernest described GIS day as:

It was a day where each class would go down to the media center and the computer lab and we have stations. And they would just kind of rotate around the different stations learning how it’s used where it’s used...They would show you maps of things that they had made with GIS. The computer lab was used to teach a little bit about using the software and showed a couple of different features that might interest students in taking the class or being interested in it for a career.

\textsuperscript{21} A plotter is a large printer used for printing large graphics and maps created on the computer.
CJ described it as an “instructional GIS day.” He remembered some of the other guest speakers. In the computer lab, “she would have people finding their houses and stuff. We had a surveyor outside using a GPS system.” During his second GIS Day celebration, CJ remembers helping in the computer lab. “I made sure everybody was able to do it in the computer lab. If they got lost, I helped them get caught back up.” The experiences students had with real world uses of GIS through projects provided valuable services to the community while learning. Through events like GIS Day and other events that invite professionals into the classroom and the school, many educators are raising the awareness of GIS and geospatial technologies without having become an “expert”. Educators are considered experts in their curriculum areas; through the use of GIS community partners educators do not have to be experts in the technology.

While providing two separate categories of understanding under the topic of GIS in schools, the technology and the users were often intertwined. The confluence of what the participants observed about the technology itself is coupled with the users of the technology.

**Confluence of Classes and Curriculum Areas and Potential Uses**

**Classes and Curriculum Areas.** Building upon the concept of the teacher as curriculum expert, Natalie provided a way to begin to introduce GIS to classroom teachers:

Teachers love curriculum, so if we back it in—technology in their curriculum – instead of saying ok we’re going to learn this piece of software, GIS…You take a piece of curriculum and say this is the curriculum – What can we do? How can we enhance it? And start from there, because they know the curriculum. And then stuff it in after the fact. That’s what we do. We say here’s the technology, learn how to use it. Ok now, what can we do with this? Nothing, it takes too much effort. So if I you start with the curriculum and work your way up…

As with any new teaching methods or technology use, in-school implementation should begin in the curriculum and the classes where it will aid in learning. Both students and educators were able to identify numerous classes and curriculum areas where GIS was or
could be implemented. Most often social studies and science classes were referenced. These subject areas often have direct ties to the earth and specific locations and places in the curriculum. Other subject areas discussed and drawn by the participants included: language arts, math, technical and vocational education, technology classes, art, music, and electives.

Kathleen observed differences between the subject areas specificity depending upon grade level. She provided an example of the difference she perceives between middle school and high school science: “Here [in middle school] it’s general science and here [in high school] it becomes Earth Science and Biology and Environmental Science. These [in high school] represent bigger groupings because here [in middle schools] it’s just introduction.” Kathleen believes that in the future, GIS, should be actually dispersed and that it is throughout all schools and in more subjects and in multidisciplinary courses. And the whole idea that it’s the kind of subject that you ought to be introducing in schools for students to analyze existing problems in an academic sense but also to provide them with career prep.

Ben could see the potential use of GIS in the core curriculum areas as a tool but he also was able to envision it as the focus of an elective course. In his representation he drew a sketch map of the United States with an infinity sign in it (see Figure 29). He stated that when he thought about where it could be used “I said infinity, basically there are no limitations – cross curriculum studies, just about anywhere in the United States or in the world for that matter.” He did follow that statement up with the limitations of teachers willing to teach it, students willing to learn it, and resources.

Potential GIS uses in schools. The overarching observation of participants on the usefulness of GIS in schools was the capability for mapping and spatial awareness. Ben drew a map of the state and described it as showing the potential uses of GIS (see Figure 29). He remarked, “Mapping. I can see it relating geographical regions, one continent or even the
world to each other.” There were a wide variety of examples of how GIS could be integrated, or had been integrated, in the schools.

**Project Oriented Uses of GIS.** When asked how she would explain to someone who did not know what GIS was and how it could be used in schools Kathleen replied:

The instruction that is project oriented and, sort of actively, engages children in a multidisciplinary fashion is richer instruction. And this is a medium that is totally driven by data, which is real and useful and, I mean, it’s real-world. That it provides students with useful experiences instead of just cramming them full of content and having them color in maps. And we do have this enormous flood of information for students to deal with and learn how to handle a lot of information in order to analyze the problems. So it’s sort of like problem solving and how it fits into that instruction that you’re trying to give to kids on their way to graduate.

**Science.** All participants provided GIS ties to the science curriculum. Ernest made connections to specific areas within science in his representation. He connected GIS to geology, meteorology and biology. Ernest explained, “I came up with, that you could use it to map out different fault lines and volcanoes or different plants or animals.” Charles discussed the first use of GIS with his students in his science classroom. His students explored the basic understanding of layers of information in GIS through an activity focused on tectonic plates and earthquakes and volcanoes. He created questions so that students would evaluate the relationships between the tectonic plates and earthquakes and volcanoes. Charles stated, “So that was something where they played around with volcanoes and earthquakes and see ‘oh yes, there’s actually a similar – correlation’ between two physical features or two phenomenon[sic].”

Natalie drew a connection between GIS and the study of environmental issues and ecology and depicted examples of weather and topology. Kathleen provided several examples of projects she had worked with in science classes. One focused on ozone for a chemistry class and another was about the epidemiology of West Nile virus for a biology
The exploration of the West Nile virus is one that could be also connected to a health class. Only Kathleen provided health courses as a potential location for GIS integration.

Social studies. The social studies classroom and curriculum was a content area for many of the participants’ examples. Ben, a social studies teacher, discussed the pitfalls of chronologically organized textbooks in social studies. He felt that this provided an opening for GIS:

You learn about this time period and you’re skipping from this part of the world – maybe Asia to what’s going on in South America at the same time. So the students do not get a really fair representation mentally. You show it on a map but there’s only so much a map does. But you show them something on a computer where you can pull two aspects of the world apart and you can show them similarities and differences.

Figure 29. Ben's Representation of GIS in Schools. Ben stated “It could be used by just about everyone. Its benefits, again, are unlimited.” For a full-page version of this Figure see Appendix W.

Ernest suggested that GIS in social studies could be used, “in history, you could map out wars and different battles that took place. And by clicking on those different battles on the map, you could get links to different information about the battles or just other famous
events.” Natalie recalled a similar project that had been completed by her classmate in the GIS in Education course focused on the Civil War troop movements. In her representation she provided examples of potential uses: “about community, weather patterns, and historical events.” Kathleen was aware of students using GIS in an international relations class at her school.

In his representation CJ suggested the use of GIS to examine the “geography, mountains, rivers, countries, et cetera.” CJ had a social studies teacher who had used the GIS software with students to explore the countries of Asia through station work. CJ also provided an example of an interdisciplinary unit on World War II that will follow the discussion of GIS in the specific curriculum areas. The use of GIS in social studies to examine wars was prevalent in the understandings of the middle school students. Other social studies applications I have observed include cultural studies, migration and economics lessons.

Language Arts. Language arts examples of GIS integration focused around books and authors. Natalie provided the example of a book review using GIS. This example was drawn from her final project in the GIS in Education course where she had students read and map books with journeys as part of the plot. Charles recalled a project by one of the GIS in Education instructors from her language arts class in which her students investigated Mark Twain’s life along the Mississippi while they studied The Adventures of Tom Sawyer.

Ben suggested that the study of a playwright or an author in an English or language arts classroom could be contextualized by the use of GIS. He noted that often authors, such as Shakespeare, were influenced by the political and economic occurrences that were happening around them. He suggested:

And just showing…the travels of certain authors. Most authors write from experiences and most authors are very well traveled. And maybe if you were
studying a particular author you could show his travels, where he went and you could show why it affected him in that place. And more or less see how or what... the book turned out ...why or how it did.

CJ provided ties to *The Diary of Anne Frank* using GIS which will be discussed as part of his suggested use of GIS in an interdisciplinary study.

**Mathematics.** Both students and educators were able to connect mathematics to GIS. Charles suggested the topics such as “proportions and natural percentages, fractions and then algebra. I mean that might be a little more challenging but like I said I haven’t given it enough thought.” Natalie suggested a link with equations such as distance. CJ suggested the use of GIS to examine triangles. In his representation he drew the Research Triangle Park (RTP) area of North Carolina. “You could research the research triangle and find distance from A to B et cetera.” Math was another subject area in which CJ was also able to tie into his interdisciplinary unit example using GIS.

**The arts.** Only one educator and one student suggested this connection. Natalie suggested the use of GIS to explore the spatial nature of art. Ernest described the potential use of GIS in technical theatre for marketing and advertising analysis of ticket sales for a production. CJ suggested the use of GIS to “make a map of a touring band.” While this example provided by CJ does not address content he was able to begin to think about geographic ties to music. The students’ ability to pose geographic questions and connections is directly linked to their experience in the GIS elective.

**Other electives.** Brain commented that the potential for GIS in high schools was not only for GIS in the core curriculum areas but also as an elective course. He suggested that it should be considered part of the technology courses offered in his school. This perspective seems based on his perception of the pressures placed upon “core” subjects when testing is
prevalent in the school. This is not an uncommon reaction to technology integration among pre-service and novice educators (Bull, 2003).

Natalie also drew a connection between GIS and the technology courses offered in her middle school. She described other vocational “tech” classes for potential curriculum connections as well. Both Ernest and CJ described the GIS elective courses offered at Maple Middle. Ernest stated,

What was being taught in the first class was more of a beginner level – how do you use it-- type deal. And the second class was going more in-depth. Using it to solve problems or just experimenting with it yourself to discover the different uses that it could be used for, the different features that weren’t taught at the beginner level.

There were other elective courses the educators and students connected to GIS. Both Ernest and Carol suggested the use of GIS in career exploration. Ernest suggested that an exploration of GIS itself as it was applied to different careers. CJ drew a connection between GIS and many of his elective classes. He suggested that in wood shop GIS could be used to “talk about certain forests.” In sports oriented classes he suggested, “like sports teams – where they are. You could put in their stadiums, how much they seat, et cetera.”

**Interdisciplinary use of GIS.** At the time of the interview CJ was studying World War II. He stated, that GIS could be used to “overlap the subjects.” He was able to tie the example of GIS in the examination of World War II and Germany in language arts because he was reading *The Diary of Anne Frank*. “So you could see where she is hiding in relationship to the Germans –Germany’s growing empire, the war efforts while they’re hiding.” CJ felt that GIS could be used to follow the progress of the war in his social studies class. “Then in math, I have it down here by itself but I am sure you could incorporate it.
Like finding the distance between Anne Frank’s house or Anne Frank’s hiding house and the Dutch socialist’s house that was down the street.”

There were numerous descriptions of potential and observed uses of GIS in a variety of subject areas. The confluence of these two categories covers not only where in the curriculum the participants see GIS but also how GIS might be used in those respective areas. The most commonly described courses were science and social studies. The other core subject areas and elective courses not suggested as commonly understood by participants. The utility of GIS in multi-discipline explorations was mentioned by both Kathleen and CJ.

**Turbidity: Uncertainty, Questions, and Raising Awareness**

The interviews and representations provided insights into many of the uncertainties about GIS in schools. Several questions also emerged from the participants. The general angst among the participants regarding GIS in schools often was attributed to the lack of awareness of the technology.

**Uncertainty.** Ben’s representation began with a giant question mark with the words, “Where,” “Who,” “When,” “Why,” and “How” (see Figure 29). He related these questions to his thoughts about individual teachers using GIS,

Why would a teacher use it? That is pretty simple – to help students learn. It’s a kind of to help my knowledge as well. That’s kind of set [he points to the images depicting the curriculum areas]. The how – it depends on the teacher. If you’re going to use GIS at all…integrate it into the classroom. That’s their choice. Every teacher is different. When, when will it be in your curriculum? And who? …

Ben continued to consider students as the who. But he also elaborated that his question mark is representative of many more questions. He explained it was a more than just one teacher

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22 Recent work in GIS in history illustrates routes and locations of World War II Holocaust sites.
asking these questions. He felt that parents, teachers and school systems should play a role in this questioning process.

Ben’s idea of the uncertainty that surrounds the decision making process around adoption of GIS in classrooms and in schools is indicative of the matching stage of Rogers’ (2003) diffusion of innovation theory. Before any decision can be made, an agenda must first be set and then the organization and its stakeholders must begin to match the needs of the organization with what the innovation offers.

Another point of uncertainty that Ben demonstrated in his representation is the sign that reads:

GIS
Not Here
Be Back @ __

Ben stated, “I used the sign to illustrate ‘Not here today, Be back at ?’...When is it going to be here, if it’s not here already?” If the decision-making process is rushed it is possible that the innovation will not succeed, even if there is a desire for the adoption of it. Rogers (2003) points out the importance of the matching stage, “Effectively matching an innovation with an organization’s need is key to whether the new idea is sustained over time” (p. 423).

Additionally, the final image Ben drew was a series of question marks. When asked how the items in his representation were connected he drew the question marks. He stated in the interview. “I just drew a blank. I don’t know.” His own personal uncertainty regarding the concepts and how they were connected were externalized within this representation.

Questions raised. This uncertainty about GIS in schools was not only revealed in Ben’s representation. Kathleen raised several questions within her representation as she drew (see Figure 30). And Natalie also raised several questions during her interview. The
students however, did not pose these questions. They seemed to contribute observations and experiences with GIS in schools rather than question the concept.

