GIS IN AP HUMAN GEOGRAPHY: A MEANS OF DEVELOPING
STUDENTS’ SPATIAL THINKING?

Megan L. Webster

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APPROVED:

Nancy Nelson, Major Professor
Joseph R. Oppong, Committee Member
Andrew J. Milson, Committee Member
James D. Laney, Committee Member and Chair
of the Department of Teacher Education and
Administration
Jerry R. Thomas, Dean of the College of
Education
Costas Tsatsoulis, Interim Dean of the
Toulouse Graduate School
Geography education is undergoing change in K-12 education due in part to the introduction of geospatial technologies, including geographic information systems (GIS). Although active engagement in GIS mapping would seem to enhance students’ spatial thinking, little is known about the mapping strategies that students employ or about changes in their geographic knowledge that would result. This study, set in a high school Advanced Placement human geography class, sought to contribute to these areas of inquiry. Participants performed a web-based GIS task focused on global population and migration. Attention in the study was on (a) the strategies students employed when investigating geographic phenomena using GIS, (b) changes in their cognitive maps, as assessed through sketch maps, resulting from the activity, (c) the relationship between GIS maps and sketch maps, and (d) the ways in which a subset of students serving as case studies explained the nature of their mapping. The study employed screen-captures, video-recordings, observations, pre- and post-study sketch maps, and interviews.

Analyses of the GIS process revealed that, in creating their maps, the students used a number of strategies, which included searching, layering, removing layers of data, adjusting transparency, editing, and noting. Although searching and layering were employed by all students, there was variability across students in use of the other strategies. With respect to changes in their spatial thinking, analyses of the sketch maps showed increases in elaboration and accuracy in terms of migration patterns. When GIS maps were compared to sketch maps, analyses showed relations for many students. The six students who served as case studies
revealed major connections between personal interests and the reasoning employed in mapping. They also described their entry points into the process.

The study shows how real-time data collection, including screen captures, as well as more static measures, specifically sketch maps, can provide insights into the spatial thinking of students while using GIS. It provides some support to educational approaches to geography in which students become creators of maps, not simply users of maps, and suggests that, through their own mapping process, students expand their cognitive maps and enhance their spatial thinking.
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CHAPTER 1
INTRODUCTION TO THE STUDY

Geography education is in the spotlight as the world becomes increasingly interconnected through globalization. Educational administrators, teachers, and curriculum developers are becoming more aware that geography education is critically important and they point to a need for students to become global citizens (e.g., Suárez-Orozco, 2005). Geography in the K-12 years can no longer be seen as a discipline that is focused only on the location of places and on factual and statistical data associated with those places. Now, its focus has shifted to inquiry learning, and students are using geography to make sense of their world (e.g., Schultz, Kerski, & Patterson, 2008). The discipline works well with strategies that support inquiry and engaging, hands-on opportunities for student learning in the classroom. As spatial thinking becomes central to geography in K-12 education, educators must consider the spatial cognition of youth—their understandings of relationships on Earth derived from experience and built upon over time—and how it is acquired and how it develops (cf. National Research Council, Committee on the Support for the Thinking Spatially, 2006; Wiegand, 2006).

The curricular changes discussed above have been supported in some classrooms by the introduction of the geospatial technology known as geographic information systems (GIS). GIS allows the user to create, manage, and visualize geographic data through mapping. Furthermore, GIS as a system provides a means of uploading data and analyzing and manipulating those data in ways suitable for education and numerous professions. The Environmental Systems Research Institute (Esri) (2006), a leading producer and stakeholder in the design and direction of geospatial technologies, has defined GIS as “an integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships,
“and model spatial processes.” GIS today is available in multiple forms, including one for desktop computers as well as an online version, WebGIS. Some research suggests that GIS is associated with changes in students’ ability to process complex information and engage in spatial reasoning (Broda & Baxter, 2002; Henry & Semple, 2012; Mitchell, Borden, & Schmidtlein, 2008).

The study reported here focused on the strategies students employed and the changes in students’ spatial cognition associated with the use of WebGIS in an Advanced Placement (AP) Human Geography classroom. In this chapter I provide an overview of geography education and then discuss geospatial technologies and spatial thinking in more detail. That is followed by a statement of the problem addressed in the dissertation, a brief description of my research approach, definitions of key terms, and specification of the research questions guiding the study.

Recent Developments in Geography Education

The study of geography in classrooms has changed due to the establishment of standards in learning, and a new course centered on understanding human relationships. In this section, I briefly discuss these two developments in geography education that are relevant to the study.

*The National Geography Standards*

By examining the National Geographic standards from 1985 to 2012, one can see the growing emphasis on geospatial technologies. In 1985 the Geography Education National Implementation Project (GENIP) was organized by several key groups: the Association of American Geographers (AAG), American Geological Society (AGS), the National Council for Geographic Education (NCGE), and the National Geographic Society (NGS). The first publication by GENIP communicated a need to focus on geography learning in schools. This publication provided guidelines for geography learning and set a structure for themes in
geography as a method of study. The goals of the GENIP focus on several initiatives to support geography education, including implementation of the National Geography standards, the use of geospatial technologies in classrooms, development of opportunities for educators to learn with meaningful materials, and advocacy for geography learning, to name only a few.

In 1994, *Geography for Life: The National Geography Standards*, a GENIP publication, provided a guide for what students should learn and the opportunities that should be experienced with regard to K-12 geography learning. This publication offered a way for students to learn geography by studying six essential elements: the world in spatial terms, places and regions, physical systems, human systems, environment and society, and the uses of geography. Within the elements are eighteen standards. The 1994 publication has since been used nationally and internationally to develop geography curriculum. In 2012, the second edition of *Geography for Life* was published. This updated edition acknowledges the ways in which our society has changed from globalization since 1994, and addresses the increased usage of technology, specifically geospatial technologies in education, and the expectations of learning geography.

The 2012 edition of *Geography for Life* provides several new ways to structure learning of geography that differ from the first version. Although the updated edition, like the first edition, provides categories for geographical content divided into the six essential elements previously listed, the updated edition emphasizes the significance of “doing geography.” The updated edition sets forth an agenda to promote geography learning in order to develop a society cognizant of global relationships by taking each standard and situating it by alignment, scaffolding, and intellectual skills. In addition, the standards also address the importance of developing both spatial and ecological perspectives.
The 1994 standards did not specifically state to use GIS, but they were designed to be flexible as innovations in technology become more readily available. For example, by the end of the twelfth grade a student was expected to “choose and give reasons to use specific technologies to analyze selected geographic problems (e.g., aerial photographs, satellite-produced imagery, and geographic information systems [GIS]) to determine the extent of water pollution in a harbor complex in South Africa or the range of deforestation in Madagascar” (p. 185).

However, the standards revised in 2012 do provide guidelines suggesting that students by twelfth grade should learn the foundations of GIS and begin using this sophisticated technology to analyze spatial data. This change reflects the growing interest in spatial thinking and implementation of geospatial technology in the classroom. The revised standards embed five sets of geographic skills introduced in the first edition that students should acquire as they progress through their education from kindergarten to Grade 12. These skills involve learning not only how to ask and answer geographic questions, but also how to obtain geographic data, classify, and conduct analysis of geographic information. These skills define the nature of learning for students to think like a geographer and build spatial understanding of human and physical relationships.

*AP Human Geography*

In the 21st century, geography education has continued to expand, including the College Board’s introduction of a new course for the Grades 9-12, AP Human Geography. The course consists of seven units of study, which include the nature and perspectives of geography; demography: population and migration; cultural patterns and processes; political organization of space; agriculture and rural land use; industrialization and economic geography; and cities and urban land use. Students take the corresponding College Board examination for the course in
mid-May and obtain college credit if successful. Currently this course is one of the fastest
growing AP courses with regard to the number of test-takers each year. For example, in 2012
over 90,000 AP Human Geography tests were given, resulting in an 18% increase in the number
of tests given in 2011. Furthermore, this course is applicable at all high school grade levels, but
most test-takers of the 2012 tests were freshmen (College Board, 2012). Spatial thinking is an
important introductory skill that resonates throughout the AP Human Geography course outline.
Students learning human geography are encouraged to consider the relationship and interactions
of humans across Earth’s surface at different scales, a skill that demonstrates the ability to think
spatially. Therefore, it is critical to investigate how spatial thinking is taught in AP Human
Geography classrooms including the standards for geography education and the tools used to do
so. When considering the extent to which geospatial technologies are included in state standards
for geography, Milson and Roberts (2008) found very few states “explicitly” identify geospatial
technologies. Furthermore, they found that the importance of using geospatial technologies by
teachers and professors is undervalued and underemphasized (p. 201). An aim of this study is to
identify the spatial thinking skills used by students in an AP Human Geography classroom when
using WebGIS to better understand the role this type of technology may have in geography
education.

GIS in Geography Education

Embedded within the 1994 standards was the role that geospatial technologies,
specifically GIS, play in developing the five sets of geographic skills. By means of GIS, users
can investigate geographic phenomena. They can create data in a cartographic way by drawing
existing data from a credible source or by uploading their own data. In addition, GIS can be used
to compare data between regions, track changes of data over time, identify regions with similar
characteristics, and provide a visual understanding of what is happening on Earth that traditional pen and paper cannot accomplish with such efficient detail.

GIS has undergone much technological advancement. It was once available only as desktop software, but today a web-based version, hosted in the “cloud,” can complete many of the same tasks previously performed only by traditional GIS desktop software. The role of GIS has also changed. GIS has now made its way from the private sector to the public sector.

GIS technology, which is being widely employed in government and industry, has been slow to transition into K-12 education classrooms, as noted by Bednarz and Bednarz (2008) and Milson and Kerski (2012). There are numerous reasons for the slow adoption of this powerful tool for geography learning, such as lack of access to technology supportive of the data, little or no teacher training and comfort with the tools, and undeveloped ways to assess its impact on learning and knowledge of the technology. Though there is increasing interest in incorporating GIS in the learning environment, this valuable tool is not required in most curricula. Nevertheless, its potential for adaptability into classroom learning is becoming increasingly visible as more and more classrooms begin to use technology to enhance content being presented. Researchers, such as Milson and Kerski (2012), have pointed out the feasibility and friendliness of new WebGIS tools and also the potential GIS has for blending students’ academic learning and their preparation for careers.

An increase in the use of innovative technologies in the classroom has fostered inquiry learning by students that is genuine and self-motivated and that connects with multiple elements of the study of geography, as pointed out by Liu and Zhu (2008). Though desktop computers are still used regularly in many schools, other technologies such as document cameras, iPads, mobile laptop stations, white boards, Flip cameras, Skype telecommunication, and cloud computing are
emerging as new sleek ways to bring teaching and learning into the 21st century. These technologies are becoming more accessible and feasible, allowing for greater opportunities for integration into K-12 classrooms.

At the heart of implementing GIS in education is the necessity of encouraging spatial thinking among youth. In their research Baker, Palmer, and Kerski (2009) noted an awareness on the part of teachers “that geotechnologies such as GIS and GPS are becoming embedded technologies in many, if not most, workplaces” (p. 182). Research also suggests that there are growing awareness and positive attitudes towards using GIS as a tool in learning (e.g., Demirci, 2009; Kerski, 2008). Though limitations exist, educators are creative in how they use the technology and provide students with the tools to be successful and knowledgeable citizens of geography. Joseph Kerski (2008), one of the most influential leaders in geography education, stated the unrelenting and simple truth: “Geotechnologies are becoming an increasingly critical decision-making tool that many educators feel must be included in education if society is to solve the complex problems of today and tomorrow” (p. 133). Simply put, GIS has a place in education; and, with focus on areas of needed research, this technology can enhance the way students view and participate in this world.

Spatial Thinking in Geography Education

One of the struggles central to the teaching and learning of geography is helping students learn to think spatially. Gersmehl (2005) defined spatial thinking simply as the process of “thinking about locations, conditions, and connections” (p. 98). In other words, it is thinking about what is happening and where it is happening and making connections across space on Earth. Jo and Bednarz (2011) noted that “thinking spatially requires knowing, understanding, and remembering spatial information and concepts” (p. 70). In the text, Learning to Think
Spatially, the National Research Council’s Committee (2006) defined spatial thinking as a set of cognitive skills:

The skills consist of declarative and perceptual forms of knowledge and some cognitive operations that can be used to transform, combine, or otherwise operate on this knowledge. The key to spatial thinking is a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning. (p. 12)

According to the National Research Council’s Committee on the Support for the Thinking Spatially (2006), “Spatial thinking uses representations to help us remember, understand, reason, and communicate about the properties of and relations between objects represented in space, whether or not those objects themselves are inherently spatial.” The committee pointed out that these objects can be “concrete” things as in a cognitive map, a mental representation of “an objective geographic space within which the objects exist” that “may transform and systematically distort objective distances and directions between places” (p. 27).

Upon entering world geography and AP Human Geography courses, students generally have very little exposure to thinking spatially about the world—its people, their activities, and their impact that define the landscape we see today. According to the Texas Education Agency (TEA) (2012), in the state of Texas students take a world cultures course in sixth grade, but the concept of thinking spatially is not introduced until ninth grade, when students take world geography or AP Human Geography. To supplement learning opportunities, numerous resources are used, such as atlases, textbooks, and now, increasingly, technology. The question remains: Are these resources helping to develop spatial thinking skills among youth? Jo and Bednarz (2009) tackled part of this question by investigating textbooks being used in the state of Texas and the questions they provide from a spatial perspective. These researchers found that, in the four geography textbooks adopted by the Texas Education Agency in 2003, questions provided in the text deal very little with spatial concepts. Though textbooks do provide visuals and
questions for students, they far too often do not challenge students to make connections between phenomena or to think about matters in a complex way.

In scholarly books and journals articles, authorities discuss spatial thinking and the need to develop spatial cognitive skills of students at a young age in order to have a better understanding of the interactions between the physical environment and humans (e.g., National Research Council, 2006; Newcombe & Frick, 2010; Wiegand, 2006). GIS would seem to be a tool for achieving this goal.

Statement of the Problem

In the 21st Century, geography entered a new era within academia and essentially made a comeback. However, it is apparent that there is a need for continued research in the learning that is associated with the new technologies, especially GIS. Two areas of research are the focus of this study.

First, much of the current research on the use of GIS in the classroom focuses on findings related to student and teacher experiences to validate its use in the classroom. Though this information is highly beneficial for identifying the significance of using a geospatial technology such as GIS in educational settings, there has been little emphasis in research placed on the process—the strategies that students take when using the technology—especially when students have little experience using any type of geospatial technology. The term strategy refers to a goal-directed “cognitive or behavioral action that is enacted under particular contextual conditions” (Graesser, 2007, p. 6). According to Alexander, Graham, and Harris (1998) the six attributes of a strategy are “procedural, purposeful, effortful, willful, essential and facilitative” (p. 130). Huang (2011) used a structured website and exploratory GIS-Interface website to monitor elementary student web browsing behaviors through the use of video-taping computer
screens. Interviews were later conducted to clarify student choice and the actions they performed using the websites. This type of analysis when conducted at the secondary level may provide a clearer picture of student’s geographical understanding as well as provide insight into how students go about using a “new” technology to investigate spatial phenomena within geography. Through this study, I sought to do just that: to learn how secondary students in a Human Geography class strategically employ the GIS technology to “map” their learning. What insights can be gained into students’ spatial thinking?

Second, a challenge researchers have experienced is how to examine changes in geographic knowledge. One method researchers have used to study the extent and the nature of learning is having students create sketch maps to represent their cognitive maps. Lloyd (2000) has described a cognitive map as a representation in one’s internal memory that relates to one’s knowledge of place and space. Sketch maps have been used by researchers to provide insights into the mental structures created through learning and the ways in which those structures change (Evans, Marrero, & Butler, 1981; Gillespie, 2010; Lloyd, 2000; Saarinen & MacCabe, 1995; Shin, 2006; Shobe & Banis, 2010). However, little research has examined variation across maps associated with students’ learning. When using GIS in the classroom, students use the technology to create multi-layered maps from geographic information that they are learning. How does GIS mapping relate to cognitive maps?

Approach to the Study

The study reported here provided multiple ways to investigate the processes associated with spatial cognition as the students used WebGIS in the AP Human Geography course. Both quantitative and qualitative methods were used to examine students’ strategies and their spatial thinking as they performed map development tasks with GIS. Data sources included
observations, video recordings and screen capture recordings, GIS maps, pre- and post-study sketch maps, and interviews. Most of the data came from all 20 students in the class, but interviews were conducted with a subset of six students who were treated as case studies and whose GIS activities are described in greater detail in the findings.

Since the study was conducted in only one classroom and with only 20 participants, my intent was not to arrive at generalizable findings regarding the effectiveness of GIS. My focus was on the process employed by those 20 students as they performed geography tasks by means of GIS and also in their changes in spatial thinking. Through a close analysis of the process-oriented data, I sought to gain insights into the variability of their strategies and into possible relations between GIS mapping and cognitive maps (as represented in the sketch maps).

Definition of Terms

*Advanced Placement Human Geography*: an advanced placement College Board course focused on the features of human interactions on Earth’s surface including such topics as population, migration, culture, politics, agriculture, economic development, and urbanization.

*ArcGIS Online*: “a collaborative, cloud-based platform that allows members of an organization to use, create, and share maps, scenes, apps, and data, and access authoritative basemaps and ready-to-use apps” (Esri, 2014).

*Cognitive map*: a representation in one’s memory that relates to his or her knowledge of place and space (Lloyd, 2000).

*Geographic information system (GIS)*: “an integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes” (Esri, 2014).
Geospatial technologies: technologies, including geographic information system (GIS), global positioning satellite (GPS), and remote sensing (RS), used to analyze Earth’s surface.

Mental map: a mental product that is also called a “cognitive map.”

Sketch maps: a map, which is in some kind of material form that is drawn by an individual to represent his or her knowledge and understanding of a particular geographic area.

Spatial thinking: cognitive processes related to “the properties of and relations between objects represented in space, whether or not those objects themselves are inherently spatial” (NRC, 2006, p. 27).

WebGIS: geographic information system (GIS) that is accessible by use of the Internet, allowing for mapping and access to data online.

Questions Guiding the Study

This study examining the use of using GIS in an AP Human Geography class was intended to find answers to the following questions:

1. What were the cognitive processes in which these students engaged when investigating geographic phenomena using WebGIS?

2. What changes in the students’ cognitive maps (as assessed through sketch maps) were associated with the GIS–enhanced AP Human Geography course?

3. How did the GIS maps relate to the sketch maps?

4. How did selected students explain the nature of their GIS maps and their sketch maps and changes therein?
CHAPTER 2

REVIEW OF RELATED LITERATURE

Each day of our lives, we live “geography.”

Charles F. Gritzner

This chapter reviews related scholarly literature on the following topics: (1) geography education, (2) spatial thinking, (3) GIS in K-12 education, (4) student strategies using GIS, and (5) cognitive maps.

Geography Education: An Overview

Geographic knowledge is embedded in our everyday activities as humans and is derived from what we see, hear, discover, and apply over the course of a lifetime. In the United States, early geographers, including Lewis and Clark, George Perkins Marsh, and Carl Sauer, made lasting impressions on the need to explore the landscape and environment. Sack (1997) stated: “Being geographical is inescapable—we do not have to be conscious of it” (p. 1). Kitchin (1996) pointed out that “one of the fundamental human needs is the need to know about the surrounding world” (p. 56). The discipline of geography has focused on the actions by humans on the environment as well as the impact of the environment on human activities. It is both a social science and a physical science. It is, moreover, a practical science, as Livingston (1992) has argued.

Geography is a multifaceted discipline with a unique and diversified history. Geography has no single definition, but, instead, according to De Blij (2005), it has a myriad of connections based on traditions involving space, the environment, and the human interactions within both. For the purpose of this study, geography is identified as the study of the distribution of physical phenomena and cultural phenomena on Earth and the relationships among them.
Geography Education: A Brief Historical Overview

The priority placed on geography and the nature of the subject have changed over time. The study of geography has not always been present in U.S. classrooms, and in some cases is still lacking today. Geography education in the United States during the early twentieth century, which focused on learning the physical nature of Earth, was often taught by teachers without much preparation in geographic knowledge and pedagogy. As geography became a part of the social studies, the learning of geography began to be viewed with a human perspective (Stoltman & Viucich, 1974).

As discussed in Martin’s (2005) history, after World War I geography education became centered not only on physical aspects, but also on their interaction with social forces. Following World War II, a resurgence for geography education was felt. As the United States became more involved in the international community, the need for increased geographic knowledge and skills became a focus of classrooms, especially at the elementary level. In elementary school, geography started with a student learning about his or her community, and the focus would expand through the years to study of the world (cf. Stoltman & Viucich, 1974). Higher education institutions started new geography programs; and new specializations, such as economic and urban geography, emerged. However, secondary geography learning was still struggling to find a place in education. In the 1960s, the High School Geography Project was an attempt to create a geography curriculum and introduce new instructional materials for geography in secondary classrooms. The study of geography in the classroom began to take form, and geography education was taking root in public education.

In the United States today, geography is a secondary school subject, and, along with history, psychology, government, and economics, it is considered to be part of the “social
studies.” According to the 2013 publication by the National Geographic Society, NCGE, AAG, and the American Geographical Society, *The Road Map Project: A Road Map for Large-Scale Improvement of K-12 Geography Education*, all 50 states have created standards for geography in Grades K-12, suggesting that geography now has a stronger and possibly more stable place in education. As the study of geography has gained more centrality in education, the foundations of the subject are of significance, specifically the ability to think spatially. As Gregg and Leinhardt (1994) argued, the study of geography helps build a structure of spatial awareness that can further learning. Vital to this type of critical thinking in geography are the use of maps and the development of visual understanding of Earth’s landscape. Because geographical concepts are often studied in connection with the real-world, students must think about all parts of the information that they are studying and use geographic skills to ask questions relevant to the data.

