ANALYZING THE DIFFUSION OF GEOSPATIAL TECHNOLOGIES

AS INSTRUCTIONAL TOOLS IN HIGH SCHOOL

GEOGRAPHY EDUCATION

by

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DEDICATION

I dedicate this dissertation to my parents, Jennifer and Lester Curtis. They encouraged me to reach for the impossible knowing that “the will of God won’t take you where the grace of God can’t keep you.” They are some of the smartest and most caring people I know. Their curiosity and love of learning inspired my own educational pursuits. Their strong nature and spirit inspired me to persevere. Thank you, Mom and Dad!

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ABSTRACT

Twenty-first century education demands that students engage in innovative technologies in authentic learning environments. With a focus on keeping geographic learning current, the geography education community strives to diffuse geospatial technologies (GST) into secondary geography education. However, these tools remain largely unused. This national study examined the current patterns of GST and decisions to use geospatial technologies as pedagogic enhancements by a sample of high school geography educators. Rogers' (2003) Innovation-Decision Process and Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPCK) research provided the two lenses for this study. These frameworks illustrate one model for the GST adoption process and provide insight into challenges to implementation beyond commonly known barriers to technology integration. Rogers' (2003) process model is helpful in understanding the phases involved in accepting innovation and informing possible actions and decisions by secondary geography educators. The findings of this research suggest that the phases may not be a sequential progression as identified in earlier innovation diffusion studies. According to Mishra and Koehler (2006), teachers exhibit sustained, integrative technology use when they develop a combination of three knowledge sets: Technological Pedagogical Content Knowledge (TPCK). The current investigation revealed significant associations among the data with an emphasis on the importance of teachers' geospatial TPCK (G-TPCK) and its influence on the diffusion of GST in high school geography classrooms.

CHAPTER I

INTRODUCTION

Problem

Despite the fact that geography is listed as a core subject (No Child Left Behind [NCLB] 2001; The Partnership for 21st Century Skills 2008), no national mandate exists for the use and integration of geospatial technologies (GST) in school classrooms, even though the demand for this approach has increased universally over the last decade. According to the National Research Council (NRC 2006) report, “There is a major blind spot in the American educational system”—American students are not systematically taught how to think spatially (NRC 2006, 231). In this study, *spatial thinking* refers to a group of cognitive skills facilitated by GST, including tools such as geographic information systems (GIS), global positioning systems (GPS), and remote sensing (NRC 2006; Oberle, Joseph, and May 2010). Of note, GST can refer to *geospatial technology* or *geospatial technologies* in the literature. For the purposes of this paper, GST refers only to the plural term geospatial technologies.

Geography educators in K-12 classrooms do not systematically integrate or use GST in their classrooms to assist with teaching geography content and thinking strategies (Bednarz and Audet 1999; Kerski 2000, 2003; Gatrell 2004; Baker 2005). This problem stems from the fact that most secondary geography educators are not prepared in their pre-service education as geography majors or minors, and they receive little geography training (Solem 2008). In some cases, teachers only take one geography course, if any at all, before they teach geography at the high school level. Therefore, educators might not understand the importance and use of spatial thinking.

Geospatial technologies encompass multiple technologies (i.e., GIS, GPS, and remote sensing) that aid in spatial analysis. However, since the 1990s, diffusion of GST, as illustrated by their acceptance and usage in K-12 geography classrooms, has been very slow (Kerski 2003). Developing savvy, technologically literate students is paramount to preparing twenty-first century global citizens (The Partnership for 21st Century Skills 2008).

The United States Bureau of Labor Statistics (U.S. Department of Labor [DOL] 2004) recognized six different categories of jobs that require the use of GST; this recognition has led to continued growth of this employment sector with an expected rate as fast as 20 percent over the next few years (Unwin et al. 2012). To succeed in an era of rapid globalization, we must innovate and include professional technologies within the daily instruction of primary and secondary education (U.S. Department of Education [DOE] 2004).

Some states have made steps toward increasing GST in their curricula. Milson and Roberts (2008) identified a few progressive states (i.e., Minnesota, Mississippi, South Dakota, Texas, and Utah) that encourage innovative practices by requiring GST are included in geography education to some degree. However, the literature suggests that the main reason for the lack of these technologies in the classroom is that geography teachers might not be equipped with the technological skills, knowledge, content-specific cognition strategies, and GST teaching strategies to educate twenty-first century students properly (Koehler, Mishra, and Yahya 2005).