Figure 30. Kathleen’s Representation of GIS in Schools. Generally Kathleen’s representations were image based mixed with supporting text. When asked about the difference in this representation Kathleen remarked, “I just felt like there was too much information that I was trying to communicate. The picture was frustrating.” A full-page version of this Figure can be found in Appendix X.

As Kathleen began to consider the opportunities necessary to raise awareness of GIS in schools she raised the first of her two questions found on her representation: “What is the rate of GIS in schools?” She remarked during the interview, “I really don’t have a sense of that -- How big the community is.” Her initial observations were based on her subscription to the EdGIS listserv (https://list.terc.edu/mailman/listinfo/edgis). She observed that for a long period of time there were very few posts. She noted there seemed only to be one individual, who was nationally recognized, that posted announcements regularly to the list. More recently, she observed other individuals posting questions to the list.

So, I’m thinking there must be more people who are participating and…but it’s still sort of the individual teacher who thinks “oh this is really cool, I’m going to use this in my class” and the kids get exposed to it that way.
This idea of “the rate of GIS” that Kathleen questions concerns the diffusion of the innovation s-curve (see Figure 7) as well as the adopter categories (see Figure 9) discussed in chapter 2. GIS adoption in K-12 schools is still in the initial stages, as shown in Figure 11, with the overlay of the innovation curve and the organizational decision process. The innovators and early adopters in the GIS in education field are the influencing factor in the rate of GIS adoption. The software manufacturers, or change agents in this process, are developing products like online GIS data and mapping and cross-platform GIS products that do not require as much of the hardware, and reduce the need for purchased software or software specific training for teachers. These accommodations are intended to influence the adoption rate as well.

Kathleen’s train of thought began with: “What’s the rate of growth? And is it the kind of thing where if one teacher gets hip to it then it just starts taking over?” She then immediately wondered, “In what community has GIS been fully integrated in to schools and instruction?” This is the second question found on her representation. She was curious if that scenario existed. “Are there some communities where they’re just taking it up and everybody says ‘Oh this is cool, we ought to be doing this’?”

The problem that many K-12 educational institutions face is the sustainability issue that Rogers (2003) noted. Many of the individual schools make a decision to purchase the software based on the use of GIS by the early adopter in their school. If this pivotal individual leaves the school what happens? This individual may influence the adoption of the technology by others in the school, as Charles has through his in-service opportunities. That person becomes the support for the other learners and if that pivotal individual in leaves the school, the question among many researchers is, what happens to GIS in that setting?
The students observed this set of circumstances arise in Maple Middle. When Ernest was asked about why he thought his school decided to have a GIS elective he responded:

I think it was a teacher influence thing. The teacher that taught the class, it kind of came and went with her. And there were a couple of other teachers, I think, that had seen it used before and were kind of pushing the school into creating an elective for it. And then GIS evolved from that.

CJ provided the following reasons why he felt the electives were no longer available:

There’s no one with enough knowledge on the subject. I don’t think anyone at Maple anymore has learned about GIS, Mr. Swan left, Mrs. King left, you sort of left. Well you were never really there. You were just kind of with Mrs. King.

Unfortunately the students are most often the individuals who suffer when GIS is not sustained in an educational institution. Ernest pointed out during the interview that the GIS elective was no longer on Maple’s list of electives. When asked why it was no longer on the list, he replied, “Well, I don’t know why. I really wish it was still there because it was a really cool class. It’s neat software that I enjoyed using. I don’t know why we don’t have it anymore.”

Natalie asked a similar question to Kathleen’s, regarding adoption, “What schools are using it now?” This curiosity about others using GIS and how they are using it has implication for the businesses and organizations hosting GIS in education list-servs and creating professional development opportunities in GIS. The data suggests the need for a community of users in the educational fields and opportunities where educators can learn about others who are in similar situations. While there are numerous websites, conferences and listservs geared toward GIS in education, there are GIS users who are not aware of these available resources. Natalie’s question lends itself to a larger discussion of the awareness of GIS use in schools and the awareness of the potential of GIS in schools.

Awareness. In my introduction, I noted the disjunct between the ubiquity of GIS and general awareness of it. Kathleen’s image is divided into three parts (see Figure 30). The
left portion of the image demonstrated her understanding of GIS in schools at the time of the interview. The right side of the image demonstrates her understanding of GIS in schools in the future. The final part of her representation is located along the bottom of the drawing and it is her illustration of how “to get from now to the future.” The starred cloud at the top of the representation is her brainstormed list of how to “raise awareness of opportunities GIS can provide.”

The formula, as shown in Figure 31, suggests what Kathleen describes must be in place for the future implementation of GIS in schools. Kathleen described her personal understanding:

On a personal level I just thought of the awareness of what it has to offer and how to make people aware. And not only what it has to offer but opportunities – the problems it can solve. Once you know that you need to know this stuff, then you turn around and shift expenditures so that you can find the money and a time to get it implemented.

This conceptualization of how to move forward in the future with GIS in schools is similar to the Agenda-Setting stage of Rogers’ (2003) innovation process. Within this first step, organizations often seek out an innovation in order to solve a known problem. However, Rogers (2003) recognized that “Sometimes knowledge of an innovation, rather than the recognition of a problem or need by an organization leading to search for a solution, launches the innovation process” (p. 423).

Figure 31. Kathleen's Formula for widespread implementation of GIS in schools. This Figure is part of Kathleen’s larger representation of GIS in schools. A full-page version of this document can be found in Appendix X.
Ben, who was very uncertain of the current status of GIS, commented on the need to

Get out there and market the product. There’s a lot of teachers in my school who have no idea what GIS stand for. And without a marketing campaign...showing teachers, this is how it works, this is why it would be good for you …you have to throw them a bone, so to speak. You can’t say ”Hey come sign up for this program. It will help you.” It has to be -- I hate to say it but its true in everything you do--you need motivation. Because this is not “here, take this class for renewal credits one time and understand it.” That’s not going to work at all.

Kathleen also believed that publicity was necessary. She suggested that other opportunities that could be used to raise awareness included school, college and professional development. But the need for teachers with an interest in GIS and supportive administrators were also important. She suggested that national events were also a way to promote the awareness that GIS could provide. The students recognized the importance of GIS Day in their interviews and representations. This annual event is an international celebration of GIS and its role in the world today. Inviting guest speakers on that day is a simple way of heightening awareness in schools and communities. Another national avenue Kathleen suggested was television. She was able to see how television shows that integrated GIS had raised awareness. However she also notes there is a downside often with the national awareness through such a medium. Kathleen raised the point that:

There’s all these television shows that talk about it but they aren’t flat-footed and saying this is GIS. This…because when you think about it, there are a lot of shows where GIS is used--maybe fraudulently, like oh we just whipped that up and get to the answer/ But it is kind of the common knowledge that there are these tools you can use to figure this out.

The idea that Kathleen raises about television shows using GIS not firmly stating “this is GIS” is an issue of awareness.

Natalie and I also had a conversation about awareness issues with GIS and other new technologies. She suggested that the beginning point for new users of any technology should
be what they are familiar with. If there is not a name to what they know, name it. Once it has a name it can then be visualized and linguistically tied to other knowledge.

**Summary of Research Question 3**

There were categories that reflected the allocentric position and the egocentric position within the context of GIS in schools. The categories of description for research question three represents a confluence of both of these frames of reference. The experiences and perceptions of each educator and student emerged to segregate their own knowledge and experience from the larger conceptualizations and thus conceptually locating themselves in very different spaces from one another.

The common categories of description that emerged surrounding the investigation of educator and student perceptions of GIS in schools were clearly defined. They included the following categories of description: a) GIS technology in schools, b) users of GIS in schools, c) classes and curriculum areas where GIS could be found/used, d) examples of potential uses of GIS in schools, and d) awareness issues. However these understandings were both allocentrically and egocentrically positioned. Often two distinct categories had areas of overlap or confluence.

From question three’s GIS in schools’ representational and interview data came two additional (though not ‘common’) categories of description: 1) GIS technology and 2) courses/curriculum areas where GIS could be found distanced from the individual. All participants were able to describe the GIS technology and discuss it situated in various classes or curriculum areas.

Other concepts were not as discernable from the individuals experiences and understandings and were located within an egocentric frame of reference. The two categories of description: 3) potential uses of GIS in schools and 4) users of GIS in schools were
positioned from the egocentric vantage point of the participant. Participants were able to describe the subject areas but were uncertain of how GIS would or could be connected to potential uses in those subject areas.

The areas of confluence of allocentric and egocentric understandings of GIS in schools created an area of turbidity. The areas of convergence were found between:

- a) GIS technology and b) the users of GIS, and
- c) GIS in classes and curriculum areas and d) the potential uses of GIS in schools.

This murky area is where the final category of description: e) awareness issues seemed to raise uncertainty and questions. The uncertainty seems to envelop issues that are directly connected with the innovation decision process—whether or not GIS is an innovation worthy of the effort and how others were integrating GIS able to meet the needs of the stakeholders.

The questions raised by the participants, regarding the rate of growth, the influence of individual teachers in the K-12 setting, and the larger GIS in education community, are indicative of the diffusion of innovations process. These questions correlate to the rate of diffusion, the adopter categories, and the stages of adoption within an organizational structure respectively. The discussion surrounding the uncertainties and the questions raised by participants are related to the issues of awareness. Even with these questions and concerns as indicators of the diffusion process, the time to reach full GIS implementation is still profound.

This ‘GIS in school’ data provides insights into the frames of reference from which the educators and students contextualize their understandings. The uncertainty and questions that have arisen from the educator perspectives begin to illuminate the turbid waters that this innovation stirs. The perceived lack of awareness of GIS and the concept of GIS in schools
as an innovation that is seen and used but often has no name, are essential issues that must be addressed during the diffusion process. The turbidity may be used by GIS in education researchers to further investigate the questions posed by these participants as well as the uncertainty and awareness issues that need more clarity. Other issues of cost, training and time must also be considered. The implications of the findings from this research question will be further discussed in chapter 5.

Analysis and Discussion of Question 4: What similarities and differences exist between student and educator perceptions of GIS, IT and GIS in schools?

The following discussion will focus first on the common areas between a) GIS and IT, b) GIS and GIS in school, c) GIS in school and IT, and d) the common features of GIS, IT, and GIS in school. This will be followed by a discussion of those understandings that are unique to the individual topics and thus indicate the areas of divergence between the three topics.

Throughout the discussion of the first three research questions that focused on categorizing the understandings of the conceptualizations of GIS, IT and GIS in schools, several of the commonalities differences between the students and educators were pointed out. In the following discussion I further summarize the similarities and differences among GIS, IT and GIS in schools. As shown in Figure 32, there are areas of similarities and differences observed among the three conceptual spheres.
Similarities in the conceptualizations of GIS and IT

The most common feature between GIS and IT is the understanding of the utility and purpose of Internet-based tools. As suggested by the data in research question one, GIS data and internet-based maps are a common understanding of students and educators. The Internet was the most commonly mentioned use of instructional technology by all participants. Educators and students viewed the Internet as a resource that opened up a world...
of possibility for most subject areas. The students most commonly referred to the Internet in instruction for research. The purposeful use of the Internet for collection of data and locating data was also described in the GIS understandings of most of the participants. This shared understanding of the availability to access information via the Internet will be further explored in the implications of the study.

**Similarities in the conceptualizations of GIS and GIS in schools**

The common awareness of the participants in this study, regarding GIS in the world and GIS in schools, was found in their understanding of the GIS technology and GIS in the community. While there were participants that did describe GIS in the context of educational uses, the technology itself was not commonly understood by all participants as an instructional technology. The connection between how GIS was viewed in the world and how GIS was viewed in the school as a distinct technology with discrete capabilities was more commonly understood among participants. GIS is seen as software with distinct characteristics that can be set apart from other IT applications.

The other common categories of understanding between GIS in the world and in the school were in the realm of community experiences and community based users. Educators and students were able to identify community-based problems and examples of GIS use for the classroom. In addition, all participants described the role of community partners in the classroom.

This finding may be influenced by the methods that these participants were taught GIS. Over time, as the *GIS in Education* course developed, course was to contact, interview and/or collaborate with a GIS professional was required. This project was intended to broaden the educators’ perspectives regarding GIS use in the community as well as to
establish a technical assistance once the course was completed. Community partnership was modeled from the earliest GIS in Education course through guest speakers.

The student participants also were encouraged to establish connections to the community through the juvenile crime data project they created in the second level GIS elective. They also participated in, and described GIS Day celebrations, where GIS professionals were invited to the school. The infusion of these methods used in the process of learning GIS for most of the participants may have influenced this finding. The significance of this finding to the teaching and learning of GIS is that drawing upon available community partners is an experience that was memorable to the each of the individuals. This ability to build a bridge between the conceptual understandings of the software in the classroom (university or middle school) to real world users and uses was significant to these participants.

**Similarities in the conceptualizations of IT and GIS in schools**

The mutual understandings that stemmed from the student and educator conceptualizations of instructional technology and GIS in schools were centered on the structures of the school. The students and educators referenced locations within the school such as computer labs and classrooms. The common users of IT and GIS in the schools were students, teachers and others such as media specialists, support staff and administrators. As the participants described their understandings, they recalled their personal egocentric experiences in their educational institutions.

As the participants discussed courses, curriculum and pedagogical considerations they were able to discuss the topics within the context of GIS and IT in the schools. A common understanding of both educators and students is that IT and GIS can be located in any subject or curriculum area. Participants were able to provide examples of GIS and IT uses in core
classes (social studies, language arts, mathematics and science) as well as in elective classes. The classroom teachers tended to elaborate more within their own subject areas. Students and the educators in support roles were able to better describe the uses of IT and GIS across curriculum areas.