**Important Influences on Geography Education**

At this point let us consider the traditions, themes, and standards that have contributed to the current focus of geography education.

*Traditions of geography.* Today the field of geography education is influenced by a document published back in 1964 and reprinted again in 1990, “The Four Traditions of Geography.” In that document its author, Pattison, suggested that much of westernized geography is based on a limited number of main traditions that have evolved over the course of geography’s history. The four traditions include the spatial tradition, area studies tradition, the man-land tradition, and the earth science tradition. Although there were times when geography education seemed to lose track of these traditions and their epistemological underpinnings, geography education has revisited them, especially in light of the renewed attention to the particularities of geographic knowledge (e.g., Donaldson, 2001; Pattison, 1990; Robinson, 1976).
In the four traditions, Pattison identified the spatial tradition as “a belief in the importance of spatial analysis, of the act of separating from the happenings of experience such as aspects as distance, form, direction and position” (p. 211). Today, spatial thinking is critical to the understanding of the distribution of phenomena on Earth’s surface and the connections or associations that can be made between those phenomena. The areas studies tradition has some connections with the spatial tradition of phenomena, but is more closely focused on the character or nature of a place. Geography in education is often taught from a regional view looking at the characteristics or attributes of a place that distinguish it from others. The man-land tradition focuses on the relationships between humans and the physical environment. This may include the impact of nature on humans such as the impact of natural hazards on humans, or vice versa, the impact of humans on the natural landscape through boundaries, culture, development, and population growth. Lastly, the earth science tradition is focused on the physical realm of Earth including the physical processes (e.g., watershed, climate, vegetation, soil building, and plate tectonics) that explain how the Earth functions and how the Earth’s landscape varies from place to place. Though these traditions were introduced in the 1960s, they have been since revisited as advancing technology as well as the education system in the U.S. changes.

Themes of geography. In 1984, the NCGE and Association of American Geographers (AAG) designed the five themes of geography. The themes, which include location, place, region, movement, and human-environment interaction, created a structure for studying geography and foundations for teaching geography. Today these themes resonate throughout the six essential elements that are implemented in classrooms. For example, in a recent study, Zeitler (2013) identified the significance of teaching the five themes of geography as fundamental concepts in studying geography, in this case when looking at recent trends in minor league
baseball. Also, Patterson (2007) identified the unique nature of geography as an *interrelated* discipline focused on several elements including the five themes of geography as necessary components to build a “sound geospatial education” (p. 147). In this study he focused on the use of Google Earth in education and its ability to foster learning among students such as gathering, interpreting, and analyzing data.

*The National Geography standards.* Today, geography education is guided, to a great extent, by a set of standards derived from six essential elements. The six essential elements include (1) the world in spatial terms, (2) places and regions, (3) physical systems, (4) human systems, (5) environment and society, and (6) the uses of geography. The ground-breaking contribution to the study of geography that came about with the 1994 GENIP publication, *Geography for Life: National Geography standards*, introduced standards for what students in the United States should be learning. This text has acted as a guideline for individual states and schools in developing their own standards and expectations for geography learning. Among those contributing to the first edition was De Blij (1995), who discussed the vital role of geography in American lives and its renewed relevance, arguing that “more and more people are discovering how interesting, challenging, and even important geography can be” (p. 23).

Now there is a revision published in 2012. As mentioned in Chapter 1, the revised second edition of the *National Geography standards* includes eighteen standards focused on the six essential elements. The update on the National Geography standards centers on the inclusion of changes in how geography is being taught in the classroom and its effectiveness. A number of scholars, including some who were cited above and have contributed to the development of the standards (e.g., Bednarz, Gersmehl, & Kerski), and the new standards are receiving attention from scholars in the field (e.g., Heffron, 2012; Shell, Roth, & Mohan, 2013).
However, the fifty states vary in terms of the influence of the standards and their degree of alignment with those standards. Because there is no national geography curriculum in the U.S., it is up to individual states to determine what students should learn. In addition to the national standards, state standards for geography education have been developed as well as a variety of ways to think about the interactions and processes that shape the cultural and physical landscapes of Earth. For example, the state of Texas developed the Texas Essential Knowledge and Skills (TEKS) of Geography (TEA, 2013). The TEKS maintain the national geography standards, ensuring a focus on geography in schools throughout the state. According to the most recent revisions of the TEKS, there are 23 elements of knowledge and skills that students should learn in the World Geography course. Topics covered in a Texas World Geography course include history, geography, economics, government, citizenship, culture, science technology and society, and social studies skills. As mentioned earlier, geography and geographic thinking are present in many daily activities though individuals are not always mindful of the connection.

Though much of geography in education has been taught using the current standards, the new course discussed in Chapter 1, AP Human Geography, has introduced geographic learning revolved around human activities and interactions.

*New Attention to Human Geography*

As geography makes a comeback in education, and as more states develop standards, educators are advancing in the use of technology as a tool to teach and study geography. They have also created state alliance organizations to promote geography education. The new course, AP Human Geography, is a college-level course designed to offer students an opportunity to gain insights into humans’ role in the world with a level of rigor that is often identified with AP courses (Trites & Lange, 2000). Additionally, students can earn college level credit for taking
the course while in high school if successful on the assessment. Challenges associated with the course include the following: what grade level to offer the course, how to recruit students to take the course, whether the course is to be one semester or two, and what preparation is required for high school teachers to teach geography at the college level (Trites & Lange, 2000). Despite these obstacles, the AP Human Geography course continues to grow each year among students in the United States and countries outside of the United States where the course is offered (Robelen, 2012). Teachers of AP Human Geography must be prepared by a College Board consultant and develop a syllabus that they provide to the College Board which ensures that expectations are met for what would be experienced in colleges and universities.

Spatial Thinking

Critical to the development of geographic understanding in any geography course, including human geography, is spatial thinking. This feature was mentioned in the first chapter, but here I focus on it in more detail. As noted previously, the National Research Council Committee (2006) had described spatial thinking as a combination of several elements including “concepts of space, tools of representation, and process of reasoning” (p. 22). Concepts of space may also be described as the ways in which one can look at Earth’s landscape with respect to distance, time, organization of space through coordinate systems, and the dimensions of Earth. Tools of space include maps, visuals, projections, and other forms of graphicacy. In order to think spatially, one must understand the relationships of space; those interpretations may determine the decisions that are made. Simply put, spatial thinking is those complex cognitive processes that are employed when investigating Earth’s physical and cultural landscapes (cf. Jo & Bednarz, 2009).
Spatial thinking continues to be included as a critical component of geography education in part because of the National Geography standards. Geography Standard 3—knowing how to analyze the spatial organization of people, places, and environments on Earth’s surface—makes the case for attention to spatial thinking in the classroom. Most notably, when students think spatially, they look at how the Earth’s surface is organized and are then able to construct and answer questions through analysis of geographic phenomena. According to Gersmehl (2005), geographical skills can either be general and applicable to other disciplines or can be skills that are specific to geography. Gersmehl identified thirteen skills of spatial thinking listed below:

1. Expressing location—who is it?
2. Describing conditions at a location—what is there?
3. Tracing connections with other locations—how is it linked?
4. Comparing locations—how are places similar or different?
5. Determining the zone of influence around a location—how far from a feature is its influence significant?
6. Delimiting a region of similar places—what nearby places are similar to this one?
7. Describing the area between places—what is the nature of the transition between places?
8. Finding an analog for a given place—what distant places are similar to this one?
9. Identifying a spatial pattern—are there biases, clusters, strings, donuts, waves, and other distinctive patterns?
10. Comparing spatial patterns—are the spatial patterns similar?
11. Determining the exceptions to a rule—where are the places that have more or less of something than expected?
12. Analyzing changes in pattern through time—how do things spread?

13. Devising spatial models—are places linked by one or more intermediate processes? (pp. 99-111)

These skills described by Gersmehl apply well to my inquiry into students’ spatial thinking. Their importance is increasingly apparent given the introduction of AP Human Geography and the use of geospatial technology. Though spatial thinking is significant to learning geography, Bednarz and Bednarz (2008) have pointed out that this kind of cognitive activity is not receiving the attention it should in geography curriculum in the United States K-12 education. Downs and Liben (1991) emphasized that spatial understanding is not intrinsically preset, and must be developed through interaction. The ability to think spatially is not a skill that is learned over night.

The building and use of spatial thinking skills have been discussed by many scholars regarding geography education and other disciplines. For example, Milson, Kerski, and Demirci (2012) referred to “a new age for spatial thinking” in considering how geospatial technologies such as GIS have changed the ways in which people investigate the world. Because GIS is a multifaceted system, users can now do more in-depth analysis with real-world data. But the authors point out that, though more in-depth analysis can be performed with ease by means of GIS, users must have spatial thinking skills to use the technology effectively. Clearly, spatial thinking as a skill must be learned and applied; GIS as a system, cannot do it for the learner. “Spatial thinking can be learned” (National Research Council Committee, 2006, p. 3), and it is important that we recognize and address the need for spatial thinking to begin at early ages as well as used across multiple disciplines. Several studies focusing on the implementation of GIS in the classroom show increases in spatial thinking abilities of students (Doering & Veletsianos,
Lee and Bednarz (2012) developed a Spatial Thinking Abilities Test (STAT) answering a need for educators and researchers to have a way to assess spatial thinking skills of students.

The term map has gone through many transformations in academia, especially in geography. Maps have been called “the language of geography” (de Blij, 1995, p. 29) and a “fundamental tool” of geography (Gregg & Leinhardt, 1994, p. 312). The skill and art of mapping today are influenced by numerous advances in technology, as well as the cartographer’s global knowledge. They come in a variety of forms. A traditional map might include a two-dimensional visual of Earth’s surface represented on paper, or it might also include a three-dimensional model of Earth’s surface known as a globe. Today, maps range from the traditional two-dimensional form or a globe to interactive mapping technology on computers, phones, and other electronic devices. Regardless of the type or style of map that is being employed in learning, business or pleasure, maps are rooted in geographic thought.

Maps relate closely with spatial thinking because they offer alternative ways to process information. They communicate geographic location, provide representations of physical and human characteristics, and present glimpses of the real-world on a smaller scale. Though maps are often thought of as navigational pieces, the functionality of maps is far more complex. Maps, which can show trends, can be used for quantitative analysis (Wiegand, 2006). They offer visual understanding (Shobe & Banis, 2010) and stimulate thought about spatial features of Earth (Wiegand, 2006). The next section highlights the development of digital mapping or images and their lasting impact on geography education.
Geographic Information Systems (GIS) in K-12 Geography Education

The presence of technology in our lives changed significantly during the latter part of the twentieth century and beginning of the 21st century. As technology has advanced, several aspects of our society have followed suit, including education. Among the new technologies are geospatial technologies which include the global positioning system (GPS) and remote sensing (RS) along with GIS, all of which allow users to acquire, analyze, and manipulate various data (Esri, 2006). As discussed by Milson, Kerski, and Demirci (2012), a geospatial technology such as GIS provides the user with the ability to manage spatial data and answer complex geographic questions to explain patterns, and interactions between humans and the environment. These innovations are more readily available and are being used in multiple capacities by people daily. In what follows, I provide a brief history of the system that has advanced cartography and our ability to map data. I follow that with a review of literature addressing studies using GIS in geography education.

The Rise of Geospatial Technology

Roger Tomlinson, who is known as the father of GIS, is credited with designing the first GIS in the 1960s called the Canada Geographic Information System, which was used to survey the Canadian physical landscape (Coppock & Rhind, 1991). Since then, GIS has developed into a geospatial technology that has forever changed the field of geography and the way we think. Milson and Kerski (2012) highlighted several reasons behind the “birth” of GIS: “the convergence of a variety of factors such as improved database and graphics technologies, theoretical developments in spatial statistics, advancements in satellite remote sensing, and the need among government agencies to efficiently manage geographic data” (p. 2). GIS opens the door for multiple sources of information to be compiled and managed in a geographic database.
Whereas maps have traditionally been limited to presenting one topic of information that is current at the time of printing, GIS can store extensive up-to-date data that can be applied and manipulated when needed. As the functionality of GIS has progressed, data and images can be readily displayed on a map, queried, or used to draw conclusions contributing to understanding relationships on Earth. This has led to an increased use of GIS in fields outside of geography.

GIS has proved to be a powerful tool used by multiple agencies, such as those associated with government, business, and schools, and also by individuals. Because of the mapping capabilities and valuable insight provided through the use of GIS, this multifaceted geospatial technology is increasingly being used by numerous organizations ranging in focus from ecological research (Turner & Taylor, 2003) to feminism (Kwan, 2002). At the community level GIS has been used to explore such topics as power structures, use of natural resources, and gender issues as geographers attempt to bridge a divide between people and their world (O’Sullivan, 2006). Wiegand (2006) observed that GIS offers its users new ways to understand spatial data and visualize relationships or trends that may not have been evident. GIS can be helpful to provide users with an alternative method to think spatially and to build a view of Earth applying an innovative approach to meet their needs. The beauty of GIS, according to Yap, Tan, Zhu, and Wettasinghe (2008), is that users can put geographic data to work by conducting spatial analysis, manipulating data to meet their needs, or storing data for later use. GIS is powerful, but it is important to understand that it is not just the computer creating maps. There is also a GIS analyst, cartographer, or other individual making numerous decisions regarding the outcome.

As discussed earlier, mapping has always been a fundamental element in geographic thinking, though the way data are mapped has transformed significantly. Today, mapping is no longer prepared only with a pen and paper. Technology has made its entrance into cartography
on a grand scale. Wiegand (2006) pointed to a *cartographic revolution* in which “GIS represents a new generation of supermaps that lie at the heart of all modern spatial decision making, whether it’s locating a new superstore, planning public utilities or managing the environment” (p. 8). The study of geography and the emerging use of geospatial technologies have afforded consistent application of reasoning skills using maps when considering interactions between humans and the environment.

*The Role of GIS in Geography Education*

As a new tool slowly making its entrance into classrooms in the United States is the implementation of geospatial technologies in K-12 education. GIS has opened doors to understanding how students perceive the world, build spatial cognition, think critically, and understand geography in ways that connect with the multiple aspects of the world in which they live. GIS first made its appearance in classroom instruction mainly within higher education institutions during the last half of the twentieth century (Milson & Kerski, 2012) and has since trickled down to educational institutions for younger students. The result during the last two decades has been a shift to increased research into GIS and its use in K-12 classrooms. Research has supported the use of WebGIS tools and has shown that it is not necessary to use the full desktop GIS to gain some of its benefits. For example, in a study focused on integrating GIS into K-12 curricula, Henry and Semple (2012) used a customized WebGIS application called the H2O Mapper that acted as a storing house for data related to water quality. The researchers found that teachers and students in Grades 7-9 were able to use the software with ease for the desired set of functions without having to know all the ins and outs of desktop GIS. This finding supports the use of this technology in applying and broadening education. Today, GIS has been introduced to elementary (Shin, 2006), middle school (Baker & White, 2003; Doering & Veletsianos, 2007;
The slow use of GIS in K-12 education is due to many factors, including lack of computer accessibility, teacher training, preparation time, and professional development opportunities (Baker, Palmer, & Kerski, 2008), as well as administrators’ and teachers’ attitudes towards GIS technology (Demirci, 2011). Additionally, restrictions to using GIS include a deficiency in hardware capable of supporting the system and a shortage of technical support knowledgeable of GIS at educational institutions. Numerous obstacles must be faced when implementing new technology but, as Wiegand (2006) pointed out, “expectations are high as GIS implies a more collaborative, open pedagogy with greater emphasis on individual or small group learning and a changed relationship between learners and teachers” (p. 8). Advances in technology will, no doubt, continue, and GIS will become more feasible and reliable—and also more available.

**Critical Thinking with GIS**

The use of GIS in the classroom has had a positive impact on fostering critical thinking among those using the technology. As discussed earlier, inquiry learning and instruction are central to educational standards and the cognitive skills students need to develop. These include the use of critical thinking. Liu, Bui, Chang, and Lossman, (2010) pointed out that, with the use of GIS in PBL higher level cognitive skills, including the “critical” level, are more often manifested than lower cognitive level skills characteristic of memorization and recall. Research on the implementation of GIS in classrooms points to the development of the thinking and reasoning that characterizes spatial cognition.
In a review of research employing GPS and GIS as instructional tools, Broda and Baxter (2002) found that activities incorporating these geospatial technologies tap into the natural curiosity of youth. In other words, GIS and GPS bring maps into a new realm for students, who can use technology to plot specific points on Earth’s surface and then map these features for further analysis. The map comes to life and so does the learning. Ultimately, the perception of the map has changed from being a static representation with only one function to being a multi-purpose way to organize information of any type.

Two studies illustrate critical thinking associated with GIS. As cited earlier, Milson and Earle’s (2007) study focused on students using online mapping resources to investigate Africa as they worked in groups to find the most pressing issue facing a particular region of that continent. In addition to showing increased engagement in the content and technology, this study suggested that the use of Internet-based GIS (IGIS) broadened students’ cultural awareness regarding the issues that people face within Africa. It was clear that the ninth grade students were thinking critically as they made observations and demonstrated consciousness of this world region, especially with the use of the geospatial tool IGIS. Motivating students to think critically outside of what they “know” or what seems to be their comfort zone can lead to new understanding and comprehension of content. In this case, it was a new sense of empathy for this complex area of the world. The other study was conducted by Mitchell, Borden, and Schmidtlein (2008), who found that GIS can help students question why particular events occur. These researchers used GIS to teach about natural hazards in a middle school classroom with an emphasis on students’ ability to reason spatially. The findings suggested that students can focus not solely on where hazards are happening but also on why they were occurring at various places. As pointed out in the study, students in middle schools are at the age where they must learn to “make connections”
and to think critically as they develop meaningful understanding of data. The technology helped reveal relationships between the people and natural hazards that were not necessarily visible by other means.

Students’ Use of GIS Strategies

The previous section focused on GIS in K-12 education. This portion of the literature review examines earlier studies, which are few in number, that provide some insights into the strategies students use as they work with GIS in learning geography. The next section of my literature review focuses on the matter of spatial thinking for which there has been more research.

GIS is a complex system that provides a means to input, create, store, visualize, analyze, and report data. Users perform their GIS tasks, in large part, through the tools that the particular GIS system makes available, including searching and layering. To date, research is limited regarding the process students engage in when using GIS, as most studies have focused on the outcome associated with GIS experience, such as motivation and achievement. Here I review three studies that have delved into the process and examined the strategies that students use.

In a study based on the ideas of wayfinding and route-finding, Wigglesworth (2003) worked with middle school students to use GIS in determining the best bike route in the city of Atlanta. In addition to completing a questionnaire, the students worked in pairs, and were involved in “think-alouds.” A key focus of the study was the use of strategies by the students to complete the task. Findings of the study revealed three major approaches by students to find the best route. Some used a “visual approach,” in which students selected what looked to be the shortest route. Another group used a “transitional approach,” in which students used visual comparisons, zooming, and a ruler to calculate distances before selecting a route. A third group
used what he called a “logical approach,” which meant the group had visualization of routes, accessed more tools of GIS, and pretests before selecting the best route.

Although Milson and Earle’s (2007) study has been discussed earlier, I mention it here too since it provided some insights into students’ GIS process. The findings of this study revealed that students felt a sense of freedom when using Internet-based GIS. One reason was identified as freedom from the textbook, and the second was identified as freedom to explore their topic of interest. There was no lock-step way in which they should use those tools. The students were able to find data they felt was relevant and to select maps and graphs they considered most important to their topic.

Huang (2011) conducted a study focused on exploratory learning through the use of either a structured or GIS-based website with elementary students to understand development of an individual’s cognitive model. Video recordings of the students’ computers offered a chance for the researcher to view the processes employed by students when accessing the websites. The findings suggested that though the students using the structured website were more efficient, they lacked the element of exploring and were driven by the information provided such as diagrams. When it came to using the GIS website, students took more time, but in doing so explored the functions of the website and searched for information needed. These actions led to greater elaboration of the material and enhanced use of geographic inquiry.

Cognitive Maps, Mapping, and Spatial Thinking

The rationale for my study was to learn about the GIS processes performed by students and to examine the relationship between GIS and students’ spatial thinking. To discuss spatial thinking, I begin with the notion of cognitive map, a hypothetical mental representation thought to encompass spatial knowledge related to geographical locations. To gain insights into
cognitive maps (sometimes called mental maps)—and, thus, spatial understandings—researchers often have people create sketch maps. In this section, I review the underlying theory of cognitive mapping and the use of sketch maps to study geographic knowledge.

Cognitive Maps as Mental Representations

The discipline of geography, with its roots in spatial thinking and cognition, supports an underlying skill by people to create mental representations or visual understandings of places. Downs and Stea (1973) defined cognitive mapping as “a process composed of a series of psychological transformations by which an individual acquires, stores, recalls, and decodes information about the relative locations and attributes of the phenomena in his everyday spatial environment” (p. 9). Much of the current literature often uses the terms cognitive maps and mental maps interchangeably. For the purpose of this paper, the terms cognitive map and cognitive mapping will be used except when quoting literature such as that by the National Geography standards that uses “mental map.” Cognitive mapping takes place internally every day as individuals move across Earth’s surface encountering familiar and unfamiliar areas in their daily activities. It is only later, when these cognitive ideas are transferred to paper, that a hand-drawn visual of a cognitive map results.

Edward Tolman first coined the concept of a cognitive map in a 1948 paper reviewing the spatial representations of animals, specifically rats. In his study Tolman found that rats were able to proceed through a maze without a food reward successfully, but were able to use knowledge of boundaries and previous paths to “shortcut” when a food source was available. He suggested humans have these sorts of “maps” and use them on a daily basis.