Today's learners need to be technologically literate. Since Kerski's (2000, 2003) seminal study, the world has changed with the advent of the Internet, Web 2.0

applications, and movement into the *Digital Information Age*. Lindeman and Vastag (2011) used the term, Digital Information Age to describe the era encompassing the huge growth of computing capacity, digital tools, social media, and *Web 2.0 technologies*. Web 2.0 technologies are online applications that make it possible for users to create and share information with multiple "communities of users, resulting in various forms of user-driven communications, collaborations, and content (re)creation" (Facer and Selwyn 2010, 32).

Advances in the Internet have the potential to change the learning environment because of increased accessibility to GST. Additionally, because of the decreased cost of software and student-computer ratio, and the availability of state and local spatial data sets, school partnerships with institutions of higher education, and the flexibility of Web 2.0 applications over the past decade, GST may become more amenable to classroom use (Bull, Hammond, and Ferster 2008).

Geospatial technologies are ubiquitous and have become the foundation of many tools, both online and in an array of mobile devices (Unwin et al. 2012). These technologies have proliferated on the Internet from simple uses (e.g., online mapping tools such as MapQuest), to GST that require more analysis by the user (e.g., virtual globes and remotely sensed images), to robust online GIS software (e.g., Esri's ArcGIS Online). Secretary of Education, Arne Duncan, advocated the use of professional technologies in K-12 education in his letter to Congress. He cited the 2010 DOE National Education Technology Plan (NETP), which "calls for applying the advanced technologies used in our daily personal and professional lives to our education system to improve student learning" (vi) and for the betterment of various educational practices.

A current assessment of diffusion of GST for instruction in K-12 geography education is essential. Here, *geography education* is broadly defined as teaching and learning about the relationships between and among places, cultures, and physical systems within or between regions in standalone geography courses or strands within the social studies discipline. The availability of online technology resources and federal support to integrate technology in education support these educational activities.

This study was designed to evaluate the degree to which high school geography teachers use GST in their instruction and to determine the extent to which training in both GST and pedagogy, specific to these technologies, play a role in teachers' decision-making about integrating such technologies into their classrooms. Further, this study offers an in-depth examination into the decision-making processes of educators who have adopted GST as instructional tools in their geography classrooms. The following objectives were applied to accomplish these goals: 1) assess high school geography teachers' levels of integration and use of GST in the classroom and 2) analyze geography teachers' decision-making process regarding these technologies. The results of this study may inform the decision-making processes of various stakeholders as to the further diffusion of GST as pedagogical enhancements for high school geography classrooms.

Theories that guided this investigation have a history in education, in general, and in geography education specifically (e.g., Doering, Veletsianos, and Scharber 2008; White 2008; Banister and Reinhart 2011). The current study used Rogers' (2003) Diffusion of Innovation theoretical framework to study the acceptance of an innovation within a given population to better comprehend teachers' decisions about utilizing GST when teaching geography. Additionally, Mishra and Koehler's (2006) Technological

Pedagogical Content Knowledge (TPCK) guided this study to result in an understanding of how educators' knowledge affects their decisions to use GST. Of note, the convention Technological, Pedagogical, and Content Knowledge (TPACK) is used by some in the education community; however, Technological Pedagogical Content Knowledge (TPCK) was used in this study.

Nature and Scope

The results from this investigation are intended to inform administrators, in-service and professional development trainers, pre-service and geography education professors, education policymakers, and others who value GST and who are interested in analyzing reasons why these technologies are or are not used in high school geography education. Determining educators' motives to use these technologies in the classroom will go a long way to inform the design of professional development and pre- and in-service training with these technologies as viable tools in geography classrooms. Additionally, understanding the accessibility and viability of GST as educational tools may influence education policymakers' decisions regarding requirements for pre- and in-service training and teacher certification. Furthermore, it was anticipated that the findings would prompt key local and state decision makers to be more proactive in their support by facilitating training, teacher collaboration, school district support, broadband Internet access and use, and improved computer access for use of technologies focused on geospatial concepts.

This study focused on analyzing teachers' self-reported data from an online survey and telephone interviews to assess their progress in determining whether to use GST in their instruction and to evaluate teachers' technological and pedagogical knowledge. Participants were certified teachers assigned by their school administrators to teach geography. It was assumed that all participants maintained basic pedagogical and geographical knowledge because they were certified and assigned to teach geography; therefore, *content knowledge*, *pedagogical knowledge*, and *pedagogical content knowledge* were not assessed.

Assumptions

Seven fundamental assumptions about geography teachers and GST uses when teaching were held during this study. First, all teachers approved to teach a geography course had at least basic geographic content knowledge. Specifically, all teacher participants were state-certified to teach social studies courses, including geography; therefore, they had at least the minimum state-required knowledge for the geography course(s) they taught. It is important to note that this assumption was based on teachers passing a state test to teach geography, which varies from state to state. However, no standard requirements exist to teach geography, thus, certification varies widely from state to state. Therefore, the quality of geography teachers is likely to vary depending on the state in which educators teach. Additionally, administrators assign teachers to geography courses, thereby, reasoning that participants had at least the basic understanding of geography. Further, participants may attend their state Geographic Alliance professional development events on their own accord and agree to be included on the listserv for individual state Geographic Alliances.