The pedagogical approach that was most commonly described was a non-traditional, project-oriented method. Students described the pedagogical approaches they experienced with various teachers. Their descriptions of the methods used while learning with and about IT and GIS were constructivist-based. The differences found between educators and students were not in how they conceptualized these topics, but in how they described and named them.

Students and support staff constantly experience different pedagogical approaches and subjects. The support staff (Kathleen and Natalie) were not generally tied to a specific curriculum area, and shifted between various subject areas and observed many different teaching methods. The classroom teachers in K-12 schools (Charles and Ben) often remained focused within their subject areas and as seen in the data, often were neither confident discussing the methods employed by other educators nor making connections to those curriculum areas.

**Similarities in the conceptualizations of GIS, IT and GIS in schools**

The common areas in the spheres of GIS, IT and GIS in schools are centered on the requirements of the technology. The necessary components of IT and GIS in the world or in the schools included: hardware, software, training and resources. The students and educators understood the basic software and hardware needs when discussing instructional technologies and GIS. Marketing to schools by companies can influence and limit understanding of the other available software and hardware products. Each participant stressed the importance of
training with regard to teachers and students using IT and GIS as well as other community users.

The final requirement elaborated upon by both students and educators was that of the need for resources when using GIS, IT, and GIS in schools. These resources include the hardware and software as well as money, time, and people. Both students and educators recognized the impact that lack of hardware and software can have when implementing IT and GIS. Both students and educators identified monetary resources as necessary to use GIS and IT, noting the inequity inherent in IT distribution and home use.

Time was a resource that was more often described by educators as a limiting factor in the implementation of IT and GIS, and the students also recognized this as a necessary component for successful implementation of GIS and IT. They described their perceptions of the lack of time their teachers had to learn new technologies as well as the rushed experiences in computer labs and classrooms.

The common ground that emerged from the student and educator representational and interview data were understandings that GIS, IT and GIS in schools created opportunities for ‘outside of school’ experiences. While some of the ‘outside of school’ experience may occur virtually there were many examples provided of opportunities to use, share and learn about GIS, IT, and GIS in schools in settings outside of the school. As shown in Figure 31, these experiences in the world provide a tangible understanding of how technologies and curriculum topics are explored and used beyond the classroom and the school.

**Differences in the conceptualizations of GIS, IT, and GIS in schools**

There were more areas of common understandings between the spheres of GIS, IT, and GIS in schools than differences. However each sphere had at least one category of description that was not paralleled by one or both of the other topics. These included the
concept of a global tool, data requirements, use of GPS and satellite imagery, traditional pedagogical approaches, and the ideas of uncertainty, questions and awareness issues.

The representational drawings and interviews of GIS in a global sense provided three distinct categories that were not similar to those of IT or even GIS in schools. The concept of GIS as a global tool was the first topic explored when addressing research question one. All of the participants described the technology as global in its reach and in its use. They drew globes and described locations in the world both across and orbiting the globe. While many of the uses of GIS in schools might be considered global, this concept did not reemerge in the context of those descriptions, nor was any other software described as a global tool. Many of the participants described uses of instructional technologies outside of the context of the school, such as the Internet, however it was not described in the spatial context as GIS was in the first interview.

The issues surrounding data access, data storage, and data collection were a common understanding of GIS in the world. While data collection was referred to by at least one student and one educator during the discussion of GIS in schools, this was not a common understanding of the participants.

Within the discussion of instructional technology there was a common understanding of different pedagogical approaches teachers used. The non-traditional approach, utilizing project based experiences and non-traditional method, was also described in the discussion of GIS use and teachers as GIS users in schools. The traditional approach, most often characterized by lecture based lessons and restrictive activities with little student choice, was elaborated upon by the participants in their discussion of instructional technology. However, as a common understanding, this approach was not found in the data regarding GIS in schools nor in GIS in the world.
The final category: uncertainty, questions and awareness, emerged from the participants’ understandings of GIS in schools. This topic was the sphere in which educators posed questions as a part of the drawing activity and in the interview. Ben’s questions of: “Where? Who? When? Why? and How?” are significant to the agenda-setting stage of Rogers’ (2003) diffusion theory. This is the initial stage when an organization begins to match the problems and needs. These are the questions asked by many educators with respect to GIS in schools and other instructional technologies. These questions must first be answered before many educational stakeholders will consider GIS integration.

The questions posed by Kathleen regarding the rate of growth in the GIS in education community and where has GIS been successfully adopted and implemented by more than one teacher are equally as significant. She too was posing these questions from the initial stage of the innovation process. She was asking about the adopter categories and the rate of adoption. She explained that her observations were of the innovators and earliest of adopters using GIS in schools but her questions allude to the greater lack of understanding of the rate of adoption of GIS and GIS implementation in schools or communities.

The students did not raise questions but observed many of the issues surrounding the lack of awareness about GIS in general and GIS in schools. Additionally, comments regarding sustainability issues that were raised by the educators contributed to the discussion. The students’ understandings of GIS in schools were based on their lived experiences. Their inquisitive nature regarding new knowledge and understanding was evident in interviews and in previous observations. They showed genuine interest in GIS and geospatial technologies and understood the existence of awareness issues however, a deeper questioning of the technology or its integration in education or the community was not explicitly evident. This
distinction between the two groups with regard to knowledge, experience and perception may illuminate the directions for research and practice.

Chapter Summary

In this chapter I provided a brief overview of the study design that was described more fully in Chapter 3. An overview of the data was provided for the reader. A description of the representational data collected at the start of each of three meetings with individual participants was given. The representational data ranged from abstract image based to text based, with most of the representations containing a mixture of both. Following the discussion of the representations were analyses of the interview data.

The significance of both methods of data collection is based in Alan Paivio’s (1991) dual coding theory. Paivio (1991) suggested that individuals cognitively code information and experiences in both imagens (images) and logogens (words). In order to more fully explore the conceptualizations of the study participants regarding the topics of GIS, IT and GIS in schools, external representations of their understandings and subsequent semi-structured interviews were employed.

The role of phenomenographic methods in the data analysis was the next discussion. The importance of the common understandings among study participants is the fundamental goal of phenomenographic methods and analyses used. Categories of description emerged from the data to illustrate shared understandings of the participants with respect to GIS in the world, IT, and GIS in schools. Through examination of the representations and hand-coded transcripts of the interviews, the categories of description emerged.

I then introduced the reader to the participants and their individual educational settings. The two male middle school students that had completed at least two semester long GIS electives and four educators that had successfully completed the GIS in Education
course at the local university. The range included middle and high school, traditional public schools, magnet public schools, and private school settings. There were two classroom teachers from different curriculum areas and two educators in support roles.

There were common frames of reference that emerged when examining the data. The participants represented their understandings of GIS from an allocentric position. They discussed GIS and their understanding of it within the context of their experiences and knowledge, however these understandings were represented at a distance from themselves. Interestingly, the data that provided the most insights were the representational data. The interview data generally provided simple elaborations of image-based understandings of GIS. The six categories of description that emerged from the data were: a) GIS as a global tool, b) personal experiences in the GIS community, c) GIS users, d) GIS requirements, e) Internet-based GIS, and f) GPS and satellite imagery. These were common understandings of the participants and were discussed in the following contexts: GIS as found in the world, GIS as used in the world, and GIS as a tool to study the world.

Conversely, representative data of IT were egocentrically positioned. The linguistically based interviews provided a richer description than what was drawn in the representations. There was a deeper awareness and connection between the participants and their insights of their own conceptual location to IT. The six categories of description that emerged from this set of interview data were: a) the settings of IT, b) IT users, c) hardware, d) software, e) Subject Area/Curriculum connections, and f) pedagogical approaches (these are also listed from the most explicit common understandings to the least explicit). The understandings that are most explicit were elucidated with both representational and interview data. The data were discussed within the context of the representational framework of one participant’s understanding of IT in K-12 schools.
The third question and analysis focused on the student and educator conceptualizations of GIS in school. The categories of description were indicative of a confluence of ideas. The categories of description that were discussed allocentrically were: the GIS technology in schools and the classes and curricula in which GIS could be found. The participants were able to discuss these concepts but placed a distance between themselves and the school applications. The egocentrically positioned categories of description that emerged were: the users of the GIS technology in the school and the uses of the technology in curriculum and subject areas. This point of confluence however did produce a turbid fifth category. The final category of understanding of the topic of GIS in schools was: awareness issues that emerged through uncertainty and questions posed by the participants. As the educators in this study struggled with the topic of GIS in schools, they had grey areas that emerged in their own understandings. They asked questions both in the representations and in the interviews. The students did not have any explicit questions, however they contributed to the common understandings of several questions surrounding the topic of awareness of GIS in schools. The significance of the quandaries and question marks are indicators of the position of ‘GIS in schools’ vis-à-vis Rogers’ diffusion of innovations theory. GIS in schools is located in the initial stages of diffusion. In an attempt to set an agenda and match organizational goals, these stakeholders are asking questions even as they move toward implementation of GIS in schools.

The final discussion in this chapter provided an overview and model (Figure 31) of the common categories of understandings between the individual topics of GIS, IT, and GIS in schools. The mutual understandings found between GIS, IT and GIS in the schools were, in descending order of frequency: the requirements of hardware, software, training, and
resources as well as the ability for all three to be found and used outside of the school. The majority of the common understandings were found between GIS in schools and IT.

In the next chapter I discuss the implications of the data and data analysis. This discussion is framed by the dual coding theory and the diffusion of innovations theory as discussed in chapter 2. The first discussion focuses on research question number five: How can student and educator conceptualizations of GIS, IT, and GIS in schools inform GIS integration in K-12 education, pre-service teacher education, and professional development? I will then discuss the implications of the use of representational and interview data on future research and GIS in education instruction. Next, a brief discussion of the implications of the phenomenographic methods is included. A discussion of the issues surrounding GIS invisibility and awareness follows. Finally, I suggest possible research directions introduced by this study.
CHAPTER 5: IMPLICATIONS AND FUTURE RESEARCH

Overview of the Chapter

In the previous chapter I presented the data and findings of the research study. This multi-case study of six individuals; four educators and two students, was framed by Rogers’ (2003) diffusion of innovations theory, Paivio’s (1991) dual coding theory and phenomenographic methods. The data collection centered around the first three research questions focusing on the participants conceptualizations of Geographic Information Systems (GIS), Instructional Technology (IT) and GIS in schools.

Paivio theorized that humans store and access knowledge in two modes: a) as images or imagens and b) as words or logogens. Drawing on these precepts, study participants were asked to represent their understandings in drawings and in subsequent interviews. Each of the three meetings with participants began with the drawing and the interviews were used to elaborate upon the imagens through the correlating logogens. This approach and the representations produced provided a deeper understanding of the participants’ conceptualizations.

Phenomenography emerged in Europe in the late 1970s as a qualitatively based research methodology. The researcher using phenomenographic methods takes a “second-order” perspective, where the understandings on the part of the researcher not considered in the construction of the categories of description. A ‘pool of meanings’ is derived from the participants’ conceptualizations. The categories of description in this study focused on the common understandings of the educators and students with respect to the research questions.
These understandings were reached through collections of both graphic representations and linguistically based representations.

Rogers’ (2003) diffusion of innovation theory was used as a framework for the findings regarding GIS, IT, and GIS and schools. Both GIS and IT are innovations in educational settings. The diffusion and adoption of these innovations are of interest as K-12 stakeholders make decisions regarding the implementation of technologies in schools affecting student learning and knowledge. I explore in this chapter the implications from the data of the diffusion process as well as adopter issues. Observations from the data of these students and educators begins to illuminate some of the issues, questions, and concerns.

In this chapter I will focus the discussion on research question five: How can student and educator conceptualizations of GIS, IT, and GIS in schools inform GIS integration in K-12 education? This question is explored using Rogers’ (2003) diffusion of innovations theory. First I will address adopter issues, such as existing GIS in education users, resistance and the role of administrators, and software manufacturers. I address the impact of the conceptualizations of GIS, IT, and GIS in schools on pre-service teacher education and professional development in GIS and IT. This is followed by an examination of the relevant decision factors for organizations when adopting a new innovation, in this case GIS. Finally, I discuss the role of the emergent issues surrounding awareness of GIS as they pertain to the implementation and adoption process.

Following this discussion is a brief overview of implications of the research methods used in this study. Included in this discussion are the uses of representational, interview data and phenomenographic methods. This will include the concept of the invisibility of the unnamed yet visible entity. Finally, I will describe my future research stemming from this
study and what is still needed in terms of GIS and IT integration and implementation in schools.

GIS as an Instructional Technology

GIS currently lies outside of “mainstream” instructional technology. While there have been articles, publications and presentations in the instructional technology field introducing GIS it still lies on the periphery. GIS can be used to teach databasing, representing data, critical and ethical data driven decision making and other goals of IT integration as found in the ISTE National Educational Technology Standards (NETS). According to Rogers, for educators to begin implementing IT and GIS as an instructional technology in meaningful ways, we must reach a level of routinization in the use of the technology.