As noted by Golledge (1999), cognitive maps represent knowledge of places developed through experiences, whereas cognitive mapping involves the user’s constructing spatial
relationships among places in those experiences. These representations vary from person to person, as no two people will have identical perceptions of a particular place. The spatial understandings that people develop may be based on a series of elements, such as landmarks or characteristics of the physical landscape. Furthermore, the level of spatial knowledge of someone living in an area for a long time would likely be more developed than that of a tourist or someone who is new to an area. It seems that, by asking students to create sketch maps, one may gain insights into their cognitive maps.

Golledge and Stimson (1997) pointed out that cognitive mapping became a major interest of behavioral geographers by the mid 1960s:

Since behavior in space was seen to be the outcome of decision-making processes that rely on combining stored information with ongoing experience, the significance of the cognitive map as the mechanism for storing, recalling, and using such information was an appealing one. (p. 225)

Cognitive maps can consist of complex relationships with the environment. Therefore, given better understandings of how people acquire and use geographic knowledge, educators may be more successful in producing material to further competency in geographic knowledge. Additionally, as Kitchin and Freundschuh (2000) proposed, cognitive mapping research may provide an inside look into improvements that can be implemented in various sources of “geographically-based media such as cartography, geographic information systems, in-car navigation systems, orientation and navigation aids for people with visual impairments, and signage placement” (p. 5). The more one develops spatial cognition about the world, the more articulate and accurate the cognitive maps will likely become.

A close look at the National Geography standards (1994, 2012) reveals emphasis on the importance of students’ acquisition of geographic skills, which include being able to create “mental maps” as a “geographically informed person.” The cognitive maps, which can and
should transform as students continue to learn throughout school and as they recognize and identify geographic phenomena throughout a lifetime, have several characteristics, as outlined by the 1994 National Geography standards. These include (a) containing both subjective and objective forms of knowledge or perceptions developed individually, (b) being used by people throughout their lifetime in various ways, and (c) lastly, changing or being refined to become more accurate by way of observation and knowledge gained about the world.

*Studies Employing Sketch Maps to Study Cognitive Mapping*

Cognitive mapping has been investigated in numerous fields of study and professions including education, businesses, and the government. Researchers have employed sketch maps to gain insight into cognitive maps. Golledge and Stimson (1997) presented several foci of this research, including connections of maps with spatial behavior, with planning, with problem-solving in crime, and with design of environments for those who are disabled. Sketch maps have been employed as assessment tools in measuring geographic understanding and spatial cognition. They are visuals that display individual internal representation of geographic elements developed as cognitive maps in one’s memory over time (Lloyd, 2000).

Though a fairly recent endeavor, cognitive mapping research has progressed over the last forty years and has seen a rebirth of interest among distinct fields other than just geography. Of particular relevance to the present research is the use of sketch maps to investigate cognitive mapping in studies involving geography education. In a study involving university geography students from 52 different nations, Saarinen and MacCabe (1995) were able to gain important insights through this approach. The sketch maps in this study showed the places the students considered to be interesting or important and also showed cross-national differences. Sketch
maps collected during the study provided a way to observe geographic literacy among nations around the world.

The use of mapping by Polonsky and Novotny (2010) was intended to provide understandings of students’ perceptions and knowledge of world regions as they compared to current literature that identified predominant world regions. Students were asked to “consider their own regionalization that would be appropriate for the organization” of a world geography course (p. 312). Each student drew two sketch maps that would be later combined into global maps. It is important to note that these sketch maps were completed on blank Robinson projection world map templates, which limit distortion near the poles by having longitude lines curve moderately. The land masses were thus more accurately represented than they would have been if a different map projection were used. The second map involved the identification of one “core” country in each region. Students were exposed to visuals of the globe that expressed elements of human geography such as demography, culture, and economic development. The ability of students to draw detailed shapes was not the focus of the analysis; instead, the accuracy of location and position was studied. Additionally, to support assessing the location of student maps, the authors relied on literature focused on defining core regions. The maps were scanned into digital images to be used in ArcGIS 9.1. The study showed that students’ drawing of maps was similar to the regional identifications defined in the literature, but there were some differences and possibly bias. For example, North and South America were sketched within the same longitudinal position, borders between North Africa and Sub-Saharan Africa were shifted, and Australia was sketched too far south, to name a few. The authors found that the sketch maps “may provide a vital basis for extensive discussion of geopolitical and cultural implications of world macro-regionalization” (p. 317). In addition, the maps provide insight into the perception
of regionalization by students compared to current geographic literature. This can be a valuable asset of sketch maps when trying to understand how spatial cognition builds after completing WebGIS lessons.

Sketch maps have also indicated different cognitive maps for two groups of people living in the same area. In a study to investigate how children perceive their neighborhood from a cultural standpoint, Gillespie (2010) used sketch maps by both Amish and non-Amish children living in the same rural area. Gillespie observed that “since children in different cultures interact with their environment in different ways, their cognitive maps, or the information about their environment that is encoded internally, are based on the particular cultural artifacts of their given culture” (p. 19). Two types of rubrics—designative and appraisive—were used as a measure in this study to categorize the sketch maps of the two subgroups. Designative elements included paths, edges, districts, landmarks and social activities (cf. Lynch, 1960), and the appraisive rubric was based on Matthews’s (1984) scheme of classification. Matthews’s scheme of classification is based on the assumption that children may see the environment as human and natural. Therefore, Matthews designed a scheme to designate the types of features youth may engage walking to and from school including “functional, recreational, natural, personal, transportational, and animal.” Gillespie observed that by using rubrics to analyze the children’s sketch maps, the perception of how the children view the neighborhood becomes discernable. The results from the study suggest differences in the social aspects of both groups. The maps of Amish students revealed more inclusive community setting, whereas the non-Amish students produced maps with a sense of neighborhood including recreational activities. Additionally, the use of the rubrics as an analysis provided insight to the understanding of what students take in from their environment such as homes, landmarks, vegetation, and landscape.
In their study of student perceptions of music regions in the U.S., Shobe and Banis (2010) found that sketch maps reveal cultural understandings. This study analyzed the sketch maps for the location of music genres, which resulted in GIS created choropleth maps derived from student responses. By having the students investigate their own cultural understanding and then comparing it with their peer’s perceptions, the authors established insight into how individual perceptions of culture are created. The analysis fostered questions among students on their experiences behind their cognitive maps, but also found that maps can be a critical tool in teaching geography. The authors stressed the importance of using maps more frequently in human geography to help students connect place to cultural understandings. The use of sketch maps can be a way to get students to think spatially about the relationships and understand regional distinctions.

A different approach to sketch maps was employed in the country of Lesotho in a study on transportation in rural Lesotho. In this study, Vajjhala and Walker (2010) used participatory sketch mapping and GIS in a community to use maps produced by hand, but to allow the storage capacity and manipulation advantages of digital mapping. Participants in the study created sketch maps of “mobility patterns and access to services” through a defined, several step process (p. 490). Group interviews were conducted to allow participants an opportunity to voice their thoughts on key destinations, routes, footpaths, and services available, but also the barriers that may be encountered when moving. A scribe for the group was designated and they used the interview data to generate a sketch map. GPS was used to collect points of the key destinations to be mapped and were consolidated into layers to be used with GIS. Vajjhala and Walker explained that their approach “balances the social and spatial dimensions of participatory mapping and GIS to illuminate local perspectives and to bring communities and local
government into the road network decision making process” (p. 490). The findings of the study highlighted the mobility of the people of Lesotho and also some differences in mobility related to gender.

Geographic knowledge is often based on visualization and also on spatial awareness, but much more is involved. Gillespie (2010) stated that cognitive maps develop as familiarity with, and knowledge, of the culture of a place changes. Though the field of geography has developed and evolved throughout history, one truth remains central to the discipline: maps. Cognitive maps built by students are individualized perceptions of the world that may include cultural similarities and differences.

When using sketch maps researchers must be cognizant of some limitations. For instance, the difficulty people may experience with regard to artistic skills (Gillespie, 2010) and challenges found with the interpretation of maps (Saarinen & MacCabe, 1995).

The Value of the Mapping Approach to Research

The prior research reviewed here shows that sketch maps can provide valuable insights into spatial cognition. The studies mentioned previously identify five key points that support the use of mapping: (a) sketch maps provide insights into cognitive maps; (b) sketch maps can differ for people living in the same area; (c) sketch maps can reveal “biases” that conflict with what is taught; (d) sketch maps can display cultural understanding; and (e) sketch maps can be used in research as a participatory mapping exercise. It is clear that mapping has played a vital role in early research and is of growing importance as the concept of spatial thinking becomes more salient in our daily lives. Research has shown that, by using sketch maps, we can learn more about the spatial cognition of individuals at any age. The nature of geography traditionally supports the use of maps to measure spatial awareness and to see how people learn about, and
view, their surroundings. Furthermore, such studies can show internal understanding of numerous topics or situations individuals encounter that help build their spatial cognition. Lastly, though many aspects of learning have changed, the use of sketch maps to understand cognitive mapping has passed the test of time. Continued research to understand the value of cognitive mapping is needed especially when considering its interdisciplinary nature and the increasing use of visual technology such as GIS.

Though some studies have focused on the way a map has been drawn and the distances between places or lengths of roads, my study focused on the development of spatial understandings of the world through the use of GIS lessons aligned with the AP Human Geography curriculum. My goal was to investigate how students view the world and how their spatial cognition changes as they move through the AP Human Geography course using GIS as a spatial tool. Sketch maps were a means of assessing such changes.

Conclusion: A Need for Research

From an analysis of current literature regarding the implementation of GIS, one can see gaps in research regarding geospatial technologies. Though much research has been conducted since Kerski’s (2003) early study investigating the implementation and use of GIS in K-12 classrooms, there are still noticeable holes in the literature. For example, access to technology and resources continues to be an issue. However, Demirci (2011) was able to use GIS as an instructional piece in a classroom with only one computer available for projecting a GIS lesson. Though this exposure did allow students to become introduced to GIS and its structure and functionality in geography learning, the question remains regarding what meaningful ways can students use GIS to enhance spatial thinking?
The gap I sought to fill concerns learning more about students’ actual use of GIS and changes in their spatial cognition associated with the study of human geography and use of GIS. Students today are stepping into an AP classroom to learn human geography at an advanced, college-level pace with little or no exposure to the study of Earth—the location of places, physical and human phenomena associated with place, and development of the cultural landscapes. My study arose from the following developments and beliefs regarding geography education: (a) geography education has undergone change and will continue to change; (b) GIS is being increasingly used in classrooms to support spatial thinking and development of geography learning; (c) spatial thinking should be developed; and (d) sketch maps have been used to measure spatial thinking of individuals.

It is important to explore the thinking process of students in order to teach them effectively. By using GIS, which is a hands-on tool, students are no longer limited to using dated textbook maps or paper flat maps. Instead, students can look at the Earth with real-time data, ask geographic questions, and apply these skills to better their own cognitive map. My study, employing GIS in an AP classroom, contributes to this line of work by investigating the strategies that students use and the impact of such a powerful technology on students’ spatial thinking.
CHAPTER 3

METHOD OF THE STUDY

*If a picture is worth a thousand words, a map is worth a million.*

Harm de Blij

Now that GIS is being used more frequently in geography education, there is a need for a better understanding of how it relates to student learning. The purpose of this study was to answer four major questions regarding the use of GIS by high school students in an AP Human Geography course:

1. What were the cognitive processes in which these students engaged when investigating geographic phenomena using WebGIS?

2. What changes in the students’ cognitive maps (as assessed through sketch maps) were associated with the GIS-enhanced AP Human Geography course?

3. How did the GIS maps relate to the sketch maps?

4. How did selected students explain the nature of their GIS maps and their sketch maps and changes therein?

The study employed multiple data sources, including student-generated sketch maps, ArcGIS maps, field observations, video- and screen-recorded use of student computers, audio-recorded interviews, and a teacher reflection journal. The research took a mixed-methods approach. Quantitative methods were employed to provide insights into the strategies employed by all students and also their spatial thinking as they used GIS to study human geography. Qualitative methods moved the study beyond those findings to examine individual students’ understandings through case studies involving interviews. As Tashakkori and Teddlie (2003) argued, mixed methods can help address research questions that are complex and call upon the analysis of both quantitative and qualitative data. The use of case studies in this research
provided an opportunity to investigate in more detail the strategies individual students employed in completing the GIS activity. It also provided insight into their cognitive mapping and its association with the GIS maps. As noted by many scholars, case study research often begins with the need to gain more in-depth knowledge about a situation, phenomenon, or action (e.g., Merriam, 1998; Yin, 2009).

This chapter begins with a description of the school context and AP course in which the study took place. That is followed by a description of the participants, the procedures for data collection, and the procedures for data analysis. The chapter concludes with a brief explanation of how the various sets of data answered the questions guiding the study.

Context and Course

The Site

The research study took place at a secondary school in a city of approximately 100,000 people located in the southwestern region of the United States. The student population enrollment of the school was in four grades (nine through twelve) and included numerous ethnicities: White (29.8%), Hispanic/Latino (38.2%), Black/African-American (20.7%), Asian (7.3%), American Indian/Alaskan (0.5%), and Hawaiian/Pacific Islander (0.1%). Approximately 3.4% of the student population self-identified with more than one ethnicity.

The daily schedule of the school began at 9:00 a.m. and ended at 4:10 p.m. During the day, students attended seven class periods, each lasting 50 minutes. As regards to technology, the school had three computer labs as well as a library with computers that teachers could access for their students during the day for technology instruction or content activities. The computer labs as well as the library were each equipped with between 25-30 computers, plus a teaching
station with an additional computer and attached projector. Additional computer labs could be found in the school, but were used primarily for the career and technology courses.

The AP Human Geography Course at This Site

As mentioned earlier, the AP Human Geography course is designed to provide students the opportunity to learn content consistent with the rigor and expectations of a college or university level introductory human geography course. At the time of the study the course was taught at this school in two semesters, although other schools could offer it in one semester only. There were seven sections of AP Human Geography at the school offered to students in ninth grade as an alternative credit for the World Geography course requirement by the state of Texas. One of these classes was the setting for the study. The College Board (2013) course description states the following regarding the purpose of the course:

The purpose of the AP Human Geography course is to introduce students to the systematic study of patterns and processes that have shaped human understanding, use, and alteration of the Earth’s surface. Students learn to employ spatial concepts and knowledge analysis to examine human socioeconomic organization and its environmental consequences. They also learn about the methods and tools geographers use in their research and applications. (p. 4)

By learning about the relationship between humans and the environment, students gain knowledge of the lasting impact of humans on Earth’s landscape in both how land is arranged and how it is developed. The College Board 2013 standards suggest that, upon completion of the course, students should have the skills and knowledge to “interpret maps and analyze geospatial data”; “understand and explain the implications of associations and networks among phenomena in places”; “recognize and interpret the relationships among patterns and processes at different scales of analysis”; “define regions and evaluate the regionalization process”; and “characterize and analyze changing interconnections among places” (pp. 4-5).
One of the key concepts in AP Human Geography is addressed in the first unit of the course, Geography: Its Nature and Perspectives. It is in this unit that students are intended to grasp the importance of spatial thinking and to begin to use a spatial perspective as a geographer to learn how to ask questions and solve problems using a variety of geographic tools. As students work through the foundations of building a spatial perspective, they later use the skill to think spatially as they progress through the remaining six units of study in the human geography course outline. Each unit includes various learning experiences, including lecture, note-taking, a unit project, and supplementary reading, and it concludes with an examination. Emphasis in this course in human geography is placed on developing an understanding of physical and cultural relationships on Earth in a rigorous learning environment. Although GIS is introduced during the first unit, the text adopted for this school’s human geography course provides only a short description of what GIS is and briefly mentions its use in the real world.

Overview of This Study

This study, which lasted twelve class days, took place during the fall semester of the AP Human Geography course, which is a two-semester course. It was conducted during the second unit of study, Demography: Population and Migration, which began seven weeks after the fall semester began.

Pre-GIS Activities

During the first week of the unit, I met with the class, introduced the study, and recruited participants. Also during that week and the following week prior to the study, the teacher collected sketch maps of the world from the students. These initial sketch maps provided my means of selecting six students from voluntary participants to become case studies. Prior to beginning the GIS assignment, students also completed a brief questionnaire regarding their prior
experiences in geography and prior use of GIS. More detail regarding these and other procedures is provided below.

The Unit

The demography unit covers two essential topics: population and migration. In studying population, students learn where population is distributed in the world, how population changes over time, and the impacts of population growth on Earth. The migration topics students investigate include the forces behind why people move, migration patterns and trends over time, and the impact of migration on both the country losing population and as well as countries gaining population. As part of this unit, students completed a lesson that used WebGIS, specifically ArcGIS Online.

The Assignments

The assignment, which is included in full in Appendix A, had two parts—one part focused on population and the other part focused on migration. It included steps students were to take to learn how to use the GIS system with minimal support and also included questions to expand their understanding of geographic phenomena using the map viewer. The assignment first provided a means to using GIS a way for students to learn about population and migration while learning how to use some of the functions of WebGIS. After finishing the assignment, the students were instructed to make two maps, one focused on population distribution and the other on migration trends. Students had access to various tools associated with GIS, including tools for searching and for adding layers of data, creating an editable layer of data using draw and identification tools, and changing the transparency of layers to view multiple layers at once. As students performed the GIS lesson, I observed and took notes. Another source of data was
screen-capturing, which the students employed when creating their own GIS population and migration maps.

Population assignment. The WebGIS population assignment asked students to follow a series of steps in which they searched and added prescribed layers of data, viewed the details of the layers such as the legend using the “Details” tab, added map notes, and changed the scale to view the data by zooming in and out. Students then documented information, inferred relationships, and supported their hypotheses on population data found in each layer focused on various topics ranging from local to global in scale.

Migration assignment. Similarly, the WebGIS migration assignment also presented students with a series of steps to follow. However, this assignment focused on the movement of people across landscapes. Students first viewed migration trends within the United States, and then they searched for layers of data to help identify current global migration patterns. Students focused on topics such as push and pull factors that might influence migration.

Creation of GIS maps. The last task of the WebGIS assignment asked students to create two maps employing GIS. The first map was to show population distribution around the world and to try to understand why it might be the way it is. Students were encouraged to add layers of data, including editable layers of data. The second map was to show migration patterns or trends and come up with any reasons behind migration. Students were again encouraged to add layers of data they felt were important and create editable layers of data. The WebGIS lesson used in the study took five days to complete, including production of the two GIS maps described here.
Post GIS Activity

At the conclusion of the GIS portion of the study, students again created sketch maps of the world. At that point, I conducted interviews with the case-study participants and also an interview with the teacher.

Participants

In this section I explain my means of recruiting participants and protecting their identities and provide descriptions of the participants. I also discuss my role in the study.

Recruitment of Participants

When visiting the class, I provided an oral overview of the study and answered students' questions. They also received a written description of the study. Students were told that their identities would be protected in the following ways: confidentiality of individual information would be maintained in any publications or presentations; those students selected to participate as case studies would be given pseudonyms to protect confidentiality if any material from the interviews was cited; and all student-created products would be locked in a cabinet accessible to only myself and the researcher advisor.

Student Participants

The twenty participants included six males and fourteen females. Their ethnic/racial identities, according to categories used by the school, included seven Asian, four Hispanic, five White, and three Black. One self-identified with more than one race. All students in the class completed the assignments associated with the study, but the completed assignments were omitted if the student or his or her parent had chosen not to participate. Of the twenty students who participated, all created two pre- and two post-study sketch maps and two GIS maps. However, one of these students did not complete the post-study sketch maps. Her products were
not analyzed for her GIS strategies or for the sketch maps and the comparison of the sketch maps to the GIS maps.

On the first day in the lab students completed a brief questionnaire that took no longer than 10 minutes to complete. The questionnaire, provided in Appendix B, asked students about their prior experiences with geography education and their attitudes toward, and interest in, geography. The questionnaire provided some background on the students that would be helpful in interacting with a subset of the participants who serve as case studies.

Case-Study Participants

Upon completion of the initial sketch map by students, six students were selected to serve as case studies. The case studies in this study allowed more insight into the use of GIS as a tool in studying AP Human Geography and building spatial perspectives of the world. The students who became case studies provided explanation of their sketch maps in interviews and also gave more detail about their thought processes when using ArcGIS Online.

The six case-study participants were selected based on their initial sketch maps. Of the six students selected, varying amounts of information were included on the initial sketch maps as well as detail and elaboration referencing population distribution and migration patterns on Earth. When the sketch maps were analyzed by the details included, I chose two with much detail, two with moderate detail, and two with little detail. If a student participated in the study, a pseudonym was used to protect his or her identity. In the sketches below, the information about students’ background in geography comes from the pre-study questionnaires and initial interviews. They are ordered here by the analysis of their sketch maps level of elaboration. The first two participants were identified as having geographically simple maps, the second two were
identified as having geographically complex maps, and the last two participants’ maps were identified as geographically informed.

Maria. Prior to taking the AP course, Maria had had little exposure to the discipline of geography. Previous social studies courses she took included Texas History in the seventh grade and U.S. History in the eighth grade. Though she did recall attending to physical features in these courses, she could not recall doing much geography besides basic concepts, such as landforms and weather in elementary school. She had a globe at home and she recalled playing with a United States map game as a youth. As a student of geography, she was confident in her ability, indicating that she understood most of the concepts she had studied thus far in AP Human Geography. Though soft-spoken and somewhat shy, she shared a personal interest in geography that included the clustering of people together and the study of ethnicity especially among schools. One challenging aspect of geography for Maria is learning dates, and she maintained that geography is “focused much more on things other than dates.” While in class, Maria was very attentive and seemed engaged in the assignments at hand.