Second, teacher participants were interested in the perpetual improvement of their geographic knowledge, skills, and pedagogy. Third, technology use by teachers is not standard. Fourth, the National Geographic's Network of Alliances for Geographic

Education represents teachers who are motivated to improve and enhance their geographic content, skills, and pedagogical knowledge. Fifth, the time and learning curve of traditional, desktop GIS applications are significant factors for teachers; however, these restrictions could be less pronounced for online GST. Sixth, geography teachers gain exposure to GST through formal or informal training experiences. Seventh, these technologies are powerful, dynamic tools when used appropriately to support teaching and learning.

Limitations

To compare the current results to Kerski's (2000) national study and provide insight into the current rate of acceptance of GST in geography education, it was necessary to develop a survey to be administered to a representative national sample of high school geography teachers. Because it was unrealistic to expect that all teachers in the United States could be surveyed, only high school geography educators who were members of the Network of Alliances for Geographic Education in their states and who taught in states with geography graduation requirements were included in the framed sample population. Alliance members included teachers who were interested in improving their skills and knowledge as educators, but who may or may not have been interested in using GST. While these educators indicated their commitment to honing their knowledge and skills, one cannot infer that they used or were willing to use these specific technologies.

According to Kerski (2000), Alliance educators are more likely to be receptive to professional development opportunities regarding content-specific technology. The interest in the current study was learning how these dedicated, highly involved educators may be more willing to include GST in their teaching designs. Therefore, selected teachers were those who would likely be motivated to learn more about geography education to be better geography teachers; however, those selected may or may not have been motivated to implement GST. It was reasoned that membership with the Alliance showed participants' willingness to improve knowledge and skills, which may suggest that they would be more likely to encounter these technologies and, perhaps, be more open to their implementation.

The Alliance databases could pose a few challenges such as access to membership emails, indirect access to contact information, and current database information. Informal inquiries were made to determine whether each state Alliance Coordinator was willing to participate in the study by allowing access to member listservs. These inquiries yielded favorable results.

Ideally, a researcher maintains control over the direct access to participants in a study. However, in this case, the state Alliance Coordinators were responsible for contacting their membership to solicit responses to the survey. It was believed that these Coordinators would communicate the study information diligently. Additionally, it was anticipated that members would have a greater affinity to their Alliances; thus, they would be more likely to answer the survey because of the direct contact from their Coordinators.

Only one state Geographic Alliance did not have a listserv or mailing list. To address this issue, the Alliance Coordinator provided contact information for the Social Studies Supervisor for the state DOE who allowed access to its social studies listserv. This listserv communication did not come directly from a person in leadership; therefore, members might not have been as likely to answer the survey compared to those who received direct communication from their Alliance Coordinators.

The remaining four state Alliance Coordinators had membership listservs or email databases to which they forwarded communications regarding this study. Therefore, the researcher did not have direct contact with participants from these states. Each Coordinator received an initial participation request and subsequent reminder correspondences. Coordinators were supplied with drafts of suggested email messages for their constituents, which they forwarded on to their membership. The willingness and ability to contact geography educators across their states based on each Coordinator's professional character was satisfactory.

Another challenge concerns the state Alliance databases, which might not have been updated, thus could have included members who are no longer active with their Alliances. The expectation was that Alliance Coordinators added new members regularly, but they might not have assessed membership at-large to determine who was still active. However, the fact that educators were on the Coordinators' listservs indicated their levels of commitment.

Some contact information may have been dated, resulting in misinformation about participants. Those who received the correspondence had the chance to provide personal information in the demographic portion of the survey. The Alliance databases were assumed to be relatively current because they reported information about their membership annually to the National Geographic Society. Therefore, email errors from the database were expected to be few in number, thus were not considered a critical limitation.

The quantitative phase allowed survey participants to respond by email, mail, or the Internet. It was expected that most teachers would take advantage of the online survey provided by SurveyMonkey, an online survey administration service. However, Internet surveys have some inherent challenges. For example, users might experience technological problems while taking the survey. Additionally, the questionnaire may be ignored, which could result in low response rates. Furthermore, a truly blind online survey is difficult to achieve. To address this issue, participant identification was removed during the data analysis. The only exception was for those teachers who indicated that they would answer the survey questions in a phone interview and those who wished to join in a door prize drawing as a reward for their contributions.