Another set of concerns brought forward by the study participants underlie the innovation decision-making process related to pedagogical approaches used in schools. The concept of the structures in Natalie’s landscape to describe IT implementation is one of the most interesting features of the instructional technology data. On the traditional side of her instructional river there was a building with an addition representing IT illustrated as an “add-on.” On the non-traditional side of the river there was only one building where IT was integrated throughout (see Figure 19). Pedagogically a shift toward understanding instructional technologies such as GIS tools for integrating content area teaching and learning would be necessary. This would ideally take place through: a) pre-service teacher education experiences, b) networking opportunities to make connections across the curriculum and c) professional development opportunities and training.
Pre-service teacher education. As the participants described the current uses of IT in K-12 settings they distinguished it by curriculum area or subject area use. Software applications were often viewed as a tool for one specific class or purpose rather than for interdisciplinary applications.

The way in which IT is perceived may be rooted in pre-service teacher education. The methods and materials of curriculum areas, such as science or social studies, have often developed independently. The conception among many educators, as expressed in the data, is that educators view IT software, hardware, and practice as curriculum specific. Pre-service teacher education is important in the diffusion of the innovation of IT. Pre-service teachers should experience IT modeled through curriculum integration. If GIS were to be included in pre-service education, new understandings of the spatial and geographic dimensions of curriculum could be facilitated. This intervention has implications for interdisciplinary curricular approaches.

Opportunities to make interdisciplinary connections. The classroom teachers in the study described their lack of knowledge of what was taking place in other classrooms and subject areas. Some teachers choose not to step out and ask what others are doing and studying. As educators begin to approach the technology from multiple vantage points it can increase the connections the students are making between classes as well as between the classroom and the world. However, those who would like to explore other classrooms are often limited by the school schedules (faculty and IEP meetings, extra duties during planning periods and lunch, other time constraints, and inflexible schedules). Schools must provide opportunities for teachers to observe one another and explore different curriculum areas and approaches to teaching.
Professional Development and training. If GIS is introduced within instructional technology courses, pre-service education courses, workshops, and in-service training it then may be considered one tool of the many options for educators to use in the classroom. GIS is currently on the fringes of mainstream instructional technology with few instructional technologists adopting and using the technology, though further research is warranted in the relationship between instructional technology and GIS. Introductory GIS articles have been published by instructional technology focused organizations. A simple but meaningful approach would be the addition of Internet mapping as an introduction within pre-service and in-service IT courses. This introduction would begin to open awareness to teaching and learning options available to teachers.

The participants acknowledged the need for training with IT and GIS. While the usefulness of in-service training and short workshops was acknowledged, the participants suggested that they be used simply to increase awareness of GIS or other IT. More in-depth courses (such as the GIS in Education course), hands-on experiences with technology and relevancy to their content area were important factors when describing ideal training situations by educators who participated in this study. GIS technology is a “missing link” between existing curricula and multidisciplinary instructional technology.

Diffusion of GIS as a K-12 Innovation

Within Rogers’ (2003) theory he describes the characteristics of adopters with respect to the rate of adoption of an innovation, as discussed in Chapter 2. The study participants described other educators as located within the “adopter categories” Rogers theorized. As innovations become addressed by schools, school districts and state educational agencies, both adoption and resistance are competing factors. The resistance issues described by the
participants and the role of other stakeholders, such as administrators, in the adoption process can also be positioned within Rogers’ model. Administrator, teacher, student and parent awareness of GIS as a technology is a major factor in making the decision whether to include GIS in the curriculum or as an instructional technology.

**Awareness issues**

There are several awareness issues that were illuminated by this study: 1) GIS as an unnamed yet visible entity, 2) the lack of awareness of the larger (local, national, or international) GIS in education community; and 3) uncertainty of how ‘GIS in schools’ functions over time. The first awareness issue is that of the unnamed visible entity. GIS surrounds us everyday, yet most are unable to name the technology. How can there be an expectation of GIS integration or implementation without an understanding of what it is, even when intuitively integrated into everyday living? Individuals who can critically examine and question the representational maps produced by a GIS will not blindly accept the representations that surround them daily.

The implications of the ‘invisibility’ of GIS represent a larger issue of the GIS industry as a whole. The industry is too self-contained and must promote awareness of the technology through explicit and overt means. GIS Day activities were important to the study participants’ knowledge of GIS. GIS Day-like activities begin to educate the general public of the technology and promote its uses. GIS Day, however, is only one day of the year and sustained awareness is necessary. Connections and partnerships between education, GIS professionals and geospatial industries must be formed. This is not only an issue of awareness and understanding but a need to educate the next generation of workers in the technologies that they will work with.
A closer examination of the digital equity issues surrounding technology implementation is crucial to this discussion. A closer examination of the equity issues raised in the context of the study remains unaddressed. As part of the larger gendered science and technology crisis, GIS and IT are in a parallel dilemma. The ability to empower individuals with a tool such as GIS is often dependent upon access to the technology itself. The emergent issues surrounding public participation GIS, or PPGIS, are relevant to implementation of GIS in areas where the ‘digital divide’ is greater. The implications of prior PPGIS research and the potential for students to effect community change through GIS projects and applications merits further discussion and research in GIS in education literature.

Community partnerships were beneficial to the conceptualizations of GIS of the educators and students within this study. Community partnership established a sustainable link between K-12 and GIS organizations, businesses and agencies. Maple Middle had community partners, interested educators and willing students.

The study participants recognized the impact of the loss of the individual who was central to GIS implementation. The innovation process cannot be borne on the shoulders of one individual. The responsibility to support an innovation must be an inclusive process. To enable better relationships, I suggest, that the reciprocal nature of a partnership requires that GIS users should be mutually informed of K-12 education as the educators and students are of the GIS partner’s work. This is an important area of need for future research.

At the current levels of GIS adoption in schools there are disparate pockets of individuals who are not connected to one another. The ability to share ideas with and troubleshoot the technology with other users is important. Charles remarked that one of the
fundamental components of the first workshop was the networking that took place. Kathleen had observed the GIS in education community from listservs and presentations. The awareness of others who may share innovative approaches or are facing similar struggles in the adoption process is critical to these early innovators. There is a need for a formally organized GIS in education community beyond a specific GIS software company or curricular affiliation. This organized community can provide spaces and places for educators to create interdisciplinary GIS curricula are needed, to network with one another and industry partners, to develop research and to share methods and materials. As the decision-making point approaches for GIS it is the GIS in education community that will shape the process and design.

As curriculum design is considered, educators are drawing on their experiences. An uncertainty of how GIS in schools functions over time surfaced as a concern of the educators. Awareness of how GIS functions in the classroom can be advanced through publications, presentations and professional development activities. The national and international core curricular organizations should be the focus of these efforts. In addition to the recently released report on spatial thinking (Downs & de Souza, in press), development of a scope and sequence for spatial skills and geographic literacy in interdisciplinary contexts would further the understanding of how GIS would be suited for existing school curriculum, pedagogical approaches and instructional technology integration.

**Decision factors for Organizations**

**Resource issues**

There was a common understanding among the participants regarding resources that were necessary to GIS and IT diffusion. They recognized the need for hardware, software,
training, and connections to the curriculum for successful implementation. These resources have financial impacts on schools and school districts should not be dismissed lightly. The two most common resources that were noted by the participants as needed or lacking were time and money.

*Time issues.* The issues of time were two-fold: a) lack of class time, and b) lack of time for the necessary teacher training and creation of lessons. The lack of class time was related to the inability to provide students with what Andrew described as ‘meaningful’ experiences. Schools must provide the time and spaces for students to investigate and think about what they are learning and how it applies in the world. Forty-five minute class periods and the inability to investigate the environment beyond the school walls are considerations that present systematic barriers to innovation. Schools as organizations must consider the best use of time for their students to support meaningful learning.

The issue of time limitations for educators cannot be underestimated. The ever increasing demands on the classroom teacher include: faculty meetings, IEP meetings, supervising extracurricular activities, advising clubs along with the normal paperwork of grading, creating lessons and materials for classes. Natalie suggested during one of her interviews that educators do not have enough time to stop and reflect on their own teaching and learning. This is a very salient point when considering the adoption of a new innovation. The implementation of a new innovation takes time. This amplifies the implication that student assistance for teachers integrating technology is an efficient option for competent and technologically advanced students.

*Financial Resources.* The structure of GIS in schools is not clearly defined to-date. The architecture of the metaphorical structure in which we try to build GIS in schools is
important. According to the participants, the considerations of the actual school structure are important, such as: instructional time, resource availability, layout of classrooms and/or use of computer labs, and access to hardware and software. New approaches to the infrastructure and structure of current schooling should be investigated based on the limitations and strengths of these current structures.

Yet issues of conceptual curriculum connections remain to be addressed. Baker (2005) suggests that for many educators, the Internet-based route is an entrée into GIS software and its capabilities. He suggests the knowledgeable and skilled GIS professionals could then provide and handle many of the hardware requirements rather than school personnel. While I agree that Internet-based mapping is a good point of entry, this approach casts a shadow. Web-based GIS is a good compromise between maps solely served and used on the Internet and the full program with limited hardware.

The communication between the industry and educators regarding their needs has resulted in the development products such as ESRI’s web-based map explorer, ArcExplorer Java Edition for Education (AEJEE), during the study period. AEJEE was introduced as an attempt to mitigate the need to purchase GIS software and use data from remote hard drives and Internet data servers and as a cross-platform GIS software specifically for classroom use. AEJEE developed in response to the educational market to smooth the transition to a newer and different version of the GIS software. As the industry has begun to address the rate of adoption of GIS by closing the gap between the innovation s-curves of Rogers’ theory of innovation adoption as discussed in chapter 2. The outcomes of this shift in the industry are yet to be articulated and require further study.
Resistance

Educator resistance was clear in the research and is relevant to Rogers’ theory of diffusion of innovations. The impact of these early adopters can also have an effect on the decision not to adopt an innovation. Educators, such as Ben, see the potential of an innovation like GIS yet struggle with the implementation due to lack of resources or time. Further research concerning these and other resistance factors must be implemented.

In order to alleviate the educator fear of the technology, expressed by the participants, the use of students as teaching assistants in the classroom is one potential solution. This not only could diminish the resistance but also could increase sustainability in adoption process.

Successful students are expected to move up through grade level and their skills and understanding of an innovation are lost to the setting. Researchers must examine further the long-term knowledge and skills acquired from GIS in one grade or level to their performance on standardized tests, future work and understanding of new concepts. If schools are able to put into place a way to programmatically sustain GIS, the students can become peer technology educators. Schools, such as Maple Middle, who service 6th, 7th, and 8th graders use events such as GIS Day to introduce the technology to the incoming classes each fall. Students may then begin to enroll in the GIS electives offered in the spring of their 6th grade year or the fall of their 7th grade year. The second level will then follow and by the time the students are in 8th grade peer educators or assistants to other interested yet untrained teachers. This can then create a cycle of diffusion and sustainability for a school, program, or community of learners.

At Maple Middle, teachers enlisted the assistance of students in the incorporation of the technology into lessons. Students who are acknowledged for the prior knowledge they
bring into the classroom are able to explore and create new ways of learning for themselves and their peers. The concept of students assisting educators in learning new ways to teach offers important implications to education.

New innovations and knowledge create a disequilibrium that many educators may not welcome. The disequilibrium is a familiar terrain for students -- daily they are confronted with new knowledge and they must begin to incorporate the new knowledge within the context of their prior experiences and understandings. Shifting the power of learning from the educator to the students creates a level of responsibility for students that is age-appropriate for middle and high school students.

Allowing students to aid in the navigation of the learning landscape is a benefit to teachers. Educators, as the content area experts, facilitate a fuller understanding of the curricula they teach. A constructivist approach does not exclude the use of objectivist methods. Often the objectivist methodologies are the best way to create a baseline understanding for the higher order thinking skills and education that educators, administrators, and parents desire from students. This is exemplified in Natalie’s representation that was used to frame the discussion of IT. The choices in the methods used are ultimately the educators but collaborating with students to accompany educators expands a new landscape of learning.

Resistance issues revolve around many different parts of the diffusion process. Educators may not believe they are involved in the decision-making process and thus resist because of the perceived (or existing) hierarchical nature of the decision. Resistance can also occur do to a lack of comfort or a perceived lack of need. In the case of GIS, some educators might ask, “Why should I use it?” GIS researchers must be able to provide insights into
these reasons. The extensive technology skills, increased spatial cognition and improved geographic literacy are three possible reasons for the inclusion of GIS in the classroom.

First, a user of GIS technology employs an extensive set of technology skills, several of which exceed the NETS standards. For example, users must make decisions about the representation of the data based information using critical and ethical methods. The necessity to organize, analyze and display information using technology is an interdisciplinary goal that GIS accomplishes. GIS users must pose questions and analyze the data exemplifying the technologies analytical power. The analysis of data in a GIS lies beyond numbers and figures; there are spatial references to the data that allow the user to consider spatial relationships of the question at hand. Nationally, many curricula areas now relate technology standards to the content specific standards. GIS, as noted by the study participants, is a tool with interdisciplinary uses that can meet those needs.

Second, is the development of spatial cognition. As students begin to understand the relationship of location, place, environment, and other geographic concepts they increase their spatial awareness. Students are expected to negotiate and navigate through spaces every day. When they reach driving age, the expectation is that they understand those spaces they are moving through. The spatial nature of GIS adds value to the curriculum. Spatial dimensions of curricula, normally lacking in K-12 schools, is greatly expanded through GIS, a tool that can be used by students to ask, think and analyze information spatially.