Suraj. This participant, Suraj, noted that he began learning about the world in elementary school and then continued with Texas History in the seventh grade and World History in the eighth grade. Though some concepts, such as exploration and Columbus as well as trade routes in Asia, were discussed, Suraj had little exposure to geography. Although he had globes and atlases at home, he explained that, if he wanted to find something, he would just use the computer. Reflecting on his experience thus far in AP Human Geography, he felt that he was a good student. He said that, if one paid attention, he or she would be prepared for the assessments and would be able to use the knowledge in the future. Suraj had a personal interest in the
element of history in geography—specifically how people migrated and how there was
documentation of events historically prior to when we had technology.

Gita. The female student called Gita had a more developed exposure to geography than
most of the other students because of her background living previously in New Jersey, India, and
the United Arab Emirates. She lived in India at a very early age where she attended a private
school. Gita started geography in kindergarten, but an actual course in geography was not
available to take until the third grade. When she moved to Dubai, where she lived for a short
time, there was no geography course. Upon returning to India, she was again in a geography
course, and by the seventh and eighth grades she felt that geography was becoming a little
harder. When she moved to the U.S., she did not take a geography course because she did not
have the option. At home Gita owned an atlas, and she made a point of stating that in India
students were required to buy an atlas. As a student of geography, she indicated liking the
subject and felt that she likely had more exposure to it than her peers. Gita found the migration
unit to be particularly interesting, since she herself had migrated.

Allie. Prior to this course, Allie had not taken much geography, although she did take
PreAP courses before enrolling in the AP Human Geography course. When it came to learning
geography, she recalled doing only a few maps in U.S. History and Texas History. Allie said she
enjoyed searching in her atlas for places she might want to go. Though this year thus far was
more difficult than previous years, she felt that she understood most of the geographical concepts
and maps. One area she found particularly challenging in studying geography was when she had
to focus on the patterns of specific topics and timelines. Allie said she enjoyed learning about
cultures and had an interest in European History. Leading up to the study, she mentioned that
she really had not heard of GIS or had much information regarding it as a geospatial tool.
Aaron. Aaron indicated that his exposure to geography started in the fifth grade when he learned some geography during a history class. In addition, he did have a geography class that was taught for one year in the seventh grade. It needs to be noted that he attended a private school prior to attending high school. When it comes to geography, he was quite honest, stating: “I feel pretty okay, I don’t think it is my strong suit. . . . It’s definitely not my weakest.” Aaron indicated that he enjoyed physical geography such as landforms. However, he did find understanding why people do the things they do, such as what would be the driving force for someone to migrate, challenging.

Christopher. Prior to taking the AP Human Geography course, Christopher had taken history as his only middle school level social science course. He had previously learned basic elementary geography, such as countries and continents. Uniquely, Christopher discussed that he felt he learned more geography outside of the classroom due to his reading and personal enjoyment of looking at globes and maps for fun. Though he had globes and atlases at home, he stated that they needed to be updated since they still included the Soviet Union. Christopher was definitely interested in the subject of geography, especially when it comes to ancient maps and how things have changed over time. He said that he felt that he was likely more interested in the subject of geography than his peers. Though he indicated an interest in geography and said that he feels that he understood most of the concepts, he pointed out that the challenge for him in learning AP Human Geography was learning the vocabulary.

Participating Teacher

The teacher participant for this study, whose pseudonym is Mrs. Katey McClure, was an experienced AP Human Geography teacher. At the time of this research, she was the instructor for four sections of AP Human Geography. She had been teaching for ten years, and seven of
those years were devoted to teaching AP Human Geography. She had taught additional subjects, such as world geography and Advancement Via Individual Determination (AVID). Her role as the teacher in the study was to teach the course as she normally would during the semester in addition to having her students create pre- and post-study sketch maps, and implement a WebGIS activity focused on Unit II. Mrs. McClure was considered a participant in the study because she was observed, interviewed, and provided information on class activities and instruction.

My Role in the Study

Because of the qualitative elements of this study, it is important to describe my role as a researcher. Merriam (1998) identified the role of the researcher in qualitative studies as an important element in the collection and analysis of data, since it is the researcher who engages in the observations and interviews and uses that knowledge to generate meaningful explanations.

Specifically, my role as a researcher in this study can best be labeled as “participant-observer” (Merriam, 2009; Teddlie & Tashakkori, 2009). At the time of the study, I had taught for a total of ten years as a teacher of the following courses: World Geography, PreAP World Geography, AP Human Geography and GIS. As an observer of student participation in the lessons, I was able to document the actions, attitudes, and overall usage of technology in the AP Human Geography classroom. Though my primary role as the researcher was to observe the activities taking place in the designated setting and collect data through other means, there were occasions during the study when I needed to participate to help students. For example, when one student was having difficulty loading a layer of data, I stepped in to help the student reload the layer. Several students asked for help with using several of the features of ArcGIS Online, such
as changing the transparency of the layer so that multiple layers of data could be viewed at the same time. Therefore, I helped the students find this feature and apply it to their layers of data.

Field notes and artifacts, such as the video recordings, online computer screen capture, and especially the student-generated sketch maps, provided the means for me to analyze the processes employed and spatial thinking developed during the study. Lastly, when participating in the individual interviews, my major role was listener as I asked questions of my participants and gathered valuable information.

Procedures for Data Collection

In studying the approaches students employed in performing GIS and also possible changes in their spatial thinking, several data-collection approaches were used. These were mentioned above; here I provide more detail.

Observations

My observations were intended to provide what Merriam (1998) referred to “knowledge of the context,” but their main purpose was to record the strategies that students employed as they performed their geography tasks. Field notes, taken to capture the experiences of students, also included a diagram of the classroom to establish the scene or environment in which the study took place. I took the notes during the drawing of sketch maps on the first day of the study, during the five days of performance of the GIS task, and during the day when students redrew their sketch maps. Thus, I had notes for seven days totaling eight and a half pages. When students were creating sketch maps, I attended to their behavior, their comments, and clarifying questions they asked. When they were engaging in the GIS task, my attention was on the strategies that they employed, such as creating layers and using tools and also on challenges or difficulties they encountered using the software and questions for clarifying the task at hand. At
the end of each day I reviewed my notes and created a typed memo summarizing the day’s activities. I had ten pages of typed memos. As discussed by Maxwell (2005), writing memos often while conducting research can allow the researcher to facilitate analytic thinking about the data collected during the study as well as foster new perceptions.

Each of the observations was approximately 50 minutes in length, except one day in the computer lab when the observation was only 40 minutes in length due to an altered schedule for a pep rally that took place earlier in the day.

*Recordings: Video and Screen-Capture*

The video recordings captured the dialogue and interactions between students as well as between the teacher and students that occurred while students completed the GIS task and created the maps. As Glesne (2011) pointed out, videotaping can be highly beneficial because the researcher has continued access to the recordings and can replay them as many times as needed for analysis. The video recordings for this study offered a visual diary of the learning taking place on multiple scales revealing details that observation notes may miss. I had three hours of video-recordings at the conclusion of the study.

Of much benefit were screen-captures recorded on computers as participants completed the GIS lesson and created the GIS maps. Screen-capture technology allowed the user of the computer to record all of his or her actions while working on the computer (cf. Smith & Smith, 2012). Although the computers had microphones, it was difficult to hear conversations in the audio playback. In this study, the screen-capture images were saved by students to USB devices to be used later for data analysis. Screen capture recordings were intended to provide a glimpse into the step-by-step process in which students engaged as they made decisions and investigated the data layers added to the map. Furthermore, the actions of students were recorded on the
computer, allowing me to move freely around the room rather than having to be stationed at any one computer. Similar to the video recordings, I had access to the recordings and replayed them as needed to acquire multiple aspects of the experience by the participants. I had approximately 121 screen capture recordings by students during the study. All students who participated in the study were able to collect at least one screen-capture while creating the GIS maps. Each of the screen captures was approximately five minutes in length totaling approximately ten hours of recordings. I took handwritten notes while observing the screen capture recordings of the participants. I had approximately 29 pages of notes.

The screen-capture recordings and video recordings offered real-time data coverage of the interactions between students and the actions of individual students during the study that was later analyzed.

**Sketch Maps**

To assess student knowledge and the impact GIS has on spatial thinking, two sets of sketch maps were collected from students—one set prior to and one set following the implementation of the WebGIS lesson. Each set included a population sketch map and a migration sketch map. There were 78 maps in all. As mentioned earlier, one student did not complete the second set of sketch maps.

*Initial sketch maps.* To create their initial sketch maps, students received two blank Robinson projection world maps, and red, blue, and green colored pencils. The instructor, Mrs. McClure, explained what a sketch map is, and then provided instructions on a slide regarding how to create the sketch map. Students created two sketch maps: one map focused on the location of high, medium, and low population density areas of the world and the other on migration patterns in the world. To create the initial population density sketch map, students
were asked to shade areas of high, medium, and low population density around the world. To identify high population density areas students used the red colored pencil. Medium population density was identified with the blue colored pencil, and low population density areas were shaded using the green colored pencil. To create the migration trends map, students were asked to put a red, plus symbol (+) in areas around the world to which people were moving, a blue, minus symbol (−) symbol to identify places from which people were moving, and a green equals symbol (=) symbol where they believed there was equal net out- and in-migration. Students were given 15 minutes to create their initial sketch maps and were not allowed to use any supplemental resources.

*Final sketch maps.* After completing the GIS assignment, students were once again asked to create two sketch maps. Each student received two blank Robinson projection world maps, and red, blue, and green colored pencils. The instructor briefly reminded students of how to create a sketch map, and then provided the class with instructions on a PowerPoint slide to create two maps. The same conventions were followed in creating the sketch map. As before, students were given 15 minutes to create the sketch maps.

*GIS Maps*

At the conclusion of the GIS task, students created two GIS maps. The first map focused on population distribution around the world, and the second map focused on migration patterns around the world. Students’ maps were all printed so that they could be analyzed for the strategies that students employed, and they were printed in color so that the layers would be apparent. They served two other purposes in the study: they were studied for possible relations to the sketch maps and were used to develop questions for the case study interviews.
Case-Study Interviews

With each student selected to be a case-study participant, I conducted two interviews as I sought a better understanding of their GIS strategies and their spatial thinking. In the interviews my focus was on the views of the interviewee in accordance with an interpretive constructionist standpoint (Rubin & Rubin, 2005). The nature of the interviews was semi-structured, which, as pointed out by Hancock and Algozzine (2006), can be particularly useful in case studies because the researcher can ask not only predetermined questions but also follow-up questions that can probe for additional information. Each interview took place after school dependent on the student’s availability and lasted no longer than one half hour, and it was conducted in the participating teacher’s classroom in the school to minimize disturbances. At times, the participating teacher (with permission of the student) was in the classroom during an interview, though she was not involved in the interview process. Each interview took place at a table in the classroom far from the door to provide a quiet space where the recordings could be clear and few disturbances would occur. Each interview was audio-recorded and transcribed.

Initial interviews. Initial interviews with the case-study participants took place after school at times that were dependent on the student’s availability, and they lasted an average of ten minutes. Several questions were prepared for all case-study students prior to the interviews. These questions helped form a base of knowledge of the individuals participating in the interview process. They included the following:

1. I am interested in learning about your background exposure to geography. Please tell me about geography courses you’ve taken before AP Human Geography.
2. There are many tools that support the learning of geography such as an atlas or globe. Do you have any things like this in your home?
3. How do you feel personally about yourself as a student of geography? (Depending on the answer, possibly ask the participant to elaborate). Do you feel as though you understand most geographical concepts?

4. What do you find interesting about geography?

5. What do you find challenging about geography?

6. Can you tell me what you know about GIS?

7. How did you go about drawing your first sketch map?

8. How do you feel about what you produced?

In addition to these predetermined questions, I also asked individualized questions, some of which focused on more specific details of their sketch maps as well as to clarify an answer provided by the case-study participant. For example, when I spoke with Christopher, he said that vocabulary was an obstacle for him this year. I tried to clarify this challenge for him by asking, “Is it just because the words are unfamiliar or maybe you have never heard them before?” Similarly, when I asked Aaron about a challenge he experienced in the course, he stated that he struggled with understanding the motives behind human activities. So, I asked, “So that challenging aspect is just understanding that ‘why’?” When discussing the sketch maps with Suraj, I asked if he used prior knowledge to create both his population and migration maps. When discussing Gita’s sketch maps she referenced a more developed country (MDC) and less developed country (LDC) project; therefore, I asked, “What is the LDC/MDC project?” Lastly, when discussing her population sketch map, Allie too focused on MDC and LDC areas of the world as she shaded in the map, but she didn’t elaborate on any specific regions. I asked, “Did you have any specific places that you knew with regard to population?” The initial interviews ranged from seven minutes to 13 minutes in length. The average was 10 minutes.
Post GIS interviews. The second interview, also conducted only with the case-study participants, was designed to help clarify the decisions that these students made and the strategies that they used as they created their GIS maps and their sketch maps. In developing the questions for each of the six individuals, I drew upon the various other data sources used in the study, which included the video recordings and screen capture recordings as well as the observation notes I took. For instance, in exploring migration patterns, Gita seemed to spend an unusual amount of time in finding a layer of data regarding disease. I asked her why she focused on disease as an explanation for why people migrate.

An important facet of this interview was the maps that these students created. Prior to the interviews I determined particularly interesting or puzzling aspects of the maps. I showed the student the map and inquired about that feature. For instance, in one of his GIS maps, Christopher identified multiple cities and urban areas having high population densities, a characteristic that was not employed by any of the other students. My interview included attention to that feature. This approach of showing students features of their products and inquiring about them has been used in composition research, where it goes by the name of discourse-based interview (Odell, Goswami, & Herrington, 1983). These post GIS interviews were, of course, longer than the initial interviews. They ranged in length from nine minutes to 29 minutes, and lasted an average of 16 minutes.

Similar to the initial interview, the post interview had several predetermined questions that helped open discussion of the GIS maps students created. The questions included the following:
1. How did you go about creating your second sketch map?

2. Can you discuss with me the process you used to create your population map using GIS?

3. Can you discuss with me the process you used to create your migration map using GIS?

4. Did you find anything interesting about using GIS?

5. Did you find this mapping program useful?

6. Did you encounter any challenges using GIS?

7. How do you feel about what you produced?

However, there were several instances in each interview that offered a chance for me to better grasp the mindset of a particular student when he or she created a map. I again used follow-up probes in an attempt to learn about the strategies the students used and also their knowledge of population and migration. For example, one student focused only on the United States when creating the migration map. Therefore, I asked the following: “On this map you focused just on the United States. Was there a reason for that?” Another example of individualized questioning was directed to one student who just stated in discussing the map that he had many ideas of what could cause migration, but then did not further elaborate. Therefore, I probed for additional information to clarify these thoughts in his process of creating the map by asking, “What were some of your thoughts of things to cause migration?” By focusing on unique features of each students’ maps, the questions offered participants voice and reasoning to be heard through inquiry. Additionally, case-study participants were asked individually to discuss their experience using GIS including what was interesting using the geospatial tool as
well as any challenges he or she encountered. Each interview was audio-recorded and transcribed.

Procedures for Data Analysis

Data analysis was continuous, offering multiple opportunities for me to develop better understanding and perspective pertaining to the research questions. In this section I describe my approach to analyzing data from the various sources.

Analysis to Determine Students’ GIS Strategies

A major focus of the study was the strategies that the students employed when performing GIS, and I had multiple data sources to provide insights: observations, video-recordings, screen-captures, and GIS maps. For analyzing these data sources, I used a common set of coding categories based on the strategic resources available through GIS. They included the following: searching, layering, removing a layer, and using graphics. The latter had three possibilities as tools: noting, adjusting transparency, and editing. Table 1 lists these strategies and provides an explanation of each.

For each student, I tabulated the use of these particular strategies. I began using the codes when I made observations and when I looked at the video-recordings, doing so mainly to see what needed to be added. However, the GIS maps and the screen captures were the most valuable sources for documenting students’ strategies in performing GIS.

The data from the observations were used only in a supplementary way because my major sources would be GIS maps, screen-captures, and, to a lesser extent, the video-recordings. In addition, I also noted case-study participants’ interactions (e.g., collaborating, asking questions) or expressions (e.g., frustration, success) while completing the GIS assignment and
creating their GIS maps. The latter were helpful in developing questions for my concluding interview with the case-study participants.

Table 1

Strategic Resources Coding Categories

<table>
<thead>
<tr>
<th>GIS Strategy</th>
<th>Description of Strategy Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Searching</td>
<td>Student was able to search for layers of data using the &quot;Add Layer&quot; function, selecting “search for layer,” and then identifying a key word or term to conduct a search.</td>
</tr>
<tr>
<td>Layering</td>
<td>Student was successful in adding a layer(s) of data to their map by clicking on the “Add Layer” tab.</td>
</tr>
<tr>
<td>Removing a layer</td>
<td>Student was successful in removing a layer(s) of data to their map by clicking on “Remove” in the search results or in the legend.</td>
</tr>
<tr>
<td>Adjusting transparency</td>
<td>Student added more than one layer of data and changed the transparency of one layer in order to see multiple layers at the same time.</td>
</tr>
<tr>
<td>Editing</td>
<td>Student created an editable layer of data to add additional information such as pushpins, circles, or identify regions</td>
</tr>
</tbody>
</table>

The calculations of data that reflected the use of different strategies by students were completed while watching the screen-capture recordings as well as from analysis of the GIS maps. The screen-capture recording was very telling of the processes and steps students took to create the GIS maps. The same codes described above were employed. Because of the technology, the coding was rather precise with the screen captures in that it was possible to count
the number of steps students took in performing a task and to note what students viewed directly as they worked. Each strategy used by an individual student during the process of creating the maps provided by the screen-capture recordings was counted only once. The final GIS maps were analyzed as a final product, and only those features not counted in the screen-capture recordings were counted.

**Analysis of Pre-Post Changes in Sketch Maps**

Through comparing sketch maps produced before and after the GIS task, I hoped to gain insights into the influence of the GIS experience on students’ spatial understandings. The sketch maps (pre and post GIS) were compared for individual students, and increases or decreases in accuracy and specificity were noted. Previous studies that employed the use of sketch maps used rubrics and rating schemes to analyze the sketch maps. Though there were several ways that researchers had created the rubrics, each was dependent on the focus of the specific study. For example, Saarinen and MacCabe (1995) used a rating scheme based on 5 categories—“poor, flawed, good, very good, and excellent”—when assessing student sketch maps of countries and continents. Gillespie (2010) used a designative scheme and an appraisive scheme to categorize sketch maps created by Amish children. Her designative scheme was based on Lynch’s (1960) urban classification, and her appraisive scheme was based on Matthews’s (1984) classification, which includes function, recreation, human, nature, animal, and transportation. Though I did not find any one rating scheme or rubric that suited my study, I found the rating schemes used by Gillespie (2010) to be helpful in considering the types of features students might include on their sketch maps or the ways in which they might shade the maps. Therefore, I identified different types of features that might be incorporated into the sketch maps, including country, regional,
urban centers, and physical features. The rating scheme I designed was based on the level of
detail included on the sketch maps as designated by three categories.

*Level of detail of sketch maps.* For each student who completed the GIS maps I
calculated the level of detail by documenting the information each student included on his or her
maps in a spreadsheet. Details in these maps included such elements as specific countries,
regions, and cities or urban centers as well as such physical features as mountains, deserts, or
bodies of water. A more detailed description of each of these elements follows:

Country: Students often identified population and migration trends by focusing on
specific countries rather than larger regions or continents. This category identifies that the
student shaded or identified specific countries when exhibiting their knowledge of population
and migration.

Regional: This category recognizes the student’s emphasis on identifying population
density and/or migration by focusing on regions including but not limited to North America,
South America, western Europe, Eastern Europe, Africa, Central Asia, the Middle East,
southeastern Asia, and East Asia.

Urban centers: Only a small number of students exhibited this category, which included
developed cities. This category shows evidence of student knowledge of urban centers in student
sketch maps whether an actual city or location of urban centers such as a megalopolis.

Physical features: Occasionally, students identified physical features on their map
evident through their specific shading. Though none of the students labeled the physical feature,
the shading was directly connected to the location of physical features revealing some
knowledge of the physical feature. Physical features included deserts, mountain ranges, and
bodies of water, such as rivers and coastlines.
Table 2

*Sketch Maps Levels of Elaboration*

<table>
<thead>
<tr>
<th>Type of Map</th>
<th>Geographically Simple</th>
<th>Geographically Complex</th>
<th>Geographically Informed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Little detail in shading</td>
<td>Some detail in shading (more than two colors per region/continent)</td>
<td>Much detail in shading (more than two colors per country, region, or continent)</td>
</tr>
<tr>
<td></td>
<td>Large regions and/or continents shaded</td>
<td>Large regions and continents shaded and a few countries individually shaded.</td>
<td>Large regions, continents, and multiple individual countries shaded</td>
</tr>
<tr>
<td>Migration</td>
<td>Very few markings</td>
<td>Some countries individually marked (fewer than 30)</td>
<td>Countries individually marked countries (more than 30)</td>
</tr>
<tr>
<td></td>
<td>Large regions or continents labeled</td>
<td>Large regions and continents labeled</td>
<td>Large regions or continents labeled with markings based on specific locations within countries</td>
</tr>
</tbody>
</table>

Level of detail had three levels: Geographically Simple, Geographically Complex, and Geographically Informed. Simply stated, Geographically Simple elaboration was the rating for maps where there was not much detail. Geographically Complex elaboration was the rating when a student shaded particularly few individual countries, regions and continents for population density, as well as countries and continent identification in referencing migration totals. Geographically Informed elaboration was the rating when a student map was highly detailed identifying multiple individual countries, specific differences of population and migration within a country, and urban centers or physical features that help explain why
population is distributed the way it is around the world. Table 2, included above, provides a rubric that I used to measure the level of elaboration associated with the sketch maps.