Third, student manipulation of GIS data enhances geographic literacy. In the U.S., as described in Chapter 1, geographic education is not a priority and therefore geographic literacy among U.S. citizens is lacking. Every subject area has national standards that are georeferenced, however, explicit geography related course work is limited in U.S. education.
The study participants offered numerous examples of how GIS was used to expand their own or their students’ knowledge of a given subject, such as: troop movements and losses in the Civil War, impact of travel on the Mississippi on Twain’s writing and community-based research projects to enhance community understanding. The students not only can understand how far the troops moved or Twain traveled but they also understand the spatial relationships of the events or literature to the geographic locations.

The need for geographic literacy in the global marketplace and in the context of Internet and multimedia communications is ever increasing. The exponential growth of GIS technology in business and industry, as discussed in Chapter 1, according to the Department of Labor (DoL), will require geospatial skills and knowledge expected from U.S. K-12 education. This point will be further discussed within the implications of the methodology.

**Implications of the methodological approach**

The use of representational and interview data based on the dual coding theory were fundamental to gaining access to the participant’s deeper understandings about GIS, IT and GIS in schools. The representations provide a spatial record of the connections and understandings the participants have created. The linguistic data provided supplemental descriptors regarding the participant’s knowledge.

This methodology also can provide an important avenue for investigation of the spatial and linguistic connections that are made by an individual regarding a phenomenon. The representations and subsequent interviews revealed a depth and complexity of understanding not previously explored. After reviewing the data it is important to note that the students learned similarly to the adults. However, the complexity of the students’ understanding of GIS was observed in their representations that were populated with more
applications for real world than the teachers. This has implications for advancement in career education and workforce enhancement.

GIS is a ubiquitous technology in the workplace, and even where it is not, many of the skills that are used when engaged with GIS are transferable to other technologies and jobs. Skills referenced by participants in this study included creating data; working with databases and spreadsheets; analyzing information; creating representations of data; posing questions; and making data driven decisions. All of these are skills that can be used by students in other courses and future employment. The connections established between what the students had observed and learned about GIS are represented in a broader more complex understanding of GIS as it exists and is used in the world.

In this research the participants were given 30 minutes, but in a professional development setting or classroom the instructor or teacher may give the learners a more limited time to draw their representation, maybe 3, 5 or even 10 minutes. This exercise would then give the instructor or teacher a precursory perspective of how the learners understand a topic through the connections they make and information they recall as well as how they store it.

**Instructional interventions**

When I began this research I did not know how or what the participants would represent. However, after reviewing the representations and the interview transcripts I began to reflect on my observations of how the students learned GIS. During the *GIS in Education* course Ben, who drew a very abstract drawing of GIS, came for extra help at least once a week to work on his final project, a curriculum based project of his choice. Often Ben did not have a specific question he wanted answered; he wanted to work on the project and
wanted someone on hand to ask questions of when he began to struggle. Based on my observations during this class, Ben struggled a little more than other students with not only how the technology worked but also with how it would be integrated into the curriculum. His final product, an exploration of Civil War battles, was tied to the American History curriculum and demonstrated a proficiency in the software and its capabilities. The observable moment in Ben’s understanding of GIS within in the semester came later than his classmates. When it seemed to “click” he leapt from his chair in the computer lab and immediately began to explain his personal understanding using the SmartBoard on the classroom. This moment was captured on film by one of the instructors.

Now, having asked Ben to produce a representation, I have a window into his representation of his conceptual knowledge. His abstract organization of the concepts and the connections made between content and his personal experiences were apparent in all of his representations. Rather than beginning with the mechanics of the software as the entry point of learning, a more global approach with personal ties to GIS might have been implemented for Ben as a learner. The use of representational drawings in future GIS instruction could then influence how the technology might be explored and taught from various perspectives. This would then differentiate the experience based on the needs of the learners thus this particular methodology has broader implications as a strategy for instructional intervention.

The importance of the data is that it is the first externalized representations of GIS and GIS in schools by students and educators. The individuals in this study learned GIS using similar constructivist methods. I would like to investigate a broader sample of representations to develop a strong sense of common understandings between instructional technology and GIS.
**Future Research**

The strongest research need as we move toward the decision-making point of GIS in education diffusion is for explicit data on the effects of GIS on assessment, learning and testing. The current trend in labor and workforce development includes geospatial technologies and related fields. This has tremendous ramifications for the expectations of business and industries of education and learning. Schools should recognize the need for geographic and spatial understandings and work toward integration and literacy in these fields. If they do not pro-actively include these in the curriculum there will be a top-down decision to integrate them based on those workforce pressures.

Research in GIS in schools and K-12 schooling is slowly growing. There is a need for further research in pre-service education and novice educator integration issues. For new educators, finding and using appropriate technologies in their classroom should include at least the new web-based mapping tools with an eventual goal of GIS integration. I would like to broaden the scope of this study, investigate GIS sustainability issues and begin to examine students’ spatial learning across the curriculum.

While this multiple case study examining in-depth the understandings of four educators and two students conceptualizations of IT and GIS in the world and schools I would like to study a larger group to broaden the scope of the research. Would a larger group of educators and students learning GIS in different locations and through various methods produce similar results? Would there be more categories of description as the pool of meanings increases in size? Would educational GIS users in other countries have similar or different conceptualizations and representations? Each individual processes and relates
their experiences differently from others, are the common understandings culturally or geographically influenced?

Additionally, I would like to investigate the sustainability issues that emerged through this research. The participants began to question the community of GIS users in education. Where and under what circumstances do GIS users, integration and programs sustain momentum? Do successful GIS programs grow organically from educator interest and diffusion or through the influence of other forces such as change agents? Are these influenced by grant-funded research, corporate sponsorship or community partnerships? And as brought forth by the participant’s observations, what happens to the GIS program when one innovator moves on?

The final line of research that I would like to pursue is to investigate students’ spatial learning across the curriculum. What spatial skills and cognitive processes are K-12 students utilizing in the classroom? Are there subject areas that are building spatial understandings implicitly or explicitly? How does the use of GIS and other IT affect spatial thinking? Where in K-12 education is there a need for spatial cognition theory research and integration? If students are expected to navigate space and representational data, how can spatial cognition theories and research further inform the K-12 learning processes? The long awaited and upcoming National Academies of Science publication *Learning to Think Spatially: GIS as a Support System in the K-12 curriculum* (in press) may begin to answer some of these questions and provide a structure for K-12 education however, it is important to me that student voices and student conceptualizations of spatial experiences and understandings be tied to spatial cognition research. The use of representations and
phenomenographic research methods can provide important context to these and other types of studies.
REFERENCES


National Geographic Education Foundation. (2002). *National Geographic-Roper 2002 Global Geographic Literacy Survey*


APPENDIXES
APPENDIX A

GIS in Education Course Demographics
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<th>Year</th>
<th>Semester</th>
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<td>Undergraduate Student <em>(Social Studies)</em></td>
<td>Pre-service Teacher</td>
<td>High School (9-12)</td>
<td>---</td>
</tr>
<tr>
<td>Year</td>
<td>Season</td>
<td>Gender</td>
<td>Race/Ethnicity</td>
<td>Status / Program</td>
<td>Profession</td>
<td>Grade</td>
<td>School Type</td>
</tr>
<tr>
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<td>-------------</td>
</tr>
<tr>
<td>2003</td>
<td>Spring</td>
<td>Male</td>
<td>Caucasian</td>
<td>Graduate Student (Instructional Technology)</td>
<td>Math Teacher</td>
<td>5th</td>
<td>Public Elementary School: Traditional</td>
</tr>
<tr>
<td>2003</td>
<td>Spring</td>
<td>Male</td>
<td>African American</td>
<td>Post-Baccalaureate Studies*</td>
<td>Information Services Consultant</td>
<td>Educators and Administrators</td>
<td>Private School</td>
</tr>
<tr>
<td>2003</td>
<td>Spring</td>
<td>Male</td>
<td>Caucasian</td>
<td>Post-Baccalaureate Studies*</td>
<td>Vocational Education Teacher</td>
<td>6-8</td>
<td>Public Middle School: Magnet</td>
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<tr>
<td>2003</td>
<td>Spring</td>
<td>Female</td>
<td>Caucasian</td>
<td>Graduate Student (GIS Certificate Program)</td>
<td>Librarian</td>
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<td>University</td>
</tr>
<tr>
<td>2004</td>
<td>Spring</td>
<td>Female</td>
<td>Caucasian</td>
<td>Undergraduate Student (Social Studies Education)</td>
<td>Pre-service Teacher</td>
<td>High School (9-12)</td>
<td>---</td>
</tr>
<tr>
<td>2004</td>
<td>Spring</td>
<td>Male</td>
<td>Caucasian</td>
<td>Post-Baccalaureate Studies*</td>
<td>Classroom Science Teacher</td>
<td>8th</td>
<td>Private Middle School</td>
</tr>
<tr>
<td>Year</td>
<td>Season</td>
<td>Gender</td>
<td>Ethnicity</td>
<td>Program</td>
<td>Specialization</td>
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<td>School Type</td>
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<tr>
<td>2004</td>
<td>Spring</td>
<td>Male</td>
<td>Caucasian</td>
<td>Post-Baccalaureate Studies*</td>
<td>Lateral Entry Social Studies Teacher</td>
<td>8th</td>
<td>Public Middle School: Traditional</td>
</tr>
<tr>
<td>2004</td>
<td>Spring</td>
<td>Male</td>
<td>Caucasian</td>
<td>Undergraduate Student (Social Studies Education)</td>
<td>Pre-service Teacher</td>
<td>High School (9-12)</td>
<td>---</td>
</tr>
<tr>
<td>2004</td>
<td>Spring</td>
<td>Female</td>
<td>Caucasian</td>
<td>Graduate Student (Social Studies Education)</td>
<td>Pre-service Teacher</td>
<td>High School (9-12)</td>
<td>---</td>
</tr>
</tbody>
</table>

*According to the University: The Post-Baccalaureate Studies (PBS) classification is designed for U. S. citizens or permanent residents who wish to undertake academic work beyond the baccalaureate degree but who are not currently admitted to a degree program.
APPENDIX B

GIS in Education Course Overview
University Course Justification:
GIS in Education (ECI 490 and GEO 490)

Geographic Information Systems (GIS) are ubiquitous technology in industry and government; serving as the spatial information bridge between the two. The Department of Curriculum & Instruction’s GIS in Education course has been offered (under the ‘experimental’ course number ECI 496e) four times since 2000; three sections in Spring 2000, 2001 and 2003, and once in Summer Session 2, 2002. As far as we know, it is the only semester-length GIS course offered at a College of Education. Most GIS teacher education is offered in summer institutes and/or weekend workshops. Numerous studies have demonstrated that short-term learning venues are inadequate to sustain GIS in classroom use.

The experimental GIS in Education course has served as a national and international model to pioneers of GIS in teacher education (Alibrandi & Palmer-Moloney, 2001). Through the experimental period, a pedagogy of constructivism, collaboration and community service has yielded higher rates of “lateral uptake” (across K-16 disciplines and across-school faculties) as well as “vertical uptake” of the technology over time (Alibrandi & White, in review).

GIS in Education has been approved as an introductory course for the cross-disciplinary GIS certificate granted by the College of Forestry, however, issues over transferable grading have prompted the proposed cross-listing as ECI 490 and GEO 490.

Offering the GIS in Education course under the two (ECI and GEO) options opens the course to university-wide students who might otherwise be unaware of its existence and allows both graded (GEO 490) and pass/fail (ECI 490) options. ECI 490 will remain because of its experimental and evolving nature as a constructivist education course that integrates the experiences and innovations of its students in a dialogic manner to improve the design of instruction. We are nationally recognized for our leadership in this process. For those interested in applying GIS in Education to GIS certificate programs for which a grade is required, the cross-listed GEO 490 option is also proposed. The ECI and GEO descriptions are differentiated in the Course Description below.
Enrollment:
Student registration in any one semester is limited by computer lab availability and seating.

Proposed Syllabus Follows, next 5 pages.
GIS in Education: ECI 490 ~ GEO 490

Instructors:
Dr. Marsha Alibrandi  Shannon White  Barbaree Duke

Office Hours: Thursdays, 4-5pm
Course Website: http://courses.****.edu/eci496e

Course Description
Geographic Information Systems (GIS) for educators. Instruction in GIS technologies with readings and applications in school-community settings. Face-to-face class with at-home ‘virtual campus’ lab components. For those of intermediate computer skills, this course facilitates development of technology portfolio products for initial teacher licensure. Readings on critical perspectives and social implications of GIS. Students will collaborate with community GIS partners in developing final projects.

Course Objectives
Students will:
Master Geographic Information System skills: integrating data based information into spatial representations
Apply GIS software to K-16 curricular or educational problems and settings
Critically investigate the uses and political agendas driving GIS in real world applications
Collaborate with community partners toward long-term sustainable school-community GIS partnership
Design a transportable GIS project for school/community use and demonstration
**NCATE Statement:**
This class is part of our College's initial program to prepare professional educators. In this course, you will work with technology to apply your knowledge of your content area to build your knowledge of pedagogy (how to teach). This knowledge of the practice of educators is called professional knowledge. Our College’s conceptual framework is available at:

http://ced.****.edu/ncate/conceptual_framework/page_H.html

**Requirements:**

**Class Attendance and Participation.**
This class involves learning a complex technology as well as critically analyzing the use of GIS in the classroom and world. It is very important that you attend all classes.

**Your participation**
It is your responsibility to attend class, be on time, and be prepared. If extenuating circumstances arise and you cannot make a class, please notify one of the instructors. It is the student's responsibility to make up all missed work. Because this is a voluntary course, no unexcused absences are anticipated. If your final project is completed before the final presentation date, your attendance is optional.