For determining inter-rater reliability, a co-rater and I first discussed distinctions across the three levels of elaboration as shown on the rubric. The rater received copies of the sketch maps to rate according to the rubrics. Before rating the maps independently, she practiced rating nine of the population sketch maps and nine of the migration sketch maps. She then independently assessed the remaining 30 pre- and post-study population sketch maps and the remaining 30 migration pre- and post-study sketch maps according to level of elaboration. A percentage of agreement was calculated between my ratings and the rater’s ratings for all students’ sketch maps. The percentage of agreement on the sketch maps regarding level of elaboration was 60%.

**Accuracy of sketch maps.** A scale was used to determine accuracy of the students’ sketch maps. The accuracy was measured as low, medium, and high. Accuracy was determined by comparing the pre- and post-student population density maps and the pre- and post-migration maps to maps generated from data located in the student textbook exhibiting both concepts. Comparison of the maps provided the means of relating student maps to an authoritative source, even though it is well known that the textbook maps become outdated rapidly.

In order to verify the reliability of this analysis too, my co-rater independently rated the accuracy of the sketch maps in the same way that she rated the maps for level of elaboration. The percentage of agreement was 75%. According to Multon (2010), an adequate percentage of agreement is 70%
Analysis of the Relation of GIS Maps to Sketch Maps

My interest was whether or not the features included in the GIS maps would be included in the sketch maps produced after the GIS task. For this analysis I placed a student’s GIS maps beside his or her final sketch maps so that I could view them at the same time in order to discover connections between the maps. I compared all students’ GIS population maps with the post-study population sketch maps and noted any similarities and differences. I repeated the process with the GIS migration map and the post-study migration sketch map. Categories of focus included country identification, regional identification, physical features, and urban centers. This analysis was documented for each student to identify individual similarities between the maps. The transcribed interviews were also included when reviewing these maps for the case-study participants in order to reveal discussion regarding relationships between the maps.

Level of Relation Between the GIS Maps and the Post-Study Sketch Maps

The GIS maps were measured for their relationship with the sketch maps. The four levels of relation for the GIS maps were based on characteristics identified in both the GIS maps and post-GIS sketch maps. Included in the comparison were details and connections shown on the GIS maps such as layers of data, creation of Map Notes, and areas of interest noted by pushpins or other identifiers, and the relation of those characteristics shown in elements identified in the population and migration post-GIS sketch maps. Table 3 provides the characteristics and brief explanation of the measures used when identifying the relationships between the post-sketch maps and GIS maps created by students.
### Table 3

#### Level of Relation: GIS Maps and Post-GIS Sketch Maps

<table>
<thead>
<tr>
<th>Level of Relation: Population GIS Map and Post-GIS Sketch Map</th>
<th>Description of relationship details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>GIS map and post-GIS sketch map show similar details, including amounts of population density, as well as physical feature attributes and urban centers.</td>
</tr>
<tr>
<td>Moderate</td>
<td>GIS map and post-GIS sketch map show some similar details, including amounts of population density.</td>
</tr>
<tr>
<td>Minimal</td>
<td>GIS map and post-GIS sketch map show few similar details, including amounts of population density.</td>
</tr>
<tr>
<td>Less or No Connections</td>
<td>Very little is comparable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of Relation: Migration GIS Map and Post-GIS Sketch Map</th>
<th>Description of relationship details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>GIS map and post-GIS sketch map show similar details including migration trends with arrows showing movement of people, and specific countries represented similarly on both maps, physical feature attributes, and urban centers.</td>
</tr>
<tr>
<td>Moderate</td>
<td>GIS map and post-GIS sketch map show some similar details including specific countries or regions with migration trends.</td>
</tr>
<tr>
<td>Minimal</td>
<td>GIS map and post-GIS sketch map show few similar details including migration trends.</td>
</tr>
<tr>
<td>Less or No Connections</td>
<td>Very little is comparable</td>
</tr>
</tbody>
</table>

In order to compare the two different kinds of maps for connections in student understanding, the pre-sketch map and post-sketch maps were first compared. Then to help explain the changes in detail of the sketch maps, the post-sketch population map and migration map were compared with the GIS population and migration maps.
Use of Case-Study Explanations of Strategies and Spatial Understandings

For the case-study participants, I reviewed all data and determined how to present each individual in my report. Because of spatial and other constraints, it was not possible to provide a full picture of the full process as performed by all six students. But it was possible to provide the student’s explanation of particularly interesting strategies. My attention was mainly on the explanations that were provided to the discourse-based questions. The explanations were not coded per se, but elements from them were used in writing the descriptions of case-study participants’ strategies.

Approaches to Answers to the Research Questions

The goal of this study was to generate data that will contribute new findings regarding the role of geospatial technology in the spatial thinking of students. Attention was on the strategies that a class of students employed in using GIS and the learning that resulted from their GIS experiences. I answered the first research question “What were the cognitive processes in which these students engaged when investigating geographic phenomena using WebGIS?” by analyzing several data sources for all students. These included the GIS maps, the video-recordings, the screen captures, and my observation notes. A common set of coding categories was employed. In addition, for the case-study participants I relied on the post-GIS interviews for clarification and elaboration. To answer the second research question “What changes in students’ cognitive maps (as assessed through sketch maps) were associated with a GIS–enhanced AP Human Geography course?” I used the data from the comparison of all participants’ sketch maps produced before the GIS task with those produced afterwards. I looked for changes in detail as well as accuracy. The third question of the study “How did the GIS maps relate to the sketch maps?” was answered through the comparison of sketch maps and
the GIS maps on the basis of detail as well as accuracy. My interest here was whether or not the features included in the GIS maps would be included in the sketch maps produced after the GIS task. The fourth and final question of the study “*How did selected students explain the nature of their GIS maps and their sketch maps and changes therein?*” was answered through interviews with the case-study participants regarding particular strategies that they employed and understandings they gained. The results of these analyses are reported in the next two chapters.
CHAPTER 4

RESULTS FOR THE CLASS

In fact I believe that research focused on discovery, insight, and understanding from the perspectives of those being studied offers the greatest promise of making a difference in people’s lives.

Sharan B. Merriam

The purpose of this study was to investigate the strategies students employed in their use of WebGIS, the changes in cognitive maps, and the possible relations between students’ GIS maps and their cognitive maps. This chapter provides the results from analyses of the quantitative and qualitative data collected during the study. The following chapter provides the case study results.

Students’ Cognitive Processes in Using GIS

The analysis of the video-recordings, screen-captured film, and review of students’ GIS maps resulted in identification of strategies applied by students when using WebGIS. Table 4 presents the numbers. In the section that follows the table, I provide more detail regarding the strategies students used when creating their GIS maps. As the table shows, the most used strategy, as one would expect, was searching which was accomplished by using the search function, followed closely behind by layering, or adding a layer. The least used strategy was removing a layer of data, and only half of the participants used transparency. Attention here is on how many students used the various strategies and later it will go to the number of times the students used the strategies.

**Searching**

In the study, 19 student participants used the search function to find layers of data to include on their GIS population map, and 17 students used the search function to find layers of data on their migration maps. The number of times searching for layers of data varied across
students for both maps. The lowest number of searches by a student was three searches using different terms, and the highest number was 16 using different terms. The average number of searches was four for the population map and four for the migration map. These figures are for use of the “Add Layer” search function available and do not include the location search tool available on the map viewer.

Table 4

Strategies Employed by Students Using WebGIS

<table>
<thead>
<tr>
<th>GIS Strategy</th>
<th>Number (Percent) of Students Using the Strategy on Population Map</th>
<th>Number (Percent) of Students Using the Strategy on Migration Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Searching</td>
<td>19 (100%)</td>
<td>17 (89%)</td>
</tr>
<tr>
<td>Layering</td>
<td>19 (100%)</td>
<td>17 (89%)</td>
</tr>
<tr>
<td>Removing a layer</td>
<td>6 (32%)</td>
<td>4 (21%)</td>
</tr>
<tr>
<td>Adjusting transparency</td>
<td>10 (53%)</td>
<td>8 (42%)</td>
</tr>
<tr>
<td>Editing</td>
<td>16 (84%)</td>
<td>15 (79%)</td>
</tr>
<tr>
<td>Noting</td>
<td>15 (79%)</td>
<td>13 (68%)</td>
</tr>
</tbody>
</table>

Throughout the entire process of creating the GIS maps, students tended to search for numerous layers of data. Table 5 lists the terms that were used the most by students when creating their population GIS maps as well as the numbers of students who used them. The terms students used in their searches are consistent with topics discussed in the AP Human Geography course. As the table shows, population density was the most frequently searched
term, and it was used by 12 students. That was followed by world population density searched by eight students, and world population searched by five students.

Table 5

<table>
<thead>
<tr>
<th>Term</th>
<th>Number (Percent) of Students Who Searched with This Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population density</td>
<td>12 (63%)</td>
</tr>
<tr>
<td>World population density</td>
<td>8 (42%)</td>
</tr>
<tr>
<td>World population</td>
<td>5 (26%)</td>
</tr>
<tr>
<td>Water</td>
<td>3 (16%)</td>
</tr>
<tr>
<td>World Bank world population</td>
<td>3 (16%)</td>
</tr>
<tr>
<td>High population density</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Population</td>
<td>2 (11%)</td>
</tr>
</tbody>
</table>

Table 6 provides a breakdown of the most frequently searched terms and the number of students who searched them while creating the GIS migration maps. As the table shows migration was the most frequently searched term and it was used by 14 participants. The second most searched term was GDP and it was used by five students. Then population density and state to state migration both were searched individually by three students.
Table 6

<table>
<thead>
<tr>
<th>Term</th>
<th>Number (Percent) of Students Who Searched with This Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migration</td>
<td>14 (74%)</td>
</tr>
<tr>
<td>GDP (Gross Domestic Product)</td>
<td>5 (26%)</td>
</tr>
<tr>
<td>Population Density</td>
<td>3 (16%)</td>
</tr>
<tr>
<td>State to State Migration</td>
<td>3 (16%)</td>
</tr>
<tr>
<td>Economy</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Employment</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Gender Equality</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>World Bank World Population</td>
<td>2 (11%)</td>
</tr>
</tbody>
</table>

But students also employed less frequently used geographic terms. Oftentimes, these geographic terms were used in a search for specific data that revealed the individual interests of students and their beliefs about what would contribute to the population and migration maps. For the population map there were 30 unique terms searched by only one student, and for the migration map there were 38 unique terms. These terms varied considerably across the students and included such words or phrases as *climate*, *crude birth rate*, *food sources global*, and *Europe population density*, with regard to the population map. Terms searched one time on the migration map also included, for example, *best education*, *conditions of life*, *gender equality*, and
push factors. These findings were also consistent with topics discussed in the AP Human Geography course. Clearly some students pulled from recently learned information in the course, since the searched terms were consistent with topics in the course. However, some choices seemed to be tied to their own personal interests.

A rarely used function of ArcGIS Online was the location search function, which is meant to locate a place on Earth’s surface. One student used this function to locate the country of France as well as the capital of China, Beijing.

Layering

The searching strategy resulted in a list of possible layers that students could select. Once students finished searching to locate data layers that met the search criteria, the next step was selecting a layer of data in the list of results produced to add to the map. Nineteen participants were successful in adding at least one layer of data to the population map, and 18 participants were successful in adding at least one layer of data to the migration maps. The extent to which they used the search strategy varied across students, and students also varied in the extent to which they added layers. For example, one student created a population map by adding only one layer of data showing population density. At the other end of the spectrum, another student added a layer of data showing climate, a layer of data showing population density, and a layer of data that was editable. By adding the third editable layer she was able to identify specific places and areas with regard to population density. Figure 1 provides a copy of this map.
The figure shows the population density map. In the editable layer of data she included pushpins and used the freehand tool to identify those places.

The numbers of layers students used. The least number of data layers added to a GIS population map was one, the highest number of data layers added to a map was 10, and the average number was four. The least number of data layers add to a GIS migration map was zero, the highest number of data layers added to a map was eight, and the average number was four. These numbers were calculated on the basis of students who completed the maps. Two students did not complete the GIS migration map. In addition, these calculations did not include editable layers of data students created and added to their maps individually, which will be discussed later. Only layers of data that students searched for, selected, and added to the maps were included in the calculations.

The kinds of layers students used. For the population maps, 14 students chose to add the same layer of data that showed population density around the world. In four cases, after using
population density as a key search term, the students continued to seek additional layers by using more specific terms such as USA population density, global population density, and world population density. In their quest for the “perfect” layer of data a step further by using the actual name for a layer of data in the search criteria such as World Bank world population, World Bank age and population, Population younger than 18, and Population older than 64. Three of these layers of data had been used previously in their WebGIS lesson. It was evident that students were able to recall the use of some data layers and apply them to their own GIS maps, but were also very resourceful in trying to narrow their search using other terms to identify data results.

In comparison to the population map, the migration map was a more difficult map for the students to create. This seemed to be because, after using migration, there were very few, if any, layers of map data to choose. Unlike the population map, students did not have a migration base map or layer of data available to use in constructing their maps. Instead, they had to take time to think of layers of data that might be associated with the movement of people. They had to infer causes.

For their migration maps, the layers of data that students created were most commonly based on particular terms associated with migration or stemming from migration. These included migration which was searched by 14 students; state to state migration searched by three students, global migration searched by two students, US migration searched by one student, immigration maps searched by one student, and global migration patterns searched by one student. But, when these terms did not return a layer of data solely based on global migration patterns, it seemed that students had to begin thinking outside of the box and use search terms such as inequality and poverty. Ultimately, students had to ask the question, “What would cause someone to stay where they are, or migrate to a new place?” In creating their maps, all students
were successful with respect to layering. However, some seemed to face challenges in using this strategy: the layer not loading, extensive lag time needed for loading a layer of data (which slowed student progress), and some layers of data requiring a special subscription for which students had not registered since they were using only the map viewer. Also, in many instances the layer of data did not include the expected information. Therefore, the student may have chosen to temporarily hide or fully remove a layer of data.

Removing a Layer

There were six students who decided to turn off a layer of data in order to view other information presented on the map. This is also a unique function of GIS: the map creator has the ability not only to add and remove data but also to select which layers of data to have actively displayed on the map.

Nine students decided to completely remove at least one layer of data from their population or migration maps. Of those nine students, six students removed at least one layer of data from their population map, and five students removed at least one layer of data from their migration map. One of the students removed a layer of data from both the population and migration maps. In addition, there were six students who decided to turn off a layer of data rather than removing the layer completely (temporarily making the layer invisible). The highest number of layers that were removed by a student was 10, the least was one. The average number of removals per student was three.

Adjusting Transparency

Adjusting the transparency of a layer or layers of data allows one to see multiple layers at once. Even though all students had learned how to adjust transparency as a step in the GIS assignment, only 14 of them chose to adjust the transparency of a layer of data at least one time.
when creating the GIS maps. The practice of adjusting transparency on the maps ranged in use by the 14 students from one time to eight times. On average, each student used the tool three times. Adjusting the transparency involved the student taking several steps, which included accessing the details tab, then selecting the contents tab, and lastly clicking on a dropbox connected to the layer where students could select “transparency.” The last step in the process of adjusting transparency involved the student determining which layer or layers of data needed to have the transparency adjusted in order to view multiple layers at one time.

Two participants selected a layer of data to change the transparency, but realized it was not the most useful layer that needed to be changed. They then proceeded to readjust the transparency of the selected layer, and then work through other layers of data until they were able to get the map to their liking. Rather than turning on and off layers to see data, those students who used the transparency tool were able to see any connections between the layers of data they chose to include.

**Editing**

Students were able to edit the maps they created using another feature of the WebGIS program by accessing the “Add Map Notes” function. This function makes it possible for users to employ another strategy: creating an editable layer of data. The creation of an editable layer of data allows the user to add features, such as points, lines, arrows, shapes, or use a freehand drawing tool. Table 7 provides a breakdown of the different types of features and how many students used each creating editable layers of data for the population and migration maps. Of the different features included in editing, arrows were used most, followed by the use of points. The least used strategy was employing the area shape tool.
Table 7

GIS Maps: Editable Layer of Data Features Used by Students

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number (Percent) of Students Who Used the Feature on Population GIS Map</th>
<th>Number (Percent) of Students Who Used the Feature on Migration GIS Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Shape</td>
<td>2 (11%)</td>
<td>3 (16%)</td>
</tr>
<tr>
<td>Arrow</td>
<td>4 (21%)</td>
<td>13 (68%)</td>
</tr>
<tr>
<td>Freehand Draw Tool</td>
<td>7 (39%)</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Point</td>
<td>5 (26%)</td>
<td>3 (16%)</td>
</tr>
</tbody>
</table>

As the table shows, the use of arrows by students was used most frequently on the creation of the migration map, followed behind by the use of the freehand draw tool on the population map. The largest number of editable layers created by a single student was two on the population map and two on the migration map.

Use of points. Points were often used by students to identify a particular place. These points of interest ranged from as small as a city to as large as a country. Students could choose from different styles of point icons: a cross, a pushpin, and a stickpin. Five students used points on the population maps. Of these, two students used pushpins only, two different students used stickpins only, and one student used a combination of stickpins and crosses. Two students each included six points which was the largest of any number on the population map. The least number of points included on the population map was two points. Points were also included on the migration map by three students, who all used pushpins. The largest number of pushpins included on the migration map was five, which was done by two students. The last student included four points of interest on his or her map.
**Use of shape features.** Another aspect of the editing strategy was circling or using a rectangle to create an area shape feature. This strategy was used by two students on the population maps and four students on the migration maps. One of the students included six circles—the highest number used—on the population map, while the other student included three circles on his map. Three students included shape areas such as a circle or rectangle on his or her migration map. The highest number of shape areas included no the migration map was three, the least was one.

**Use of arrows.** Participants used the arrow feature when creating an editable layer of data on both maps, though the purpose of arrows was different. Arrows could show the directional movement of people from one place to the next in a way that a layer of data did not. As one would expect, the use of arrows in this way was employed most on the migration maps. A second use of arrows was to point towards areas of land or places, which was employed most often on the population map. Overall, four students used arrows on the population map and 13 students used arrows on the migration map. This suggests the students made more use of arrows to show directional movement than to identify particular places associated by population clusters. Figures 2 and 3 show two different ways students edited the map with arrows. Figure 2 shows how a student used arrows to point out major population centers of the world.
Figure 2. Map showing the use of arrows to identify population centers.

Figure 3. The use of arrows to show migration patterns and the movement of people.
Use of the freehand draw feature. Students were also able to select an area of land to identify by using a freehand draw strategy. Unlike use of the shape or line tool, use of the freehand draw feature enabled the user to select a specific area that he or she wanted to highlight on their map. The freehand draw strategy could be used to draw a line whether straight or with curves, or identify an area of land with flexibility. This strategy was employed by seven students on the population map. Figure 4 shows an example of a student using the freehand tool to identify the southern and eastern region of Asia as centers for large populations. Two students used it on the migration map. For example, one student used it to draw circles around major population centers instead of inserting a circle using the shape area tool. A second student used the freehand draw tool to identify large areas of land to show where people may migrate.

![Figure 4. Map showing editing to identify regions using the freehand tool.](image)

The largest amount of visuals created by students using the freehand tool on the population map was 13, and the least was one. The largest use of the freehand tool on the migration map was four visuals by one student and the least was two. If a student was not able
to find a suitable layer of data, he or she became innovative using the features provided by the online mapping program, one of which is called “Map Notes.”

*Noting*

Students could create their own layer of data showing population distribution or migration trends by adding notes on editable layers. This strategy was used by 15 students on the population map and by 14 students on the migration map.

Through noting a student could do such things as adding a title, selecting an icon, highlighting an area using the freehand tool or other shape identifier, and adding a web address link. This was possible through the “Add Map Notes” feature. The unique feature of the map notes layer is that if the student or other user clicked on the icon or areas designated in the layer, the information was accessible for viewing in a pop-up box. Noting was performed by many, but not all, students in their map-making process. They could thus add personal knowledge and ideas to the maps they created, especially when they did not find the layer they sought. This feature offered a chance for students to add pertinent information they felt helped explain population and migration. As discussed previously, of the 17 students who created an editable layer of data on the population map, 15 of those students added written map notes to their maps. Similarly, for the migration map editable layers of data were created by 15 students. Of these 15, 14 students added written notes associated with features of the data layer. The map notes added by students varied in length from a simple category name to a detailed explanation. For example, one student added a note on his population map that simply said “hardly any people” with regard to a shape area identifying the Sahara Desert. Another student added a lengthier note on the population map that, with respect to China, said, “The most populous country in the world, but NIR officially decreasing because of anti-natalist policies.”
Additional Observations Regarding Creation of the Two GIS Maps

The results presented above suggest some differences in strategy use in creation of the two maps. Overall, the population map had a higher use of the featured strategies based on individual students’ process when creating their map. The use of a particular strategy varied among students, for example, the addition of arrows to their maps. Some students were more comfortable than others in the use of different strategies, including transparency and editing as well as noting. When compared to the population GIS map, the migration GIS map seemed to be more challenging. For example, two students did not complete a migration map. Some complications contributed to the difficulty. First, there were several layers of data that were “not responding” while students were completing the GIS activity. Although students were patient to wait and see if the layer would load, this delay may have hindered student completion of the assignment. Second, several students said that they experienced difficulty when creating the maps because they would choose a layer of data but received a message stating the layer was not accessible without a membership to ArcGIS Online. When the layer would not load, the students tried to return to their maps and instead found a blank map. This led to frustration because they had made maps, but had to start over. Third, participants may have spent too much time creating the population map, which were produced first, and did not leave enough time to create the migration maps. And fourth, as mentioned above, after entering a general term, they had to come up with possible causes of migration to create additional layers.