**Facilitation of Class Discussion.**
In line with the university Writing and Speaking initiative, you will prepare and lead the class in discussion of required readings at least once during the semester. See the syllabus for those dates.

**Final Project**
You will create a transportable GIS project (i.e., .apr) that can be used in a classroom or by an educational institution or organization. This will be in a topic/content area of your choice. This project will include various GIS data that the student finds on the internet, is given by an agency, researches, collects, and/or creates. The final products for this project will be:

1. a transportable .apr project that corresponds to K-16 curricular and/or administrative goals
2. a lesson plan/procedure file for recreating the project (to be discussed further in class)
3. Metadata and bibliographic references for all retrieved data, files, images and references

(ECI 490) Participation in Messageboard Discussions.
Each week you are required to participate in the online discussion before coming to class. You will respond to the prompt that is posted (that correlates with the assigned readings or activities) and then respond to at least one of your classmates’ responses in a threaded discussion format.

Grading:
Grading will be based on quiz grades, class presentations, and the Final Project, weighted in the following manner: Quizzes = 25%, Presentations, Virtual Campus and other in-class or homework assignments=25%, Final Project=50%. Pass/fail option is available to all students.

The following +/- letter grade scale will be used for this class:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>97-100</td>
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<tr>
<td>A</td>
<td>94-96</td>
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<tr>
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<td>84-86</td>
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<tr>
<td>B-</td>
<td>80-83</td>
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<tr>
<td>C+</td>
<td>77-79</td>
</tr>
<tr>
<td>C</td>
<td>74-76</td>
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<td>C-</td>
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<td>67-69</td>
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<td>D</td>
<td>64-66</td>
</tr>
<tr>
<td>D-</td>
<td>60-63</td>
</tr>
<tr>
<td>F</td>
<td>59 or less</td>
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</tbody>
</table>

Required and Optional Texts:


**OPTIONAL:**

1. *Getting to Know ArcView GIS* (most recent edition) by Editors of ESRI Press (editor); Publisher: Environmental Systems Research; ISBN: 1879102463 Book & CD: $45


**Students with disabilities**

See: http://www.****.edu/provost/offices/affirm_action/dss/

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 555-****. For more information on *************’s policy on working with students with disabilities, please see: http://www.****.edu/provost/hat/current/appendix/appen_k.html


**Academic Integrity:**

The student code of conduct is available at: [http://www.fis.****.edu/****legal/41.03-codeof.htm](http://www.fis.****.edu/****legal/41.03-codeof.htm)

“8.3 The act of submitting work for evaluation or to meet a requirement is regarded as assurance that the work is the result of the student's own thought and study, produced without assistance, and stated in the student's own words, except as quotation marks, references, or footnotes acknowledge the use of other sources. Submission of work used previously must first be approved by the instructor.”

The honor pledge will be used in this course: “I have neither given nor received unauthorized aid on this test or assignment.” It is the teacher's understanding and expectation that the student's signature on any test or assignment means that the student neither gave nor received unauthorized aid.

**Transportation**

Students are responsible and liable for their own transportation to community partner sites. Initial interviews with community partners may be done by telephone or Email (we recommend spring break if you are currently teaching).

**Course Schedule:**

Course meets Thursday evenings from 6 to 8:50 pm in Poe Hall, Room 422.
In inclement weather, Emailed instructions will be sent: CHECK YOUR EMAIL!

<table>
<thead>
<tr>
<th>Week #</th>
<th>Planned Activities</th>
<th>For Next Class:</th>
</tr>
</thead>
</table>
| 1      | I. Introductions, Find a Study Buddy, Project/Photo Release  
II. Text books and Syllabus  
III. Wolfware (submit brief introduction to Message board & submit a word doc to "Submit Assignments") & Virtual Campus (VC) Request code from **** Library. VC Preview  
IV. ESRI Schools Request Information  
Purchase Textbooks  
NOTE: Visit class website for price discounts  
Read Chaps 1-2: Alibrandi, do GIS connection activities from CD |
| 2      | I. Questions about activities, Virtual Campus, etc.  
II. ArcVoyager Buttons & Functions Continued: Earthquakes, Faults, and Volcanoes Case of the Missing Ship/ Chocolate Caper  
III. Displaying Data Legends & Creating simple Layouts  
IV. VC Preview:Tables, Promote, New Set  
V. Turn Me Loose: Create your own "Where are you?" assignment requirements | Complete Module One of the Virtual Campus: Send a copy of your certificate to us a Wolfware Submit (copy the file from VC)  
Begin your "Where are you?" Submit to wolfware 2 documents: Clue and answer in text (.txt or .doc) and a map view layout (.jpg) Due in week 4 |
<p>| 3      | I. Questions about the Virtual Campus or last week's class? | Begin Module 2 of the Virtual |</p>
<table>
<thead>
<tr>
<th></th>
<th>II. QUIZ: Practical applications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>III. Spatial Cognition and Competencies (Dr. Alibrandi)</td>
</tr>
<tr>
<td></td>
<td>IV. Finish going over Where are you?</td>
</tr>
<tr>
<td></td>
<td>V. layouts, Query-building</td>
</tr>
<tr>
<td>4</td>
<td>Transition to ArcView</td>
</tr>
<tr>
<td></td>
<td>Posing Good Questions</td>
</tr>
<tr>
<td></td>
<td><strong>VC Preview TAKE OPEN NOTES!!</strong> QUIZ next week!</td>
</tr>
<tr>
<td></td>
<td>Setting the working directory</td>
</tr>
<tr>
<td></td>
<td>Tables</td>
</tr>
<tr>
<td></td>
<td>Queries/Convert to Shapefiles</td>
</tr>
<tr>
<td>5</td>
<td>I. Questions about the Virtual Campus or last week's class?</td>
</tr>
<tr>
<td></td>
<td>II. Curriculum connections (Barbaree ppt)</td>
</tr>
<tr>
<td></td>
<td>III. Community Partner Assignment (handout) <strong>Due March 2 via Wolfware submit &amp;</strong></td>
</tr>
<tr>
<td></td>
<td>(Assign Beyond Maps 1-3 and individual chapters)</td>
</tr>
<tr>
<td></td>
<td>IV. Brentwood .apr activity</td>
</tr>
<tr>
<td></td>
<td>V. Bringing in data from the web - zipping and unzipping &amp; Projections, Projection issues, and Projection wizard. See handout and data on resources page.</td>
</tr>
<tr>
<td>6</td>
<td><strong>Lab Hour Available:</strong> (email instructors for assistance)</td>
</tr>
<tr>
<td></td>
<td>I. Presentations: from Beyond Maps <strong>no more than</strong> 10-12 minutes; 6-8 PPT slides</td>
</tr>
</tbody>
</table>

|   | Campus: |
|   | Check the message board for online discussion. |
|   | Submit your "Where are you?" **Submit to wolfware** 2 documents: Clue and answer in text (.txt or .doc) and a map view layout |
|   | Complete/submit VC Module 2 |
|   | Complete Module 2 of the Virtual Campus |
|   | **Reading:** Beyond Maps Chapters 1-3 |
|   | Begin VC Module 3 |
|   | **Prepare** Beyond Maps Chapter PPT presentation for next week. |
|   | **Reminder:** |
|   | Complete Module 3 |
|   | **Read** Chapter 5 of GIS in Schools and post your thoughts and/or impressions of GIS in
II. Discussion: Critical issues of GIS technologies
   WHOSE technology is it? Whose agendas are represented in GIS formats, policies & products?
   Why is a critical examination of GIS essential to ethical representation and application? (STS)

III. Data Resources (online, ****, ESRI, County sites, Geography Network) See our class resources page to get to these data sites and introduce Final Project (requirements, expectations, ect.)

Project Proposals will be due after Spring Break via Wolfware.

---

I. Questions about Virtual Campus or last week's class?

II. Creating data from primary sources: Recent Earthquake data

III. Scenario: Using local data, teams will represent a controversial issue before the County GIS Department. (Building an .apr) Cooperative activity

VC Preview >>> OPEN NOTES!! QUIZ next week!! <<<

IV. Joining Tables

V. Mapping Our World activity/Assignment

---

7

Begin Module 4**

Explore **** GIS in Education website and resources and post your thoughts to the message board (ECI 490)

Practice Joining Tables!

Contact Community Partner

Interview due next week.

---

8

Open Lab: (email instructors for assistance)

Discuss Community Partnerships

Practical App QUIZ: Joining Tables and smoothing data

Continue working on VCMod. 4

Community Partner
<table>
<thead>
<tr>
<th>Guest Speaker: Steve Morris, ****’s GIS Library</th>
<th>Interview Due</th>
</tr>
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</table>
| **9** SPRING BREAK: NO CLASS  
VC Module 4, Lesson 4 | Complete VC Module 4, Lesson 4 |
| | Read 4, 6, 8, 10 & 13 in GIS in Schools  
Post your Top 10 hits on the message board (ECI 490) |
| **10** I. Questions about the Virtual Campus or last week's class?  
II. Discuss community partners  
III. Mapping Our World activities discussion  
IV. Advanced Legends (saving your .avl file) | Begin Module 6  
Over the next month: Present the basic Wake County GIS presentation to a class or colleagues. Have someone take a digital photo of the presentation. |
| **11** I. Questions about the Virtual Campus or last week's class?  
II. Hotlinking / catch up on skills workshop (Build your own .apr)  
III. Satellite imagery and Aerial Photos (using photos as a base map, photo extensions, downloading aerial photographs)  
IV. Research data for the final project (time permitting) | Complete VC Module 5  
Work on final project - finding data, etc. |
| **12** Lab (email instructors if you want to meet) | Begin Module 6 |
| Complete VC Module 6. Turn in PDF version of your certificate by | |
April 1 at 11pm via WolfWare. This can be found in your Virtual Campus Course Transcripts Section. You can email it to yourself or download the pdf -- it must be sent to Work through the Trimble GPS Tutorial (http://www.trimble.com/gps/) This requires a flash/shockwave plug-in.

| 13 | I. Questions /Concerns?  
    | II. Guest Speakers: GPS presentation 6-7:30pm Please be prepared to go outside and be on time to class!  
    | III. Making projects transportable | Complete Module 6  
    | Work on final project - finding data, etc. |
| 14 | Lab (email instructors for assistance)  
    | Assisted Work on Final Project | Work on final project - finding data, etc. |
| 15 | Lab (email instructors for assistance)  
    | Assisted Work on Final Project | Work on final project - finding data, etc.  
    | **Project MUST be Transportable!**  
    | For next week |
| 16 | Final Project Presentations  
    | A final transportable copy of your project and data should be turned in at this time  
    | Evaluations |

Previous Syllabus found on following pages.
<table>
<thead>
<tr>
<th>Week</th>
<th>Topics/Activities</th>
<th>Skills Focus:</th>
<th>Assignment/s</th>
<th>DUE</th>
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</thead>
<tbody>
<tr>
<td>Jan 9</td>
<td><strong>Introductions (Course, Team)</strong> Simulation: Small Town Web Exploration: What is GIS &amp; What are its potential Educational applications? Introduction to essential skills à Skills Self-Assessment</td>
<td>Geographic Problem-solving Multi-tasking with multiple windows Net-Surfing, Searching &amp; Bookmarking Your Unity account and Email Accessing the Class Locker Intro to ESRI’s virtual campus</td>
<td>Web Exploration &amp; Presentation WebQuest (yellow sheet) Getting to Know ArcView GTKAV Chapters 1-3 Virtual Campus Module</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Presentations (Webquest) Review of GTKAV (Quiz) ArcVoyager: World Atlas Where are you? Earthquakes! &amp; Open Notes</td>
<td>File management, Extensions, etc.- Downloading files File Transfer Protocol (FTP)- BEGIN LAYOUTS</td>
<td>· GTKAV Chaps 4-6 · Design a &quot;Where Are You?&quot; in ArcVoyager · Virtual Campus Module 2</td>
<td>Virtual Campus Module 1</td>
</tr>
<tr>
<td>Date</td>
<td>Activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
| 30   | Review GTKAV 4-6 (Quiz)  
Where are You?  
Exchange  
Earthquakes  
The Missing Ship  
   | File management, Extensions, etc.  
Downloading files  
File Transfer Protocol (FTP)  
Screen captures/Screen prints  
**ADVANCED Layouts**  
Excel and database principles  
   | (Load ArcVoyager, SE)  
Revise "Where are You?"  
Virtual Campus Module 3  
   | Virtual Campus Module 2  
   |
| Feb 6 | Review GTKAV 7-10  
Race & Ethnicity activity  
"Turn Me Loose"  
   | Compressing/decompressing files with WinZip  
Importing Image formats:  
   * .bmp, .jpeg  
What data is available on CD and where to find it,  
   | GTKAV Chaps 7-10  
   | Virtual Campus Module 3  
   |
| 13   | Review GTKAV 11-12  
**Review Projections, Map Units, and Distance Units**  
"Turn Me Loose" (cont.)  
Lesson Plan format  
   | Shapefiles: .shp’s  
Project Window management (.apr’s)  
Designing GIS learning activities  
**Problem-solving and the NC CD of data**  
   | GTKAV Chaps 11-12  
Design a Lesson Plan using NC Data  
   | Virtual Campus Module 4  
   |
| 20   | Guest Speaker: Gary Thompson  
**Integrating GPS**  
   |   | GTKAV Chaps 13-14  
   | Virtual Campus Module 5  
   |
| 27   | Review Chaps 13-14  
**ACTIVITY**  
   | Importing **DATA FROM THE WEB**  
Documenting Sources with Metadata  
   | GTKAV Chaps 15-16  
   | Virtual Campus Module 6  
<p>|</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Mar 6</td>
<td>Review Chaps 15-16 Using Add Event theme (activity with hotlinks)</td>
<td>Creating Hotlinks Asking the map questions (Queries) Make appointment to meet with a GIS technician or office Preliminary project proposal</td>
</tr>
<tr>
<td>13</td>
<td>SPRING BREAK</td>
<td>GIS in the Community: Field Visit</td>
</tr>
<tr>
<td>20</td>
<td>Constructing an .apr Project with learning activities …</td>
<td>Making projects transportable Using DRGs and DOQQs With a partner, select from Chaps 5-9, a priority (6, 7, 8 or 9) Considering your priority, what data sets would you choose to represent your interests? Present next week Field visit report</td>
</tr>
<tr>
<td>27</td>
<td>Presentations from Beyond Maps</td>
<td>Union, Clip, and Intersect Heads up digitizing Creating your own themes Revised Project Proposal identifying data sets needed</td>
</tr>
<tr>
<td>April 3</td>
<td>Guest Speaker: Steve Morris, GIS</td>
<td>Slide/Lecture Individual projects</td>
</tr>
<tr>
<td>Librarian</td>
<td>Assisted Final Project Lab</td>
<td>Individual projects</td>
</tr>
<tr>
<td>--------------</td>
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</tr>
<tr>
<td>10</td>
<td>Guest Speaker: GPS with Curt Johnson, Gary, NC Geodetic Survey Thompson</td>
<td>Individual projects</td>
</tr>
<tr>
<td>17</td>
<td>Assisted Final Project Lab</td>
<td>Individual projects</td>
</tr>
<tr>
<td>24</td>
<td>Project Presentations!</td>
<td></td>
</tr>
<tr>
<td>May 1</td>
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</table>
Teaching GIS in Middle School: Scope and Sequence Outline

I. What is GIS
   A. GIS: What’s the Scoop?
   B. Where is GIS?
   C. Where is here? (GIS fable/How do I get there?)

II. Maps and Data
   A. Online Maps
   B. ArcVoyager
      1. Teach Me
      2. Show Me
      3. Point Me
      4. Turn Me Loose Project
   C. ArcView 3.x
      1. Adding Data
      2. Managing Data
      3. Querying, Selection, and Convert to Shapefile
      4. Latitude, Longitude, and Map Projections
      5. GPS
      6. Hot Linking

III. Projects
   A. How Do You Get There? Project
   B. Where Are You? Project
   C. Research and Mapping Project
   D. Puzzles Project

IV. Extensions
   A. Joining Tables
   B. Geoprocessing
<table>
<thead>
<tr>
<th>TIME (class days)</th>
<th>SKILL</th>
<th>ACTIVITY</th>
<th>RESOURCE(Author)</th>
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<tbody>
<tr>
<td>2-3</td>
<td>Intro to GIS</td>
<td>GIS: What’s the Scoop?</td>
<td>Duke</td>
</tr>
<tr>
<td>2-3</td>
<td>Intro to GIS</td>
<td>Where is GIS?</td>
<td>Alibrandi</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>GIS in the Classroom</em></td>
</tr>
<tr>
<td>2</td>
<td>Spatial Cog.</td>
<td>How Do I Get There? Project</td>
<td>Alibrandi, Duke</td>
</tr>
<tr>
<td>2</td>
<td>Spatial Thinking</td>
<td>Map Mysteries</td>
<td>Kerski</td>
</tr>
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<td>2</td>
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<td>Online Maps</td>
<td>White</td>
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<tr>
<td>2</td>
<td>ArcVoyager/ArcView</td>
<td>Getting to Know your Buttons</td>
<td>Alibrandi, White</td>
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<td></td>
<td></td>
<td></td>
<td><em>GIS in the Classroom</em></td>
</tr>
<tr>
<td>1</td>
<td>Show Me</td>
<td>Show Me Practice ?s</td>
<td>ESRI ArcLessons</td>
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<tr>
<td>.5</td>
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<td>+Case of the Missing Ship</td>
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<td>Point Me Practice Questions</td>
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<td>Earthquakes, Volcanoes and Faults</td>
<td>Thompson, Hagevik</td>
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<td>Making and Mapping a Simple Table</td>
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<td>Text files into GIS</td>
<td>Adding Current Earthquake and Hurricane Data</td>
<td>Duke and White</td>
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<td>TIME (class days)</td>
<td>SKILL</td>
<td>ACTIVITY</td>
<td>RESOURCE (Author)</td>
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<td>Layouts/Symbols</td>
<td>Creating a Layout</td>
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<td>ArcView</td>
<td>Saving a JPEG Map</td>
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<td>Spatial Thinking</td>
<td>☀Where Are You? Project</td>
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<td></td>
<td></td>
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<td>and Duke</td>
</tr>
<tr>
<td>1-2</td>
<td>ArcView Data</td>
<td>☀Adding Data to ArcView</td>
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<td>Organization</td>
<td>☀Managing Data and Metadata</td>
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<td>Query/Analysis</td>
<td>Querying, Selection and Convert to Shapefile</td>
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<td>Latitude, Longitude, Map Projections and Great Circles</td>
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<td>☀Moving Points from GPS into GIS</td>
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<td>(Consider a guest speaker on GIS)</td>
<td></td>
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<td>1 week</td>
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<td>+Puzzles Project</td>
<td>Duke</td>
</tr>
</tbody>
</table>

**Symbol Legend**

* Activities to exclude for 9-week version of the course.
+ Activities to minimize or offer as extra credit assignments for the 9-week version (For example, choose 1 of 3).
☀ Activities to choose lesser time requirement for 9-week version.
Resources


GIS in Education Online: <http://www.ncsu.edu/gisined>.


White, Shannon H. 2004. GIS in Education Activities for Students and Teachers.
APPENDIX D

Letter of Introduction & Informed Consent Form
Dear ___________ and Family,

My name is Shannon White and I am a researcher at Atlantic Coast University. Over the next two months, January and February, I will be conducting a study of students and educators and their understandings of Geographic Information Systems (GIS). The purpose of this study is to investigate the conceptualizations of GIS, Instructional Technology (IT) and GIS in schools. Specifically, I am interested in how students and educators and students represent these concepts in drawings and how they describe GIS, IT and these technologies use(s) in schools. The attached Informed Consent Form explains the research project in detail but I also wanted to give you some idea of my personal background and why you have been selected as a possible participant in this study.

I was an educator at Colonial Williamsburg for four years prior to moving to North Carolina. I moved to Raleigh to work on my Master’s degree in Social Studies education. I also completed a GIS certificate program while enrolled at NC State University. One of my personal goals was to complete my Ph.D. in education. The opportunity arose to continue my work studying GIS and IT in the Department of Curriculum and Instruction at NC State. While taking classes I have also taught courses in introductory geography, cultural geography and GIS in Education. I have worked with numerous elementary, middle and high school teachers to integrate GIS technology in the classroom. In addition, I have taught teacher workshops and assisted in teaching middle school GIS classes. This technology is the focus of my dissertation and of personal interest to me as a social studies educator. Mapping and spatial skills are very important to understanding how we influence the world around us and are influenced by that same world. GIS in education research is very limited at this time and I hope that this study will help GIS researchers, software developers and educators better understand how students and educators think about and conceptualize the technology.

I have chosen the participants based on their prior knowledge of and work with GIS in the middle school. As a student who has completed at least two GIS courses and has assisted in teacher workshops about GIS, your views and opinions are important to future generations of GIS users in the schools. I will conduct three interviews in which you will be asked to draw a concept map of a given topic. Then I will ask you several questions about the representation and the topic. I will arrange the interviews by phone with you to fit your busy schedule.

I have included a more detailed description of the entire study in the attached Informed Consent document. If you decide you would like to be a member of this study, please sign the last page of the Informed Consent Form and return it to me in the self-addressed, stamped envelope I have included. I look forward to hearing from you and please feel free to contact me if you should have any further questions about this study. My home phone number is: [redacted] and my cell phone number is [redacted]. My email address is: Shannon_White@ncsu.edu. Thank you for considering this request.

Sincerely,

Shannon H. White
North Carolina State University
INFORMED CONSENT FORM
(Minors)

Title of Study: Student and Educator Conceptualizations of Geographic Information Systems, Instructional Technology and GIS in Schools

Principle Investigator: Shannon White, Doctoral Student
Faculty Sponsor: Marsha Alibrandi, Ed.D.
Associate Professor
College of Education, Department of Curriculum & Instruction
Dept. of Curriculum and Instruction

We are asking you to participate in a research study. The purpose of this study is to investigate student and educator conceptualizations of and experiences with Geographic Information Systems (GIS, Instructional Technology (IT) and GIS in schools. Very few schools in the U.S. currently use GIS in interdisciplinary instruction. The future development of GIS education will benefit from an understanding of student and educator knowledge, understandings and experiences associated with GIS, IT and GIS in schools.

INFORMATION
Participating in the Study:
1. Each student will:
   a. Participate in three (3) interviews
      i. Each interview will take place at an agreed upon location (such as after school in a classroom) in the Raleigh, Durham, Chapel Hill, North Carolina area.
      ii. Each interview will be in video and audio taped.
      iii. Each interview will last approximately 1 hour.
      iv. Interviews will be conducted after school or on weekends
      v. Location and time will be agreed upon by the researcher and the parent(s) and student.
   b. Produce a representation (drawing) at the start of each interview.
      i. The time for these drawings is included in the interview.
2. Time Required
   a. Each interviews will require approximately sixty (60) minutes each.
      i. These will be video and audiotaped and later transcribed.
   b. If additional information is required, the researcher will conduct follow-up telephone interviews or email communication only on an as-needed basis.
   c. Meetings will be conducted over a six (6) to eight (8) week period in the Winter of 2005.
   d. Transcription and reporting will be completed in the Winter of 2005.
   e. Preliminary research reports will be sent to educators, students and parents in the Spring of 2005 for review.
      i. At that time, consent forms will be issued in case the educators see fit to reveal the community or school name.
      ii. Audio and video tapes will be destroyed unless the researcher is given permission in writing to use them for future presentations and articles.
   f. It is anticipated that the final dissertation will be completed in the late Spring/early summer of 2005.

RISKS
The risk involved in participating in this study is minimal as the questions and concept mapping tasks are similar to routine classroom activities.

BENEFITS
Benefits to students and educators include a reflective opportunity on the learning of a technology and the knowledge that they are pioneers in GIS education. Successive “generations” of educators and students using GIS will benefit from an understanding of the conceptualizations and understandings of GIS users known as “early adopters.”

CONFIDENTIALITY
The information in the study records will be kept strictly confidential. Data will be stored securely. No reference will be made in oral or written reports that could link any one individual to the study. Audio and video tapes will be destroyed unless the researcher is given permission (below) to use portions or excerpts of them for future presentations and articles.

Do you agree to let the researcher use your video and audio tapes in presentations and articles? (Please select one) Yes ________ No ________

COMPENSATION (if applicable)
Students will receive GIS gear (i.e. hat, tee-shirt, buttons, etc) for their participation in this study.

EMERGENCY MEDICAL TREATMENT (if applicable)  N/A

CONTACT
If you have questions at any time about the study or the procedures, you may contact the researcher, Shannon White, at Campus Box 7801, Raleigh, NC 27695-27801/ 402-H Poe Hall, or (919) 821-5521(h)/(919) 696-5059. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. Matthew Zingraff, Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 7514, NCSU Campus (919/513-1834) or Mr. Matthew Ronning, Assistant Vice Chancellor, Research Administration, Box 7514, NCSU Campus (919/513-2148)

PARTICIPATION
Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed at your request.

CONSENT
“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may withdraw at any time.”

Subject's signature_______________________________________ Date _______________

For Students under 18:

I, __________________________, parent/legal guardian of the above student, have read and received a copy of this form, and approve of the student’s participation.

Parent signature_______________________________________ Date _______________

Investigator's signature__________________________________ Date _______________
Introductory letter to adult participants

Dear ___________________,

My name is Shannon White and I am a researcher at Atlantic Coast University. Over the next two months, January and February, I will be conducting a study of students and educators and their understandings of Geographic Information Systems (GIS). The purpose of this study is to investigate the conceptualizations of GIS, Instructional Technology (IT) and GIS in schools. Specifically, I am interested in how students and educators and students represent these concepts in drawings and how they describe GIS, IT and these technologies use(s) in schools. The attached Informed Consent Form explains the research project in detail but I also wanted to give you some idea of my personal background and why you have been selected as a possible participant in this study.

I was an educator at Colonial Williamsburg for four years prior to moving to North Carolina. I moved to Raleigh to work on my Master’s degree in Social Studies education. I also completed a GIS certificate program while enrolled at NC State University. One of my personal goals was to complete my Ph.D. in education. The opportunity arose to continue my work studying GIS and IT in the Department of Curriculum and Instruction at NC State. While taking classes I have also taught courses in introductory geography, cultural geography and GIS in Education. I have worked with numerous elementary, middle and high school teachers to integrate GIS technology in the classroom. In addition, I have taught teacher workshops and assisted in teaching middle school GIS classes. This technology is the focus of my dissertation and of personal interest to me as a social studies educator. Mapping and spatial skills are very important to understanding how we influence the world around us and are influenced by that same world. GIS in education research is very limited at this time and I hope that this study will help GIS researchers, software developers and educators better understand how students and educators think about and conceptualize the technology.