Differences between the Pre- and Post-Study Sketch Maps

Comparison of the pre- and post-sketch maps was based on eight measures focused on the level of elaboration and accuracy. The pre- and post-study population and migration sketch maps were scored as to level of elaboration geographically simple, geographically complex, and
they were also scored on accuracy—low, medium and high. The reader should note that only 19 of the 20 students are included. One student did not submit a second set of sketch maps due to an absence on the day that the data were collected. Therefore, the statistics for the sketch map results were calculated only for students who turned in both maps.

**Level of Elaboration**

Overall results for scores for level of elaboration of the sketch maps are presented below in Table 8. Most apparent is change with respect to detail on the migration map.

Table 8

**Sketch Map Results: Level of Elaboration**

<table>
<thead>
<tr>
<th>Map</th>
<th>Number (Percent) of Students Receiving Rating of Geographically Simple</th>
<th>Number (Percent) of Students Receiving Rating of Geographically Complex</th>
<th>Number (Percent) of Students Receiving Rating of Geographically Informed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>4 (21%)</td>
<td>12 (63%)</td>
<td>3 (16%)</td>
</tr>
<tr>
<td>Pre-</td>
<td>3 (16%)</td>
<td>11 (58%)</td>
<td>5 (26%)</td>
</tr>
<tr>
<td>Post-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Migration</td>
<td>11 (58%)</td>
<td>2 (11%)</td>
<td>6 (32%)</td>
</tr>
<tr>
<td>Pre-</td>
<td></td>
<td>7 (39%)</td>
<td></td>
</tr>
<tr>
<td>Post-</td>
<td></td>
<td>7 (39%)</td>
<td>5 (26%)</td>
</tr>
</tbody>
</table>

Eleven students were scored “geographically simple” on the pre-study measure, but only seven received that score on the post-study measure. This meant changes in “geographically complex” scores. Table 8 shows the number of students who received a particular sketch map
rating based on the level of elaboration. It does not show change for particular individual students; results for individual students will be provided later.

Table 9 shows students’ pre- and post- scores for elaboration for both maps. Analyses of the pre- and post-study population sketch maps showed an increase in the level of elaboration by four students on the population map and six students on the migration map.

Table 9

*Sketch Map Results: Level of Elaboration for Individual Students*

<table>
<thead>
<tr>
<th>Student</th>
<th>Level of Elaboration on Population Map</th>
<th>Change?</th>
<th>Level of Elaboration on Migration Map</th>
<th>Change?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gita</td>
<td>C</td>
<td>I</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Raina</td>
<td>S</td>
<td>C</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Denise</td>
<td>S</td>
<td>I</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Maria</td>
<td>S</td>
<td>I</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Elizabeth</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Anita</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Layla</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Christopher</td>
<td>I</td>
<td>I</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Kathleen</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Peter</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Carrie</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Henna</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Kamal</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Suraj</td>
<td>S</td>
<td>S</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Aaron</td>
<td>I</td>
<td>I</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Allie</td>
<td>C</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Sahl</td>
<td>I</td>
<td>C</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>Valerie</td>
<td>C</td>
<td>S</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Alexa</td>
<td>C</td>
<td>S</td>
<td>=</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* I=Informed, C=Complex, S=Simple. In the table, the students are listed according to gains and losses in relation to the ratings of their population and migration sketch maps.

As the table shows, when comparing the pre- and post-study population and migration maps, 10 students stayed the same in their level of elaboration on both maps. Three students
improved on both maps, six students improved on at least one map, five students declined on at least one map, and one student declined on both maps.

Level of Accuracy

Overall results for scores for level of accuracy of the sketch maps are presented below in Table 10. Most notable is the movement of many students from low to medium accuracy scores for the migration sketch map. This table shows the numbers of students who received scores for sketch maps with particular ratings based on accuracy. It does not show change for particular individual students, shown in Table 11.

Table 10

Sketch Map Results: Level of Accuracy

<table>
<thead>
<tr>
<th>Type of Map</th>
<th>Number (Percent) of Students Receiving Low Accuracy</th>
<th>Number (Percent) of Students Receiving Medium Accuracy</th>
<th>Number (Percent) of Students Receiving High Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Map 1</td>
<td>6 (32%)</td>
<td>11 (58%)</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Map 2</td>
<td>5 (26%)</td>
<td>11 (58%)</td>
<td>3 (16%)</td>
</tr>
<tr>
<td>Migration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Map 1</td>
<td>8 (42%)</td>
<td>9 (47%)</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Map 2</td>
<td>2 (11%)</td>
<td>15 (79%)</td>
<td>2 (11%)</td>
</tr>
</tbody>
</table>

As Table 10 shows, population sketch maps increased in accuracy for five students. Accuracy remained the same for 12 students, and accuracy decreased for two students. Analysis of the migration maps revealed an increase in the accuracy of the maps by six students.
Accuracy levels remained the same for 12 students, and one student decreased in the level of accuracy.

Table 11

*Sketch Map Results: Level of Accuracy for Individual Students*

<table>
<thead>
<tr>
<th>Student</th>
<th>Level of Accuracy on Population Map</th>
<th>Change?</th>
<th>Level of Accuracy on Migration Map</th>
<th>Change?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kamal</td>
<td>L</td>
<td>M</td>
<td>+</td>
<td>M</td>
</tr>
<tr>
<td>Denise</td>
<td>M</td>
<td>H</td>
<td>+</td>
<td>M</td>
</tr>
<tr>
<td>Alexa</td>
<td>L</td>
<td>M</td>
<td>+</td>
<td>M</td>
</tr>
<tr>
<td>Maria</td>
<td>M</td>
<td>H</td>
<td>+</td>
<td>L</td>
</tr>
<tr>
<td>Gita</td>
<td>M</td>
<td>M</td>
<td>=</td>
<td>M</td>
</tr>
<tr>
<td>Elizabeth</td>
<td>M</td>
<td>M</td>
<td>=</td>
<td>L</td>
</tr>
<tr>
<td>Anita</td>
<td>M</td>
<td>M</td>
<td>=</td>
<td>L</td>
</tr>
<tr>
<td>Layla</td>
<td>L</td>
<td>L</td>
<td>=</td>
<td>M</td>
</tr>
<tr>
<td>Christopher</td>
<td>H</td>
<td>H</td>
<td>=</td>
<td>H</td>
</tr>
<tr>
<td>Kathleen</td>
<td>M</td>
<td>M</td>
<td>=</td>
<td>M</td>
</tr>
<tr>
<td>Peter</td>
<td>M</td>
<td>M</td>
<td>=</td>
<td>L</td>
</tr>
<tr>
<td>Raina</td>
<td>M</td>
<td>M</td>
<td>=</td>
<td>L</td>
</tr>
<tr>
<td>Valerie</td>
<td>L</td>
<td>L</td>
<td>=</td>
<td>L</td>
</tr>
<tr>
<td>Carrie</td>
<td>L</td>
<td>L</td>
<td>=</td>
<td>L</td>
</tr>
<tr>
<td>Henna</td>
<td>M</td>
<td>M</td>
<td>=</td>
<td>L</td>
</tr>
<tr>
<td>Suraj</td>
<td>L</td>
<td>L</td>
<td>=</td>
<td>M</td>
</tr>
<tr>
<td>Allie</td>
<td>M</td>
<td>M</td>
<td>=</td>
<td>M</td>
</tr>
<tr>
<td>Sahl</td>
<td>M</td>
<td>L</td>
<td>-</td>
<td>M</td>
</tr>
<tr>
<td>Aaron</td>
<td>H</td>
<td>M</td>
<td>-</td>
<td>H</td>
</tr>
</tbody>
</table>

*Note.* H = High, M = Medium, and L = Low. The table is organized according to gains and losses in relation to the ratings of their population and migration maps.

Table 11 shows, eight students remained at the same level of accuracy in both the pre- and post-study population and migration maps. Eleven students improved in accuracy on at least one of the maps, two students declined in accuracy on one of the maps. No student improved in accuracy on both maps.
Additional Observations Regarding Elaboration and Accuracy of the Sketch Maps

*Population sketch maps.* Among the sketch maps of students, similarities existed in the labeling of more densely populated areas of the world. For example, in the pre-study sketch maps all students identified China as having high population density, and 18 students identified India to have high population density. The United States was also identified individually by 11 students to have high population density. In the post-study sketch map, students again identified these countries individually with high population density; however, in smaller numbers: China was shaded by 17 students, and India was shaded by 16 students.

Several countries in addition to the most populated countries were individually identified often in both sets of sketch maps, such as the shading of Canada by 16 students, the shading of Russia by 16 students, the shading of Australia by 10 students, the shading of Brazil by eight students, and the shading of Mexico by seven students. On the other hand, there were places consistently not labeled individually by most students; these places tended to be regions or large areas of land that were shaded. Examples of shaded regions included Africa, Central America, Central Asia, Europe, the Middle East, and Southeast Asia. Very rarely did a student shade a specific country in any of these regions individually. A possible explanation for this is that students lacked knowledge about a particular area and felt more confident shading it one color as opposed to individually by country.

Students shaded multiple colors signifying varying population densities within the countries and regions, contrasting the “one color fits all” seen in many of the pre-study sketch maps. One change in the population sketch maps was the amount of detail included on the maps by students. For example, in the pre-study sketch maps, variations in population density were included three times in individual countries and nine times within regions by students. In the
pre-study sketch maps, Africa was shaded with multiple colors to show differences regionally by nine students, the highest of any country or region. However, the amount of detail increased when looking at the post-study sketch maps. In this set of maps, students used multiple colors to shade in 17 individual countries and 21 regions. Australia as an individual country had the most occurrences of multiple shades to identify population density in the post-study sketch maps. For example, one student shaded the coastline of Australia to have high population density, but shaded the interior of the country with low population density. In this case, the student may have learned the physical characteristics of Australia and those areas that are permanently settled as opposed to those that are not due to extreme climate conditions.

*Migration sketch maps.* The pre-study migration sketch maps students produced had few markings and identification of migration trends. However, similar to the population sketch maps, there were some countries marked individually. These included Australia, Brazil, Canada, China, India, Mexico, Russia, and the United States. The United States was identified by 17 students to have in-migration in the pre-study sketch maps. There were three students who included both equal in- and out-migration, and in-migration as characteristic of the migration trends. However, in the post-sketch map, all 19 students identified the United States as having in-migration. Mexico was identified by 12 students to have out-migration in both sketch maps. With respect to regional changes, Africa was identified in the pre-sketch map by 13 students to have out-migration, but that number increased to 16 students in the post-study sketch maps.

Similar to the population sketch maps, the migration maps had areas of the world that students did not label individually and/or they used large symbols to cover an extensive area of land. Areas most often labeled in this way included Africa, Europe, South America, Southeast Asia, and Southwest Asia. Again, though the migration maps had less elaboration overall to
begin, this pattern may reflect lack of familiarity with areas of the world they have not studied or
did so for the first time this year.

The accuracy of the migration maps was greater in the second sketch map, especially
when referencing migration trends. Those students who showed locations of physical features in
their shading on their population density map or took particular interest in making sure that
known urban centers were shaded as high population density, were consistent in doing so on both
maps.

Relation of GIS Maps to Sketch Maps

When the post-study sketch maps were compared to the GIS maps, some relations were
noted. In what follows I present results of these comparisons for the population maps and the
migration maps. As explained in Chapter 3, the determination of degree of relations came from
judgments that I made: no connections, minimal connections, moderate connections, and major
connections.

As an example of major connections, let us consider one student’s paired maps. This
student’s GIS migration map noted in-migration to include several areas such as Europe, the
United States, and Australia. Out-migration was identified by the student in Africa, South
America, and Southeast Asia. The student identified the same places and migration trends on his
or her post-study migration sketch map. Another student had used a layer of population density
on her GIS map. When this map was compared to her sketch map, the areas shaded with high,
medium, and low population density were consistent with the data provided on the population
density GIS layer. This connection suggests that the student acquired new knowledge using GIS
that was then reflected on her post-study population sketch map.
Population Map Connections

Table 12 provides the results of comparisons of the GIS population maps and population sketch maps. Out of the 19 participants, 17 students exhibited identifiable relationships, but the extent of those relationships varied across those students.

Table 12

<p>| Relationship Level of Students’ Post-Study Population Maps to Their GIS Population Maps |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|</p>
<table>
<thead>
<tr>
<th>Number (Percent) of Students with No Connections</th>
<th>Number (Percent) of Students with Minimal Connections</th>
<th>Number (Percent) of Students with Moderate Connections</th>
<th>Number (Percent) of Students with Major Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (11%)</td>
<td>5 (26%)</td>
<td>10 (53%)</td>
<td>2 (11%)</td>
</tr>
</tbody>
</table>

Students who exhibited moderate relationships between their GIS maps and post-study sketch maps often had more than one connection, but these connections were generally very broad. An example of this type of relationship was often seen where students highlighted countries or regional areas for their population density on the GIS map and post-study sketch map. Population clusters, including China and India, were highlighted as having high population density on both the GIS map as well as the post-study sketch map by 11 students. One student whose connection was rated “moderate” placed several pushpins on her GIS population map identifying areas of high population density, including the northeastern region of the United States as well as Texas and also India and China. The post-study population sketch map also had these areas shaded in red showing high population density.

An example of a minimal connection made between the GIS map and sketch map involved identifying Brazil as having high population density on the GIS map and having Brazil
shaded for high population density on the sketch map. Though there was a connection, it was the only one.

Migration Map Connections

Similar to the population post-study sketch map and GIS maps, students’ GIS migration maps and migration sketch maps were analyzed for their relationships. The level of the relationship was also measured, and the results are portrayed below in Table 13.

Table 13

<table>
<thead>
<tr>
<th>Number (Percent) of Students with No Connections</th>
<th>Number (Percent) of Students with Minimal Connections</th>
<th>Number (Percent) of Students with Moderate Connections</th>
<th>Number (Percent) of Students with Major Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (21%)</td>
<td>2 (11%)</td>
<td>8 (42%)</td>
<td>3 (16%)</td>
</tr>
</tbody>
</table>

Of the 19 students who participated in the creation of the sketch maps and GIS maps, 13 students exhibited connections between their GIS migration map and their post-study migration sketch map. Those students who did not show connections or patterns directly between the GIS maps and the sketch maps in most cases focused their GIS maps on a specific region of the world, such as the United States or a specific state, whereas their sketch maps used a different scale and were based on a global view. As the table shows, the largest number of students experienced moderate connections between the post-study migration map and GIS migration map.

Major connections were seen on three students’ maps. One example of this type of connection involved the use of arrows to show the directional movement of people from one
country to others on the GIS map that were also noted on the sketch map. In one case, the labeling was quite specific with in-migration being shown to be in Nigeria from neighboring countries on the GIS map as well as Nigeria being labeled specifically on the sketch map as having in-migration too. One reason for judging this to be a major connection was the layer of data showing a higher level of development in Nigeria than surrounding countries. An example of a moderate connection was when a student labeled in-migration to Europe, the United States, and Australia on both maps as well as accurately labeling out-migration from Africa and South America. An example of minimal connections made was the labeling of the United States southern border with in-migration on both the GIS map and the post-study sketch map.

Summary of Overall Results

The results of the study provide evidence of the strategies students used when creating the GIS maps, the changes experienced between the pre- and post-study sketch maps, and the relationship between the sketch maps and the GIS maps. The most used strategy was searching, and almost all of the students used layering as well; results also showed editing and noting were used by numerous students on both maps. However, not all students were successful in using the different strategies introduced in Chapter 3. For example, two strategies—removing a layer and adjusting transparency—were applied the fewest times by students when creating their maps. Two reasons might explain the lack of use of these strategies: the student’s forgetting how to apply each strategy or having too little experience with GIS to identify when it is best to use these strategies. All student participants engaged in exploring the functionality of the online GIS program. However, some did so more freely. As to the changes in the sketch maps, the analyses showed that many students increased in spatial thinking with respect to the population and migration maps. For example, more elaboration in the differences in population distribution in
specific countries and regions was articulated by some on the population maps. The migration sketch maps revealed an overall increase in the amount of knowledge students had regarding where people are moving from and to around the world. Interestingly some students did decrease in the level of elaboration between the pre- and post-study sketch maps. A comparison of the sketch maps to the GIS maps revealed some degree of connections which suggests that many students revealed knowledge they learned making their GIS map to the post-study sketch map.
CHAPTER 5

GIS EXPERIENCES OF SIX OF THE STUDENTS

As a valuable part of the data collection process in this study, my attention went in some detail to the GIS experiences of six individual students selected to be case-study participants in the investigation. As discussed in Chapter 3, these six students were selected based on their original sketch maps regarding population distribution and migration trends. For them I had the same data collected for the others: pre- and post-study sketch maps, GIS maps, and screen captured recordings. However, in addition to the data collected from all students, each of the case-study participants was interviewed individually to discuss the strategies used and products created when using WebGIS. The interviews offered a chance to “hear” the voice of the student as he or she discussed the maps created.

This chapter first provides a description of the selected students’ experiences individually. After that, attention goes to some trends I saw across the six students’ processes when working with WebGIS. I conclude with a summary of the findings.

The Students and Their GIS Strategies

Selecting six case-study participants proved to be an enlightening experience as each individual was distinct from the others in terms of his or her educational background and his or her understanding of AP Human Geography. The six also varied in their approaches to GIS mapping. This section describes their experience and the approaches they used while using WebGIS to create maps reflecting population density and migration. The case study experiences are in order with regard to the level of elaboration provided on their initial sketch maps beginning with geographically simple (Maria and Suraj), followed by geographically complex (Allie and Gita), and then geographically informed (Christopher and Aaron).
Maria

In describing her GIS strategies, Maria provided insights into the ways in which she determined layers she would use. To begin, she searched for a variety of different layers throughout the process. For her population density GIS map, she reflected in some detail on the layers she chose to use in creating the map. One layer she thought would be beneficial was a layer of data showing change over time. She found this to be a valuable layer because it would show how population changed as countries developed. Two additional layers of data she had searched and added included one showing population density, and another provided data from the World Bank showing population change over time.

While creating layers for her population map, Maria employed several strategies, which included editing to create a layer of data employing pushpins and the drawing tool, to identify the areas that she knew had the largest populations. For the population map, the areas she chose to identify with pushpins included the west coast of the United States near Los Angeles; central Mexico near Mexico City; the western coast of Africa near Nigeria; Western Europe; India; and China. She used a draw tool to create a circle when she wanted to highlight a region of the east coast of the United States centered on the original thirteen colonies. It was important to her to draw attention to the area along coastlines because she thought that these places would offer more “opportunities” to people and would thus have more population density. In addition to the population change layer and the editable layer she created with the pushpins, Maria also included a layer of data that showed weather patterns. She discussed the importance of weather on population settlements because she thought areas which are too hot or too cold are generally areas where people move from rather than to.
The migration GIS map Maria created included a variety of features. One that she found most useful was editing to create a layer of data that included the use of arrows as a way to show population movement. Figure 5, a copy of her migration map, shows how she specifically placed the arrows to show movement pointing from the eastern hemisphere to the western hemisphere, based on her knowledge that a place such as the United States attracts many people for migration. The figure shows use of several different layers of data that were modified in terms of transparency so that she could show connections between gender and population density and also movement of people.

![Figure 5. Maria’s GIS migration map.](image)

Particularly interesting in Maria’s GIS-mapping was her engagement with social and economic issues for which she searched for layers of data using the terms gender inequality, World GEM (Gender Empowerment Measure), and condition of life. This topic she believed to be a large factor in why people move because women are “restricted in their different environments” and want to have equality such as in power, education, and the ability to reproduce. A second layer she included on her map focused on “poverty” as well as “job
availability.” This layer of data she saw as vital in explaining why people might leave to find a better way of life, especially when they are trying to take care of their families. In discussing this selected layer, she gave examples of movements from Africa to Europe, specifically Germany, “where guest worker programs are widely in practice,” and of a brain drain, the educated and talented people of Middle East moving to the United States where they may attend college or find jobs and be successful economically. While creating the maps, Maria used several of the functions of the online mapping program, including accessing the legend to determine the contents and design of the layers of data, and she applied different levels of transparency to show multiple layers of data at one time in order to identify patterns between layers.

Maria told me that it was hard at first to “think of layers to choose.” She stated that she was “trying to think of good examples that would show the population,” but found this to be difficult. So, instead, she changed her thought process from looking for population layers to identifying the reasons for people to live in areas. It seemed to me that she was using a “logical approach,” in much the same way as the students in Wigglesworth’s (2003) study. For example, she searched by using such terms as climate and economy, which she considered relevant for densely settled areas. She noted that she liked envisioning the entire world rather than just the United States.

Comparing of Maria’s pre- and post-study sketch maps, showed moderate connections. Her population sketch map had specific countries identified through shading that were also pointed out by the use of pushpins on her GIS map. She discussed an increase in the amount of detail she put on the population post-study sketch map because she had learned a great deal. She had learned about the large size of families in some areas of the world, about regions that are
sparsely populated due to forests such as in South America, and about the reasons that countries can support more population than others. Her migration post-study sketch map also had moderate connections with her GIS map, and it increased in detail as well. Clearly, there were changes in her ability to think spatially by the discussion of layers she searched and the maps she created. According to Gersmehl (2005), by selecting a layer of data to show change over time, a student employs spatial reasoning regarding the nature of geographic phenomena or patterns on Earth’s landscape. Spatial thinking was also revealed as this student used the editing feature to include points identifying locations of importance on her map. By including layers of data to explain population density and migration patterns, Maria constructed a map that identified locational features; however, she felt free to break the structures apart when explaining their trends and features. The use of multiple layers of data in understanding migration trends also revealed spatial thinking skills as she compared different geographic phenomena to learn what would make people want to move to a location.

Suraj

Suraj focused, to a great extent, on his visual portrayal of major factors relevant to population and migration. To create his population GIS map, Suraj first changed the base layer of his map to a light gray base map. For this map he added a layer of data with red dots to provide more specificity and used the editing strategy to draw circles for areas of high density. One large circle was placed over North America, and a second large circle was placed over East Asia that extended to South Asia. He also employed stickpins to label specific places and created notes. When he created the stickpins, he used noting as a way to personalize the map with his own knowledge. For example, he labeled India with a stickpin and added a note stating that “India is the second most populous country and is predicted to become the most populous in
the world in a few decades.” He placed another stickpin in the United States and stated that “the US is the 3rd most populated country in the world because of the constant immigration combined with the NIR.” Another pushpin and corresponding note that he added were related to China. He stated that it is the most populated country “but NIR is slowly decreasing because of anti-natalist policies.” To search for the layer of data to use in his population map, Suraj had to go through a couple of searches to narrow the results. He used such terms as *population* and then *world population*, which proved to be better for findings suited to his need.

For the migration map, Suraj made use of some strategies he had used previously. He used the same population density layer he used on the population map, and then used editing as a way to add circles to indicate places where people migrate, such as the United States, Europe, and Australia. Figure 6 provides a copy of Suraj’s migration GIS map. He had contemplated why people may migrate to these places and used a logical approach to conclude that one reason was for more business opportunities. Useful to him were data focused on good incomes. Again, he used a light gray base map and, as before, he added notes, such as “US is good because of economic opportunities.” Suraj also used editing to create a layer of data in which he inserted several arrows to show the movement of people around the world. He called this editable layer *Migration in the World*. Suraj’s map includes a layer of data showing population density around the world. In addition, the student created an editable layer of data that included the use of arrows to show the directional movement of people as well as the major places people are moving too.

When discussing his post-study population sketch map, Suraj acknowledged that he made some changes from his first sketch map. One of these changes included South America, which he previously thought was highly populated but learned that it was not due to the vegetation and
climate. The change he discussed reflects how his spatial thinking expanded to consider factors that might impact population distribution. Additionally, Suraj’s experience of analyzing data regarding population distribution is a good example of his ability to think spatially; he used reasoning to consider the factors that influence where people settle. His post-study migration map revealed major connections with the GIS migration map by means of such labels as in-migration with respect to Europe, North America and Australia, and out-migration with respect to Africa, South America, and Southeast Asia.

![Suraj’s GIS migration map.](image)

**Figure 6.** Suraj’s GIS migration map.

As Suraj created his population map, his use of identifying places using the editing feature showed that he was thinking spatially about location. In addition, as he looked at places with business opportunities, he used the spatial thinking skill of comparing places to understand where people may choose to live. He exhibited spatial thinking skills by applying his knowledge of geographic phenomena as well as his ability to reason and communicate geographic understanding of Earth. In these ways, his performance reflected some aspects of spatial thinking that were addressed by the NRC (2006).
Gita

Gita took her GIS experience quite seriously. Her searches for layers were based on what would be most effective and what would be most informative, but she made some choices that resulted in having to redirect how she was searching in order to find the results she wanted. To create her population density GIS map, she first had to find a layer that she felt would be valuable as a starting point. She did have difficulty at first finding a layer of data that showed population density because she did not find much from her initial results. As she explained, she could not find “really good results” that would become layers. However, her extensive searching finally did find a layer showing population density. She added the layer and then proceeded to access the layer’s legend to investigate the purpose of the colors on the map regarding high and low population densities around the world.

Much of her attention was focused on two high-population density areas, China and India, for which she had prior knowledge and interest. She considered why population is high in those places. For China, she came up with their economy, high intelligence levels, and skill sets. Furthermore, she thought that a place like China is developed especially in technology, and she had read “that one out of every three things you own [is] made in China.” Having lived in India, she told me that she wondered why people were clustered in the northern part of the country because it is mountainous and can be very cold. That was surprising to her because she did not remember northern India to have a large population. However, the data illustrated on the map suggested otherwise. In creating layers, she did confirm her prior knowledge of the high populations along the coast, such as near Bombay.

In order to identify both China and India on the map, Gita used editing to add arrows to the map pointing at both countries and a few notes in a pop-up box discussing the population of
both countries. Gita stated that she “didn’t want to put a lot of arrows,” and so she considered
China and India as the two main countries worth mentioning with regard to population density.
Figure 7 provides a copy of Gita’s population map, which shows her layer of population density
as well as an editable layer of data that includes arrows to point out population centers and
accompanying notes.

Like Suraj, Gita saw relations between the population map and the migration map. For
her migration map, Gita applied some insights from her population map. She added the
population density layer because she thought migration could be a factor in understanding the
population density of a place. However, she ran into difficulty when trying to find migration
trends or reasons for migration to occur in an area. She was employing logic, trying to find
layers of data that would explain why people might want to move. Several ideas she had as to
why people might move from a place included war, political instability, and low income.
Though she could not find the explanations she sought, she did find a layer of data showing the
location of Dengue Fever and thought it might be a reason behind why people would want to
move. To find this layer of data, she searched “high epidemics” and “diseases.” The basis for
searching for this disease topic was her knowledge of such diseases as malaria, and she thought
that Dengue too might be a reason for people to want to move. Using both the population density
layer and the Dengue layer, she highlighted areas that people may want to move to by employing
the freehand drawing tool.
Gita mentioned that she ran into problems finding layers of data related to diseases, epidemics, and malaria that might have been useful. She also faced challenges from inconsistent Internet access, which stated the program was not responding, and so she would wait patiently or shut the computer program down and restart. Despite these difficulties, she considered it “amazing” to be able to create maps with GIS and share them with other people. Throughout the process of making her GIS maps, Gita used several different spatial thinking skills. In particular, she expanded her geographic thinking beyond—and even in contradiction to—her own life experiences. Gita also thought about the conditions at a specific location and how they might impact the movement of people. She was considering connections between places, which was identified as a spatial thinking skill by Gersmehl (2005).

In comparisons of Gita’s post-study sketch maps and the GIS maps, the results were mixed. For example, her post-study population sketch map revealed minimal connections, showing only two major relationships: first, the population of India on both maps was identified

Figure 7. Gita’s GIS population density map.
as high population density, and, second, the population of China was identified as having high population density on both maps. Her post-study migration sketch map revealed moderate connections among places where people might want to move, including Europe and the United States. From reviews of the maps, it was clear that Gita did make some connections, even if they were only the two on the population map. These findings suggest that Gita did experience changes in her cognitive map by employing spatial thinking skills.

Allie

Of the six case studies, Allie was the one who experienced the most difficulty. Her approach was based on what might be considered the most obvious terms, population distribution and migration trends. Of the various strategies, she used searching, layering, and removing, and did not employ any editing or noting on her maps. This recursive process of adding and removing took so much time that she was not able to complete the migration map.

She experienced difficulty in determining layers to include in her population density map, trying to decide what to put when searching to find a layer of data. She began by searching the term world population. After finding a layer, she added it to the map, but she then removed it and began a new search. She then searched population density and added a U.S. Population Density layer, which she retained. From the results of the same search she also added a layer showing Tokyo’s population density, which she removed shortly thereafter. She finally decided to use a layer of data focused on population density of the world and changed the transparency of the layer so that both the continent boundaries and population densities could be seen at the same time. Figure 8 provides a copy of Allie’s population map showing the population density layer, and the use of transparency to view the names of places at the same time. Allie did say that she found some of the layers helpful. One was a layer of data showing population change over time.
which included a timeline that could be played to show chronological changes with regard to population. Though Allie started to search for things to include on the migration map by searching for migration patterns, then world migration, and lastly, migration, she was not able to create a migration GIS map while participating. Unfortunately, according to Allie, she just ran out of time.

In comparisons of Allie’s post-study population sketch map and population GIS map, results revealed moderate connections. Areas that were identified as having high population density such as eastern Africa, China, India, Europe, and Southeast Asia were found on both maps. Additionally, Russia and Canada were identified as countries with low population density on both maps.

Allie felt that she had more information after completing the GIS activity, particularly with respect to more developed and less developed areas of the world with high populations. She employed spatial thinking skills by observing the conditions of a place when applying the transparency feature to view both population distribution as well as the specific locations and names of those places. Additionally, Allie also included a layer of data that showed population change over time—an inclusion that suggests that she was using spatial reasoning to understand the changes seen on Earth with regard to population. By using this layer of data, Allie was analyzing changes on Earth’s landscape, specifically population. This process of considering how features on Earth change over time was identified by Gersmehl (2005) as a spatial thinking skill.
Though Allie only showed one layer of data on her GIS population map, she did have moderate connections with the way she shaded her population density map such as high population density in Europe and eastern Africa.

Christopher

Most notable about Christopher’s process was emphasis on cities. Like many of the other students, he began the creation of his population map using a population density layer of data. He then took a route used by none of the others when he searched for cities. Then he added a layer of data showing major world boundaries and places. Christopher took time to use the zoom function of the GIS program by changing the scale affecting level of detail in areas like India and Europe viewing major cities and the connections with population densities.

Christopher realized that he also needed to explain why population is distributed the way it is. He struggled a bit before he remembered “the four mega population areas” from a geography lesson. He then proceeded to employ editing by adding a layer of data in which he
marked each of the four areas with a pushpin and used noting as a way to add personal knowledge about the population of those areas. Figure 9 provides a copy of Christopher’s GIS population map. Similar to some of the other case-study participants, Christopher found the use of transparency beneficial to show more than one layer at once. He also was unique in contemplating the effectiveness of various features, such as editing and including pushpins, in presenting a GIS project to others. He stated: “If you were trying to make a presentation or show like a big map with like a bunch of different details, the pins could be very useful because you can just go over them and see like a whole bunch of information about that pin and what is represents.”

When first discussing the GIS maps Christopher stated that he had not finished the second map. However, he did include a migration map even if he identified it to be not complete. To create his migration map, Christopher conducted a search using the term development, then revised the search to countries development and world development, and finally added a layer showing GDP that he made transparent. He searched for some layers of data focused on migration, but had difficulties. He found that one layer of data was not accessible because he needed a subscription with the GIS program, and another potentially useful layer of data had a problem loading. Several additional layers he had added to his map during the process including countries with refugees, BC immigration, world reference overlay, world boundaries and places, and Esri population world, but he had these layers turned off so that the data would not show on the map.
Christopher then moved from a global level to a more localized area, and chose a state migration map layer for the United States that showed in- and out-migration for each state. This layer of data provided him with a foundation for the rest of the assignment. He then focused again on cities, and he stated that he learned from the GIS assignment and the textbook that “America is like one of the only places where people are migrating away from urban areas and going back to the rural.” In order to show these movements of people, he employed editing and used arrows identifying those places with many cities and the direction of migration flow away from them to areas with lower population densities. He ended up with a map of the United States showing arrows displaying movement from cities to the interior part of the country. When asked why he focused only on the United States, he stated that “it gave us the most accurate map.” This map showed the student’s focus on only the United States to show migration trends. The student used several layers of data including a population density layer, a layer showing state-to-state migration, and an editable layer of data using arrows to show directional
movement. Transparency was employed on the map to show connections of current population centers and migration to new areas.

Christopher had been impressed with the great variability of kinds of map layer data when he tried using GIS before on his own: “To be honest, the first time I used it I was just looking around like I would with Google maps, and I zoomed in over Singapore just because I wanted to see if I could zoom in all the way.” He added a layer of data, but, because he had changed the scale of the map, he was unable to see the layer of data or actual results. He realized, though, that, because he could see the plumbing of Singapore, he had to zoom out to view the actual map layer. By changing the scale of the map to view a greater level of detail of features on the map, Christopher was conducting a spatial analysis of data. As discussed by the NRC (2006), the use of representations are critical in the abilities to think spatially and to communicate knowledge about relationships. Christopher was demonstrating both with respect to population and migration. Additionally, he expressed location on his map by including points to identify specific locations and made connections between layers of data by using the transparency feature. His use of both features are closely connected with spatial thinking as discussed by Gersmehl (2005), who associated comparing locations and understanding spatial association between features with spatial thinking, and as discussed by the NRC (2006) with respect to the use of tools for representing data that can meaningfully communicate relationships of phenomena.

Christopher’s pre- and post-sketch maps were rated “geographically informed,” but there were changes in the amount of detail he included on the maps. For example, he talked about Lake Victoria having a high population density from maps he used and therefore shaded that region with high density on his post-study sketch map. In addition, the areas he shaded in China
and India were more defined to the same population density shown on the GIS population density layer he used. Though Christopher had no connections between his post-study migration map and the GIS migration map, he did have several connections between the population post-study sketch map and the population GIS map. For example, the areas he identified with high population density and pushpins on the GIS map were all shaded with high population density on the post-study sketch map. Furthermore, the remainder of his map as it was shaded revealed very close connections with the information he included on the GIS map; the accuracy was high.

Aaron’s approach to each of the two maps focused on a single theme. For the population map, it was water, and, for the migration map, it was development. The water theme had also been a salient feature for Christopher. To create his population density GIS map, Aaron began by looking at where people cluster, especially near water. He showed the amount of water in certain countries and overlaid the layer of data on his population density map to show a correlation between water accessibility and population size. This, he pointed out, revealed those areas of the world with little population and lack of water as a resource. Figure 10 shows Aaron’s population map with reference to water availability. The map provides insight into the connections he wanted to show between water resources and population settlements. Two layers of data were included: one showing population density and the second showing access to water resources. Transparency allowed him to show connections between the two topics.
Development as a concept was important in Aaron’s approach to the GIS migration map, and he focused on the development of countries. He explained its relevance: “I figured that people from less developed countries would want to migrate to more developed countries and so I put arrows into MDCs from surrounding LDCs such as the US, from Mexico into the US … People move to MDCs for a better life because it’s more developed.” Finding the “right” layer of data relevant to development entailed a series of trial and error. Though he found multiple layers of data, he had some difficulties finding a layer of the exact information he wanted. After searching, he finally did find a layer that was “perfect,” and he used transparency to reveal connections with data already included on the map. One spatial thinking skill that was clearly being employed by Aaron was connecting location of population to features of the physical landscape, such as access to water. Gersmehl (2005) discussed this type of spatial thinking as a “zone of influence around a location.” To further exemplify this style of thinking, Aaron, like some of the other case-study participants, employed the transparency feature to analyze two different types of geographic phenomena. In these ways, Aaron demonstrated his ability to use
visuals of representation and reasoning to understand how humans interact with their environment.

Aaron valued the capacity of GIS for customization as well as portrayal of multiple layers of data at one time. He also found it interesting that there is such an “open source” feel to this program by means of which people can create layers of data and make them available to others. He stated: “It’s like everyone in the world can contribute a Lego block to someone and then that someone can build something magnificent.”

The level of relation between Aaron’s post-study sketch maps and his GIS maps varied. His population map revealed moderate connections with very good detail including the way high population density was shaded along the east coast of the United States, western Europe, India, China, and Australia were all represented on the sketch map. The migration map he produced showed even more relation when comparing the maps such as the arrows showing the movement of people on the GIS map were labeled similarly on the migration post-study sketch map. Furthermore, one country he highlighted specifically with high migration on the GIS map, Nigeria, he made sure to label with high migration on the post-study sketch map. He was able to recall and to place data on his post-study sketch maps, and he demonstrated that he gained geographic knowledge by applying his ability to think spatially.

Commonalities across the Six Students

For all of the case-study participants, this was the first time for them to use the WebGIS: ArcGIS Online. Christopher had mentioned using Google Maps, but had not used the same type of WebGIS program that was used in this study. All but one of the six had heard of GIS. They knew GIS existed or had heard of it, but all indicated that they did not know much about the
system and how it is used. In the previous descriptions, my focus was on their individuality. Here I present some commonalities that I saw across their experiences.

First, the students often had an *entry point*, or some starting point of knowledge, to begin creating their maps. For example, with Maria the entry point focused on climate and economic opportunities when she created her population GIS map. Suraj took interest in finding layers to simply show population density as a starting point from which he could add detail and build a map. Gita’s entry point on migration started with one idea, but, when this did not produce the results she was looking for, she tried new ideas. Allie was similar in her entry point, searching for terms dealing directly with population distribution and migration trends. For Christopher, the entry point was cities as he searched for data on the population map, and this focus on cities resurfaced as a point of interest on the migration map. For Aaron, the entry point was water resources when he was trying to explain population distribution.

Second, students used web-GIS in a *logical* way to find the data they needed or to create a new layer of data to fill in the gap of missing information. Maria also considered the importance of climate and weather as essential elements behind why people settle in certain areas. Simply put, those areas with better weather may attract people to live as opposed to areas with extreme weather conditions. Suraj also used a reasoning approach, wanting to confirm his hypothesis when he searched for layers of data by not only using the terms associated with population but also looking for possible business opportunities. Though he only included one layer of data on his migration map, it was logical to him to show where there was high population density as he sought to support his understanding of where people are moving from and to through the use of arrows. Gita investigated threats that would make people want to move from a place, such as epidemics and disease. Allie chose to search for data associated with the
major topics of the maps, including population and migration. Christopher focused on cities and features associated with highly populated cities. Lastly, Aaron, who thought that water is essential for living, suggested that areas with access to water would likely have higher population densities when compared to areas that have limited access. The case-study participants all took an approach that made sense, using their understanding of geography and building on their spatial thinking skills.

Lastly, these case-study participants all showed some personal interest in how they connected with the maps they created. Maria was very interested in the social and cultural relationships that influence migration. Suraj relied on his interest in economics and opportunities for employment to guide his map. Gita, who was a particularly good example when it came to connecting personally with the creation of the population and migration maps, discussed her own experience migrating. She reflected on her knowledge of where people live in India as displayed on the maps as she compared those patterns to her own experiences with the same regions. Christopher’s interest in urban areas as a place for high population guided his decisions as he created both of his sketch maps. Aaron’s interest in the importance of water as a necessity to sustain life was a main focus of his maps.

Summary of Findings for the Case-Study Participants

The case-study component of my study provided some insights into particular students’ GIS process that could not be gained from the data collected and analyzed for all students. This chapter illustrates the uniqueness of the students’ experience—the variety of search terms and layers that they employed and the kinds of reasoning that they used when they created their maps. In addition to seeing the individuality of the six students’ experience, I was able to see
three commonalities: having an entry point, employing logic, and relating the mapping process to one’s own interests.
CHAPTER 6

DISCUSSION OF THE FINDINGS

This chapter provides an opportunity to discuss students’ strategies in using GIS in their learning of geography and the use of sketch maps to assess spatial thinking. In the first section, I discuss findings associated with the process in which participants engaged when using GIS. The second section focuses on findings relevant to changes in their sketch maps that might be associated with changes in spatial thinking. The third section discusses the findings relating GIS maps and sketch maps. I conclude the chapter by discussing how this study can contribute to understandings of new ways in which students learn geography in K-12 education and how those experiences can be shaped based on student use of technology, especially GIS.

The Cognitive Process: Strategies

A large part of this study was devoted to investigating the process in which students engaged when using WebGIS. As discussed in Chapter 2, to date, there are very few studies (e.g., Huang, 2011; Wigglesworth, 2003) that analyze the process involving the choices students make when using this type of technology. As GIS continues to slowly be implemented into K-12 classrooms, it is important to understand how students might apply its functionality when completing a task, whether it is at an expert level or a novice level. The analysis in this study of the steps and decisions made by these students using WebGIS to create maps has revealed several findings with regard to how students embraced the software, in many cases for the first time. As students worked with GIS in this study and, with little experience, used technology to visualize relationships, the process they used supports Henry and Semple’s (2012) study of the application of GIS in education. Even with little knowledge of how to use GIS, users can learn basic skills with ease that will expand learning through visualization. The use of GIS offered
students a unique way to interact with different layers of data in order to identify relationships
that they may not have previously considered. Furthermore, this study contributes a new view of
how WebGIS can be used in the AP classroom to expand knowledge based on topics in the
College Board course outline and to elevate learning.

*Flexibility of Process*

GIS offered students opportunities to explore a multitude of data and to employ different
types of strategies to make the two maps. Strategies students used included searching for data to
use, adding a layer of data, removing a layer of data, changing transparency, editing, and noting.
Though students learned how to use each of these strategies when completing the first part of the
GIS assignment, it became apparent to me, after reviewing the screen-capture recordings, that
some students felt more comfortable than others in using some strategies. Searching and adding
layers were the strategies that were employed the most by students when creating the maps.
Students used the search function as a gateway to possible explanations for current world
population distribution and migration patterns. However, the process of searching was not an
easy task for students because they quickly found out that more information was available for
access on the WebGIS program than they had expected. Through searching, students tried to
identify characteristics of places based on geographic phenomena. This strategy employs spatial
thinking because the user must consider what types of data may be valuable to use on the map.
Searching challenges the user’s knowledge of content as he or she seeks to find relevant data and
to communicate it effectively. Interestingly, after searching, some students chose not to add a
layer of data but, instead, became creative and employed the editing strategy to create their own
layers.
Students embraced the functionality of GIS by establishing ownership of their individual products. The innovative and creative strategies students employed in constructing their maps reflects prior research, such as that by Kerski, (2003), which found that, when using geospatial technologies such as GIS, students are analyzing data and creating ownership in their own way. This study offered a valuable opportunity to learn more about the personal process and specificity of the maps by the use of case studies. The case-study participants revealed, by means of their own voices, the processes they used when working to create maps; there were some similarities, but no two students followed the exact same path. The flexibility of GIS is one of the advantages of using this type of technology in an educational setting: the task assigned can either be structured or it can offer individuals or groups a chance to determine their own route in the creation process.