The participants will be chosen based on their completion of a GIS in education course. As an educator who has successfully completed the GIS in Education course at NC State I would like to invite you to participate in this study. Your views and opinions are important to future generations of GIS users in the schools. I will conduct three interviews in which you will be asked to draw a concept map of a given topic. Then I will ask you several questions about the representation and the topic. I will arrange the interviews by phone with you to fit your busy schedule.

I have included a more detailed description of the entire study in the attached Informed Consent document. If you decide you would like to be a member of this study, please sign the last page of the Informed Consent Form and return it to me in the self-addressed, stamped envelope I have included. I look forward to hearing from you and please feel free to contact me if you should have any further questions about this study. My home phone number is: (919) 821.5521 and my cell phone number is (919) 696.5059. My email address is: Shannon_White@ncsu.edu. Thank you for considering this request.

Sincerely, Shannon H. White
North Carolina State University
INFORMED CONSENT FORM
(Adult)

Title of Study: Student and Educator Conceptualizations of Geographic Information Systems, Instructional Technology and GIS in Schools

Principle Investigator: Shannon White, Doctoral Student
Faculty Sponsor: Marsha Alibrandi, Ed.D.
Associate Professor
College of Education, Department of Curriculum & Instruction

We are asking you to participate in a research study. The purpose of this study is to investigate student and educator conceptualizations of and experiences with Geographic Information Systems (GIS), Instructional Technology (IT) and GIS in schools. Very few schools in the U.S. currently use GIS in interdisciplinary instruction. The future development of GIS education will benefit from an understanding of student and educator knowledge, understandings and experiences associated with GIS, IT and GIS in schools.

INFORMATION
Participating in the Study:

3. Procedures
a. Four (4) students and four (4) K-12 educators will be interviewed three (3) times at agreed upon locations (such as after school in a classroom) in the Raleigh, Durham, Chapel Hill, North Carolina area in video and audio taped interviews of interviews of approximately 1 hour (students) to 1 1/2 hours (educators).
b. Educator and student interviews will be conducted after school or on weekends and will be negotiated by the researcher and the educator/parent and student.
c. All interviews will include the production of a representation (drawing). The time for these drawings is included in the interview.

4. Time Required
a. Three (3) individual student interviews will require sixty (60) minutes each. These will be video and audiotaped and later transcribed.
b. Three (3) individual educator interviews will require one hour and a half (1 1/2) each. These will be video and audiotaped and later transcribed.
c. If additional information is required, the researcher will conduct follow-up telephone interviews or email communication only on an as-needed basis.
d. Meetings will be conducted over a six (6) to eight (8) week period in the Winter of 2005. Transcription and reporting will be completed in the Winter of 2005. Preliminary research reports will be sent to educators, students and parents in the Spring of 2005 for review. At that time, consent forms will be issued in case the educators see fit to reveal the community or school name. Audio and video tapes will be destroyed unless the researcher is given permission, in writing, to use them for future presentations and articles. It is anticipated that the final dissertation will be completed in the late Spring/early Summer of 2005.

RISKS
a. For students, the risk involved in participating in this study is minimal as the questions and concept mapping tasks are similar to routine classroom activities.
b. For educators, the risk involved is comparable to participating in a normal conversation providing information about their knowledge regarding a course or a project.

BENEFITS
Benefits to students and educators include a reflective opportunity on the learning of a technology and the knowledge that they are pioneers in GIS education. Successive “generations” of educators and students using GIS will benefit from an understanding of the conceptualizations and understandings of GIS users known as “early adopters.”

CONFIDENTIALITY
The information in the study records will be kept strictly confidential. Data will be stored securely. No reference will be made in oral or written reports that could link any one individual to the study. Audio and video tapes will be destroyed unless the researcher is given permission (below) to use portions or excerpts of them for future presentations and articles.

If you agree to allow the audio and video tapes to be used in presentations and publications, please initial here _____________.

COMPENSATION (if applicable)
Educators will be asked to join the researcher for a restaurant meal at a time convenient for the participants. Students will receive GIS gear (i.e hat, tee-shirt, buttons, etc).

EMERGENCY MEDICAL TREATMENT (if applicable) N/A

CONTACT
If you have questions at any time about the study or the procedures, you may contact the researcher, Shannon White, at Campus Box 7801, Raleigh, NC 27695-27801/ 402-H Poe Hall, or (919) 821-5521(h)/ (919) 696-5059. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. Matthew Zingraff, Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 7514, NCSU Campus (919/513-1834) or Mr. Matthew Ronning, Assistant Vice Chancellor, Research Administration, Box 7514, NCSU Campus (919/513-2148)

PARTICIPATION
Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed at your request.

CONSENT
“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may withdraw at any time.”

Subject's signature_______________________________________ Date _________________

Investigator's signature____________________________________ Date _________________
APPENDIX E

Prompt for Representational Drawings & Interview Protocol
Background Questions for Interview 1:

I would like to begin with a few background questions before we begin. This will help me get to know you a little better and become comfortable with the camera and tape recorder.

- Please state your name and your age.

- Can you describe your personal educational background (degree completed, grade you are in)?

- How would you describe the school/educational institution you work in (attend)?

- How would you describe your role in that institution? (How would you describe yourself as a student?)

- Can you describe any hobbies or extracurricular activities, clubs, etc that you participate in?

- Is there anything else you would want me to know about you?
Prompt for Representational (Concept Map) Drawings

Hand participant 1-2 sheets of 11”x17” paper and pencils and black pens.

This is an investigation, not a test of either your knowledge or your drawing ability. I would like to know what you think, not what you have learned in school or what another person thinks. Please draw what is in your mind. You can draw things that are imaginative and fun as well as things you know. You can either draw an object or write a word in a shape to represent an object. These drawings should be quick and simple. You start with your first drawing and then you draw other things that come to your mind. The order in which you draw is not important but it is important that you draw lines between drawings that you feel are linked or connected. Make the joins how you want them and don’t worry if your final drawing has few lines or many lines. You have been given a large piece of paper so that you will have plenty of room to draw everything that you want. Here is exactly what I want you to do.¹

....

1) Interview 1:

I would like to know your ideas about Geographic Information Systems (GIS).

This will be the title of your map. [Pause]

Think about the types of GIS. What is needed for a GIS to work? Who are the people who use GIS? Where it is found? Why GIS is used? How are these things connected?

¹ This prompt was created using the model used in the studies by Somekh, B., & Mavers, D. (2003) and Mavers, D., Somekh, B., & Restorick, J. (2002).
2) **Interview 2:**

Today I would like you to think about Instructional Technology.

This should be the title of your map. [Pause]

Think about the types of technology that are used in schools. What types of technologies are used? How is instructional technology used? For what reasons are they used? Where is instructional technology used? Who uses instructional technology? Who should use instructional technology? How are these things connected?

3) **Interview 3:**

Today I would like you to think about GIS in Schools.

This should be the title of your map. [Pause]

Where is GIS in schools? Where could GIS be used in schools? What does GIS look like in schools? How is GIS used in schools? Who uses GIS in schools? How are these things connected?

... 

Take a minute or two to think before you start drawing.

Time allowed: 30 minutes

When 7-10 minutes before the end (or if participant is completed earlier): Now before you give me your concept map (mind map) please take about 5 minutes to write a list of what you have drawn). Give additional sheets of paper as needed.

Thank you very much. You have done that really well. Please make sure your name is on your concept map and your list. Take a break and stretch as needed. Take a moment to review what student/educator has drawn. Begin interview.
Interview Questions

Questions for all interviews:

• I find your concept map very interesting. Could you please tell me about it?
• Is any part of your map especially important? Why?
• Where did you start to draw and why did you start there? Can you explain the order in which you drew your map?
• Can you tell me how you know all of these things?
• If you’d had more time, would you have drawn anything else?
• Why have you connected your drawings in the ways that you have?
• Would you like to add anything further?

Additional Questions for Interview 1:

• Can you tell me about the different ways GIS is used in the world?
• Can describe the users of GIS?
• Can you describe where GIS is used in the world?
• How would you describe your GIS knowledge?

Additional Questions for Interview 2:

• Can you tell me about the different ways Instructional technology is used in schools?
• Can you describe where instructional technology is in the schools?
• Can you describe who uses instructional technology?
• How would you describe your knowledge of instructional technology?

Additional Questions for Interview 3:

• Describe who you think should use GIS in schools?
• Describe how you think GIS should be used in schools
• Where should GIS be used in schools?
• How would you describe your knowledge of GIS in schools?
APPENDIX F

Table of Data Collection Schedule
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<th>PARTICIPANT</th>
<th>REPRESENTATION 1</th>
<th>INTERVIEW 1</th>
<th>REPRESENTATION 2</th>
<th>INTERVIEW 2</th>
<th>REPRESENTATION 3</th>
<th>INTERVIEW 3</th>
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<td>(His Home)</td>
<td>February 17, 2005</td>
<td>(His Home)</td>
<td>March 9, 2005</td>
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<td>February 12, 2005</td>
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<td>February 9, 2005</td>
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<td>KATHLEEN</td>
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<td>February 8, 2005</td>
<td>(Her Office)</td>
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<td>CHARLES</td>
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<td>February 11, 2005</td>
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<td>March 21, 2005</td>
<td>(Her Home)</td>
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<td>(Her Home)</td>
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APPENDIX G

Ernest’s Representation of GIS
GIS

GIS's are unique solutions to many different needs.

Many jobs use GIS to help make decisions.

People that use GIS come from many different places and jobs.

These people and jobs are what make GIS what it is and how it is different.

Everyone has a different use for it.

You need to know what you are aiming at getting a map of.

Think about what kind of layers you need.

Think about why you need this particular map and all the different possible uses for it.

Data sheets.

Crime investigation.

Police stations.

Construction companies.

Parks and recreation.

Electric and phone companies.

Roads, airports, highways.

How to direct traffic for DOT.

Many different other software can be integrated into GIS to make it better or more unique and specific to a certain area.

GIS in the world.

School systems.

Where to put building in relation to color scheme, etc.
APPENDIX H

Charles’ Representation of GIS
APPENDIX I

Ben’s Representation of GIS
APPENDIX J

CJ’s Representation of GIS
APPENDIX K

Kathleen’s Representation of GIS
Geographic Information Systems
APPENDIX L

Natalie’s Representation of GIS
First time I used GIS -
Unlocking the Car at State Parking lot.

Book Review - GIS in classroom 6th Grade Students

Traveling to & from CT & NC using GIS to get directions

Global Where found Everywhere!

Individual cars

Weather patterns

GIS used to solve problems locally, state, nation, government

Safety/security/Cartography

Large Issues

Tracking vehicles or stationary to get points

Uses of GIS

- Military
- Business
- Industry
- Infrastructure
- Weather
- Recreational
- Map travel
- Cars
- Education

How works:
Satellite to a point

Vehicle & record coord.
APPENDIX M

Natalie’s Representation of Instructional Technology
Instructional Technology

- Kaleidoscope
- Classroom
- Tests
- IT
- Teacher
- Facilitator
- IT User
- Students
- Instructional
- Skills Analysis
- Transform Standards
- Life Testing
- EOGE
APPENDIX N.

Charles’ Representation of Instructional Technology
APPENDIX O

Ben’s Representation of Instructional Technology
Instructional Technology
APPENDIX P

Kathleen’s Representation of Instructional Technology
Appendix Q

Ernest’s Representation of Instructional Technology
Appendix R

CJ’s Representation of Instructional Technology
Appendix R

CJ’s Representation of Instructional Technology
Instructional Technology
APPENDIX S

CJ’s Representation of GIS in Schools
APPENDIX T

Natalie’s Representation of GIS in Schools
GIS in Schools

- SS Classes
- Language Arts
- Science
- Social Studies
- Math
- Science
- History
- Art
- Music
- Physical Education
- Health
- Business
- Technology
- Engineering
- Environmental Science
- Geography
- Architecture

- Distance
- Other
- Problem Solving
- Special

- GIS
- Higher level skill
- Learn computers
- Technology
- Teachers a chance to step outside the box with students as partners.

- GIS
- USED
- HERE
- Middle School

- GIS
- Modules
- GIS
- Idea

- Design communities
- Environment
- Movement of .... Patterns
APPENDIX U

Ernest’s Representation of GIS in Schools
APPENDIX V

Charles’ Representation of GIS in Schools
APPENDIX W

Ben’s Representation of GIS in Schools
APPENDIX X

Kathleen’s Representation of GIS in Schools
GIS in Schools

What is the rate of growth of GIS in schools?

In what communities has GIS been successfully integrated into schools' instruction?

Now Where it is?
- Academic
  - Middle School
  - High School
- Individual Teacher
- Geography
- Science
- Social Studies

Future
- What it could be?
  - Academics
    - All K-12
  - Use Greater numbers of Teacher + Administrators
    - In multi-discipline courses
    - Available to students for career prep.
  - Resource Planning
    - More widely applied in more schools
    - Siting new schools
    - Bus route assignments
    - School districts
      - For satisfying particular ethnic and socio-economic requirements

How are these things connected?

To get from here ... to here, conditions must exist that provide

Awareness of what GIS can do + awareness of what GIS can provide = Need to know + GIS = GIS widely used

How to offer to analyse problems

Time

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