The ways in which students used the strategies when creating the GIS maps varied. For example, as reported in Chapter 4, application of arrows was done in two ways: students used the arrows to point out places of significance regarding population density or they used arrows to show directional movement. This finding suggests that how features of GIS are used is heavily dependent on the person creating the map. Strategies such as employing arrows in two different ways also suggests that the functionality of GIS is versatile; users are not confined to using the technology in only one way.

Not all students were successful employing the different strategies of GIS discussed in Chapter 3. For example, the strategies of removing a layer of data, adjusting transparency, and noting were used the least by students when creating their maps. Not using these strategies may reflect individual choice, but it may also reveal a lack of experience in using GIS by students as to when to employ specific strategies, especially with regard to adjusting transparency and
editing. Ultimately, the flexibility that GIS offers resulted in processes that were individualized and driven by the interests of the student. This relation to the student’s interests supports Wiegand’s (2006) discussion of GIS as a tool that allows for individuality. This finding is valuable because, as individuals, students have had diverse experiences and bring varying levels of knowledge to the classroom. Put another way, their cognitive maps vary.

In commenting on his or her GIS strategies, each of the case studies discussed what seemed interesting in using WebGIS for the first time. These comments included the ability to customize maps to one’s own liking, the global perspective that one can take in applying different strategies for investigating topics, the large number of maps available, the ease of using the program, the “open source” nature of WebGIS with its many different layers of data in one place, and features available in the layers, such as timelines to view change. Similar to Milson and Earle’s (2007) findings, in this study students were not tied to a textbook, and this freedom allowed for flexible use of strategies and for student-driven strategies based on students’ own interests and curiosity using the program. This type of learning is hard to find in classrooms today where curriculum being taught is often prescribed and assessment-driven.

Commonalities

For many students, the process they used to create the GIS maps often evolved from the beginning to the final product. However, there were several commonalities identified by all students that were later more defined by the use of case studies.

The results of the analysis of the screen capture recordings and review of the GIS maps revealed that students used searching and layering strategies the most in creating their maps. When searching for layers of data to include on their maps, there were also some similarities. For example, as discussed in Chapter 4, many students used several obvious terms directly
related to the focus of each map, such as *population density* and *migration*. However, as discussed in Chapter 4, it was also common among many students to search for other terms that were not directly related to the topic. These less commonly used terms included factors that may explain why people live in certain places such as *crude birth rate* and *food sources global*, or how developed an economy is that may identify the movement of people from one place to the next including terms such as *best education* and *conditions of life*. In addition to using the searching and layering strategies, almost all students employed the use of another strategy in creating their maps. Besides the use of the searching and layering strategies, students also applied the editing and noting strategies to personalize their maps. For example, though many students chose to use the editing strategy, the data features on their maps included shapes, arrows, points, and drawings created with the freehand draw tool. Furthermore, the style of the features was often changed by the student as his or her perspective changed. Although there were some commonalities in approach, the final data included on the map often varied. Lastly, there were challenges encountered by many students when creating the maps, such as layers of data not responding and difficulty narrowing down the use of terms to search.

Although most data regarding students’ strategies came from all participants’ screen captures, more detail was provided in interviews with the case-study participants. During the interviews three commonalities were noted across the six students: (1) students tended to have an overall approach to take for completing the map; (2) students had some entry point as they began creating the map that directed their path; and (3) personal interests of students were salient in their quests to find data relevant to their geographic reasoning process. For example, some students used a *logical* approach to begin their search for identifying why people live where they do, or why people move. They often began searching using familiar terms, but if they were not
able to find data relevant to their map, they had to change gears. The relevance of this type of thinking has been suggested by Wiegand (2006), who also pointed out there are multiple ways to view spatial data and uncover connections between layers of data that cannot be done using a traditional map.

When creating the population maps, some had, as their entry point, a hypothesis to explain why population is distributed the way it is or why people move. Often the search resulted in numerous layers of data that helped explain the spatial distribution of phenomena. In contrast, for the migration map a number of the students had to stop and begin to ask geographic questions of the natural and cultural landscapes that might explain what they viewed on their individual maps.

Important to note, in discussing the findings, is the importance of each student’s individual interests. This study revealed that students do bring their own personal connections to geography. Discussions with the case-study participants helped to explain why students included different pieces of information on their maps. This type of data can be valuable for teachers, who can see how the previous experiences of students as well as their current interests can contribute to a meaningful learning environment. My study has contributed some insights into the strategies used by students when creating maps using GIS and underscores the importance of students’ prior knowledge, and personal interests. It also emphasizes the role of spatial thinking, which is discussed next.

Spatial Thinking and the GIS Experience

Spatial thinking, which is, of course, significant to geography education, was a key component of this study. As acknowledged in Chapter 2, the National Research Council (2006) stated that spatial thinking involves several elements, including knowledge about space, such as
Earth’s landscape, the use of tools to visualize phenomena, and “the process of reasoning.” The National Geography standards (2012) have identified “mental mapping” as an important component in building geographic knowledge. This study attempted to tap into the cognitive maps of students as they learned about population and migration and to investigate how those maps changed. Similar to previous studies (Gillespie, 2010; Saarinen & MacCabe, 1995; Shobe & Banis, 2010), sketch maps were used in this study.

Changes in Spatial Thinking

The use of sketch maps was a way to identify students’ knowledge prior to using GIS and after using GIS. These products served as a means of assessing how their knowledge changed. Initial sketch maps by the students revealed greater knowledge about some countries and regions of the world than about others. As noted above, students were able to identify certain specific countries in both sets of sketch maps. These countries included such places as the United States, China, India, and Canada, to name a few. Additionally, students in many cases shaded regions of the world with regard to population density. This identification of regions revealed differences in students’ prior knowledge associated with their cognitive maps. The initial set of sketch maps created by students established a foundation of the knowledge they had as they began a new unit of the AP Human Geography course outline as well as prior to using a geospatial tool to investigate geographic phenomena. As pointed out in an earlier study (Saarinen & MacCabe, 1995), this type of data created an opportunity for dialogue about the perceptions individuals had with regard to boundaries, culture, or other geographic phenomena which could be discussed during the case-study interviews. Additionally, in this study a follow-up sketch map was a means of identifying if and how student’s cognitive maps changed after using GIS. The findings support previous research findings from Polonsky and Novotny (2010)
on the value of sketch maps in learning. Therefore, the maps could be assessed for changes in
the understanding of such phenomena when comparing the pre- and post-study sketch maps.

The sketch maps of this study revealed in most cases positive changes in the level of
elaboration as well as accuracy when referencing population distribution. The migration maps
showed a greater increase of elaboration and accuracy by students, suggesting a lack of
knowledge of migration trends at the beginning of the unit. According to the sketch maps
analyses, some students did not increase in their level of understanding of population distribution
and migration trends, and a few individuals seem to have regressed in their knowledge. There
are several reasons that this may have occurred, such as lack of interest in completing the second
sketch map, too little time to complete the sketch map, or little to no change in their cognitive
map. I anticipated some limitations in the use of sketch maps. But the benefits of being able to
have a starting point from which to measure the acquisition of new knowledge as recalled and
included on the second sketch map for each student far outweighed the limitations. Furthermore,
the use of a post-study sketch map offered a chance to investigate any connections with the
student-created GIS map and the possible changes in his or her cognitive map. As discussed in
Chapter 4, for many students there were connections between the two maps, though the level of
connections varied.

Overall, the use of sketch maps in this study was supportive of several key points from
previous studies that identify the value of mapping discussed in Chapter 2. The sketch maps
provided insights into the mindset of each student with regard to his or her cognitive map; they
revealed individual understanding of population distribution and migration trends; they brought
to light misinterpretations of the material being taught; and they encouraged active learning.
Spatial Thinking Associated with the GIS Maps

In order to identify if a student had experienced changes in his or her cognitive map related to the GIS experience, efforts were made to identify changes in spatial thinking that were associated with aspects of the GIS maps.

Sensitivity of the Sketch Maps

As demonstrated in Gillespie’s (2010) study, the use of a rubric was valuable in this study to measure relations between the sketch maps and the GIS maps. The results of scoring each map with use of a rubric offered a chance to categorize the sketch maps based on the level of elaboration and accuracy and to categorize the GIS maps by the types of connections visible in the post-study sketch map. Most students fell into the category of “moderate connections” when comparisons were made. Surprisingly, though, some students’ sketch maps showed little or no connections with the GIS maps. The lack of connections between the maps may have been because the GIS map focused on only one region of the world whereas the sketch map had a global scope. Or the lack of connections may have been because students chose not to identify the same types of information on the maps or to provide the same level of detail. The sketch maps provided rather static information regarding students’ spatial thinking and their cognitive maps. In the following, I discuss students’ dynamic use of spatial thinking as it was employed and developed through their GIS mapping.

Search for Patterns and Explanations

In this study, GIS provided a means for students to apply spatial thinking. WebGIS gave students a global to local scale of the world and tools to construct maps with layers of data showing population distribution and migration trends. Therefore, students were able to visualize phenomena in a new way that a textbook or paper map could not offer—an important part of
spatial thinking. The data could be viewed at different scales with a click of the mouse, and students had opportunities to make connections between phenomena on Earth’s landscape.

Furthermore, if students created new layers of data or added multiple layers of data and changed the transparency, a new possibility emerged to search for patterns between phenomena. This process of connecting ideas through layers and determining which layers to use involved geographic reasoning on the part of the student. As discussed previously, Jo and Bednarz (2009) found textbooks to be lacking with respect to teaching students how to think spatially or use a spatial perspective. The present study suggests some ways in which GIS can develop inquiry among students regarding geographic phenomena. For example, this study shows how students, by using such tools as interactive visuals and engaging in spatial reasoning, can learn about the relationships between humans and their environment. By employing spatial thinking skills, students had to determine what would be the best layer or layers of data to use when visualizing a concept and how to view the data in a meaningful way. This may have included the use of transparency or editing strategies to create a map that revealed relationships between the data and their understanding of its distribution on Earth. This is one way that GIS skills and spatial thinking skills overlap. By using different strategies when creating the maps, students were able to describe features in an area, to compare places with one or more layers of data, and to draw connections between places with similar features. This style of thinking, reasoning, and consideration of geographic data aligns well with the concepts of spatial thinking. The use of GIS in this way offers an opportunity for students to think spatially that Jo and Bednarz (2009) found to be lacking in geography textbooks.
Analytic Aspects of Students’ Spatial Thinking

One attribute of GIS relevant to spatial thinking is its capacity to encourage students to question what they are viewing. They must analyze why things are happening and where things are happening in the world, as they did in this study when focusing on population distribution and migration trends. The use of GIS facilitated the development of this kind of analysis, which is encouraged in the National Geography standards (2012). To create the population map, many students opted to search for layers of data that showed population on Earth. But they also attempted to show in their maps why the population on Earth is distributed in this way. This part of the map-making process stimulated students to think beyond the basic layer of data showing population density and investigate the why. Prior research (e.g., Baker, 2005) has noted that this type of inquiry learning is critical to becoming a geographically informed person.

Not all students made it to this point, as several included only a basic layer of data showing population. However, for those who began to think critically about the information presented before them, the connections between population settlement and other geographic phenomena took hold. The use of tools to learn geography, such as GIS in this study, suggests that students are able to build relationships among geographic phenomena from natural curiosity, as identified in previous studies (e.g., Broda & Baxter, 2002). Similar to the findings by Huang (2011), this study found that students using GIS tended to take time to think about what they were viewing on the maps and its value in understanding the interactions between humans and the environment.

Spatial Perceptions of Earth

The findings of this study suggest that, as students learned about population distribution and migration patterns using a new geospatial tool, changes unfolded in how they viewed the
Earth, which may or may not have been picked up by their sketch maps. The discussion of these perspectives of Earth and how they evolve is highlighted as an essential component in geography education by the National Geography standards (2012) and is reflected in the title of the first section of the AP Human Geography course, “Geography: Its Nature and Perspectives” (College Board, 2013). Clearly, a significant part of learning geography and developing skills to think spatially involves using a spatial perspective. In many cases, students, such as those participating in this study, have no prior formal exposure to studying geography before entering the AP Human Geography classroom. Several of the case-study participants reflected on prior knowledge during the interviews, but also discussed new spatial understanding of phenomena on Earth after using GIS. For some, this new information challenged previous thoughts regarding the locations of population and migration patterns. The use of maps as a tool in learning geography is a complex process that must involve opportunities for students to explore data in multiple ways to build and apply their spatial perspective. GIS is a new tool with many promising possibilities to do just that. This study provides an interactive way for students to be exposed to GIS, create final products exhibiting knowledge of defined topics, and enhance spatial thinking capabilities. Therefore, these findings may contribute to a more defined role of GIS in a World Geography or AP Human Geography classroom because it can help students develop spatial understanding and awareness.

Conclusion

The results of this study can contribute insights into how educators, curriculum writers, and scholars can investigate, develop, and implement new ways for students to learn geography in K-12 education. GIS in K-12 education can help create globally literate citizens through its ability to enhance spatial cognition. As our world becomes increasingly technological, a new
focus of the role technology plays in our everyday lifestyles has revealed a current need to
develop skills associated with using tools such as GIS to enhance how students learn. Though a
mapping system, GIS uses spreadsheets, presentation formats, comparison of data, and query
skills that can be useful in multiple disciplines in addition to geography. Furthermore, this study
recognizes that it is not only the final product that tells the story of how students learn, but it is
also the process they take to get there. Although the paths are variable, commonalities in GIS
strategies seem to exist, at least they did for students in this study, in terms of having an entry
point, related to explaining current population distribution and migration trends.

Developing the ability to think spatially and applying that spatial thinking to geography
are critically important, particularly as our world becomes more interconnected. As discussed
earlier, spatial thinking can be developed, and this study provides some insights into the ways in
which its development might relate to the use of GIS. Unique to this study is its focus on the
GIS strategies employed and on the building of spatial skills relative to human geography in an
AP classroom. Geography education has an exciting future as research continues to identify
ways to enrich learning opportunities and to investigate the role that technology, including GIS,
can have on learning.
Ap Human Geography
ArcGIS Online Activity

Demographics of the United States and World

Part 1: Investigating population distribution, population change, and migration patterns around the world.

1. Access the ArcGIS Online webpage [http://www.arcgis.com/features/](http://www.arcgis.com/features/). Click on the tab at the top right corner to login using the following username: and password:

2. Once you login, select “Map” at the top of the page and a New Map will open; it should look like the image below:

   ![Map Image]

3. Click on the “Add” tab and select “Search for layers.” A search/dialogue box will appear—type in “Population” and click on “GO.”

   ![Search for layers]

4. Click on add for the “USA Population Density [Extended Support]” layer. The map will immediately add the layer. Click on the “Details” tab at toward the top of the page then select the legend tab to open the Map Legend to understand the colors and data.

   ![Legend Image]
5. Fill in the map legend here as to how it appears for the map:

**USA Population Density**

**Persons per square mile**

6. Scale the map by zooming in and out to make the contiguous US as well as the states of Alaska and Hawaii visible in the map viewing screen. What areas of the US have high population density?

   ____________________________

   ____________________________

7. Using the same view, what areas of the US display a lower population density?

   ____________________________

8. What might be possible reasons for the current population density trends in the US?

   ____________________________

   ____________________________

9. While holding down the Shift key, click the left mouse key and draw a box around the state of Texas to zoom in. What did this do to the scale of the map? How did the legend change?

   ____________________________

10. Now that you are looking at Texas, click on the counties that have the highest population density. List the county name and population density below:

    ____________________________

    ____________________________

    ____________________________

    ____________________________

    ____________________________

    ____________________________
11. Search for map layers that you think will help identify why these 5 counties have the highest population density. You can add the layers to the map, and then select the “Contents of the map” tab and the arrow to the right of each layer to use the transparency tools to see multiple layers of data. What map layers did you select to help prove your hypothesis?

12. Using the zoom in/out tool on the map view screen, zoom back out to view the entire contiguous US. Click on the “Add” tab at the top of the map and select “Add Map Notes” – Label this layer: High Population Density States. Edit the map by dropping a pin on 5 states of your choice with high population density. Add whatever type of information you want to the notes for each state you select. List them here:

13. What may be the impact of the states with such high population density?

14. Search for the layer “USA Population Younger than Age 18 (Extended Support)” using the Add, Search for layers tab. Click “Add” to add the layer of data to the map. Click on the “Details” tab to view the legend. Using this information, which states have 26-33% or more of their population under the age of 18? (Hint: you may need to turn off the map notes layer you created to see all of the states)

15. What can explain the reasons behind states with young populations?

16. Make sure that all other layers are turned off and click on the three states that have high percentages of youth. List the state name and percent of youth.

17. Zoom in to each of the states and describe the areas where the highest percentages of youth are living.
   Texas
   Utah
   Idaho
18. Search for the layer named “USA Population Older than Age 64 (Extended Support)” and add it to your map.

19. Make your map view all of the US. The majority of the US has a percentage of ____________________ population older than Age 64. (Hint...Use the legend).

20. How do you think age may impact population distribution/density? ____________________________________________

________________________________________

Population Change over Time

21. Turn all layers off, and search for the layer “USA Population Change 2010-2012 (Extended Support)” add this layer to your map. *Make sure to view the contiguous US, Alaska and Hawaii. What 3 states have between 1.3% to 2.5% population change from 2010-2012?  
   a. __________________
   b. __________________
   c. __________________
   d. __________________
   e. __________________

22. What state experienced no population change at all? ________________________________

23. What states do you think will continue to see experience change in the future? ________________________________

24. Why do you think populations change in the US? ____________________________________________

________________________________________
25. Search for the following layer “World Bank World Population” – Add this layer to your map. Make sure to turn off your US population change map. At the bottom of the map, there is a timeline. What years does the timeline cover? ______________ to ____________

26. Press the play button on the timeline to watch how population changes over time around the world. What do you notice?

__________________________________________________________

__________________________________________________________

27. According to the legend, in 1959 what were the most populous countries? ________________

__________________________________________________________

28. By 2009, what 2 additional countries have increased in their population? ________________

__________________________________________________________

29. What countries do not have any data? Why do you think this is? ________________

__________________________________________________________

30. Overall, what is happening to world population in most countries?

______________________________

31. What regions of the world are the most populated, what about the least populated?

Most: __________________________

Least: _________________________

Save your map using the following label: Lastname Firstname Population.
Migration

32. From your knowledge of human geography, what factors can cause population to change in a country or region?

33. Turn off all of your layers and search for all layers dealing with migration. When you find the layer, “State to State Migration 2011 Feature Service – State to State Migration,” add the layer to the map. Click on the map details and write a brief description of what the map is showing.

34. Open the legend and view the map, what do you notice with regard to state to state migration?

35. List below the Bottom 5 states that have high out-migration. What factors do you think contribute to their high number of out-migrants to other states?
   1. 
   2. 
   3. 

36. List below the Top 5 states that have high in-migration, and list them below. What factors do you think contribute to their high number of migrants moving into their state from other states?
   1. 
   2. 
   3. 

37. What may be some of the push and pull factors that explain migration in the United States?

Search for any layers of data that you can add to your map that may show some of these push and pull factors and list them below:

38. Now that you know where people are migrating internally within the United States, create an editable layer of map notes to draw in arrows showing those patterns and label regions as needed. Click on “Add Layer” and scroll down to “Map Notes.” Name this layer Migration in the U.S. Add visuals such as arrows to show where people are moving, as well as label regions as needed using pushpins or shapes.

39. Search for layers of data that help identify current global migration patterns as discussed in your text book. What did you find?

40. What impact(s) may be experienced from current population distributions around the world and current migration patterns?

Save your map using the following label: Lastname, Firstname, Migration.
Part II: GIS Maps

1. The second part of this lesson will focus on the creation of two maps using ArcGIS Online. Now that you are familiar with the functionality of the system, you will have to tasks to complete.

   a. Population Densities of the World: Create a map identifying the places or regions of the world with high and low population densities. Include any layers of data that you feel will help explain why population density is high and low in those regions. In addition, create an editable layer of “Map Notes” to identify key elements of your map, such as place names, or other facts you feel will help explain population distribution around the world.

   b. Migration Patterns of the World: Create a map identifying regions of the world where there is high out-migration, those areas of the world experiencing high in-migration, and those areas of the world that are experiencing equal migration (the number of people immigrating is equal to that of people emigrating). Include any layers of data that you feel will help explain the current migration trends. In addition, create an editable layer of “Map Notes” to label or insert visuals to identify key elements of your map.
APPENDIX B

SURVEY
Survey

1 = poor  2 = fair  3 = good  4 = excellent  5 = not sure/not applicable

Use the scale to identify your proficiency level in the following tasks

<table>
<thead>
<tr>
<th></th>
<th>1 = Poor</th>
<th>2 = fair</th>
<th>3 = good</th>
<th>4 = excellent</th>
<th>5 = not sure/not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest in the study of geography</td>
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<tr>
<td>The ability to use a computer</td>
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<td>The ability to use a map or globe</td>
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<tr>
<td>The ability to use Geographic Information Systems (GIS)</td>
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<tr>
<td>The ability to use Global Positioning Systems (GPS)</td>
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</table>

Select the answer to the best of your knowledge:

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<th></th>
<th>None</th>
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<th>2</th>
<th>3</th>
<th>More than 3</th>
</tr>
</thead>
<tbody>
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<td>Number of globes at home</td>
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<td>Number of computers at home</td>
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<tr>
<td>Use of an atlas per year</td>
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<tr>
<td>Use of GIS or online mapping per year</td>
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REFERENCES