Another common limitation to this type of study involves the disparity of participants' access to computers. Usually, individuals without access to computers represent those from lower socioeconomic or education levels (Madden 2006; Greene, Speizer, and Wiitala 2008). In this study, all educators had access to the Internet. The Internet presents a final potential challenge; specifically, the lack of a list of email addresses from which to form a sampling frame (Fricker and Schonlau 2002; Greene, Speizer, and Wiitala 2008). The Alliance Coordinators used in this study controlled access to the contact information for their members; therefore, the lack of email addresses was not an issue.

In the qualitative phase of this study, participants were asked to volunteer for telephone interviews. The phone interviews were designed to 1) determine pedagogical strategies, if any, that teachers learn regarding the incorporation of GST into geography instruction; 2) determine whether these technologies are valued as pedagogical enhancements when teaching geography; and 3) reveal insight from participants about their colleagues' uses of GST.

Volunteer surveys or interviews may be biased in that participants have vested interests and might have hidden agendas. For example, teachers could feel disenfranchised regarding their abilities to influence their access to and inclusion of GST in their classrooms. Additionally, volunteers might have included only those teachers who have used these technologies, as others who have not used these technologies might have been concerned that no one would be interested in what they had to contribute. However, it would not harm the study if only those who used GST responded.

Identifying GST training as a deciding influential factor might be a limitation to this study. In fact, formal or informal training of various technologies might not be a major influencing factor on the development of geography teachers' knowledge. In this case, the results of the survey and telephone interviews indicated other factors for consideration. Finally, as the survey announcement was sent to Alliance listservs in five states, some participants might have fallen outside the scope of this study. Only high school geography teacher responses were included in the data analysis.

Situated within the Literature

Geospatial Technologies: Instructional Technologies for the Discipline of Geography

Bednarz and Bednarz (2008) stated, "Spatial thinking is crucial to the discipline of geography" (253). Geographers look for relationships about, with, or in space, and assess their meanings to explain a given situation or to predict outcomes. Thus, thinking spatially underpins geographic cognition. Unfortunately, students may spend more time memorizing facts and much less time thinking geographically. In other words, students spend less time analyzing situations spatially, including making observations, hypothesizing, and evaluating data critically (Gersmehl 2008). To assist in this type of cognition and learning, spatial tools are needed.

According to Gersmehl (2008), these spatial tools include "maps, graphic information systems (GIS), remote sensing, and other technologies for displaying and analyzing spatial data" (vii). Researchers have recognized spatial thinking as a group of cognitive skills facilitated by tools such as GIS, GPS, and remote sensing (NRC 2006; Oberle, Joseph, and May 2010). These tools have been termed GST, which is in keeping with Bednarz and Bednarz (2008) who referred to these technologies as "Geographic Information Systems (GIS) that include its supporting science, geographic information science (GIScience), and related spatial visualization tools such as remote sensing (RS)" (249).

Geospatial technologies enable teachers to prepare knowledgeable, critically thinking 21st-century students. Additionally, these technologies are viable tools "for involving students in spatial analysis and the study of places and regions" (Meyer et al. 1999, 571). Specifically, technologies such as GIS, help students solve real-world problems by engaging in data-driven inquiry as explained in various studies and guidelines, including the 1) NRC standards (1996); 2) Benchmarks for Science Literacy (American Association for the Advancement of Science [AAAS] 1993); 3) National Educational Technology Standards (International Society for Technology in Education 2000); 4) National Geography Standards (Boehm and Bednarz 1994); and, 5) the Partnership for 21st Century Skills (2008) report.

With GIS software, students can explore data about a place and engage actively in higher order thinking to solve problems and predict outcomes. Valued as an appropriate tool for high school students, as well as students in other grades, GST assist in developing "logical thinking abilities and understanding spatial relations" (Wigglesworth 2003, 28). As early as 1999, Hill and Solem stated that advances in computer technology have created a "new frontier in geography education" (100), and the geography education community needs to be ready to meet the challenges presented with these advances. Geospatial technologies are instructional tools for the geography discipline. Now is the time for further analysis of GST implementation in high school geography instruction.

Lee and Wizenreid (2009) recognized Cuban's (1986) definition of *instructional technology* as one of the best in the field. Instructional technologies pertain to

> Any device available to teachers for use in instructing students in a more efficient and stimulating manner than the sole use of the teacher's voice. Hardware and software, the tools themselves, and the information these tools convey define the technology (4).

This definition is used throughout this paper to describe instructional technologies.

According to Mishra and Koehler (2006), for sustained technology use by an educator to occur, he or she must secure technological, pedagogical, and content knowledge sets regarding the technology. The teacher must understand how a specific technology applies to his or her discipline and know teaching strategies and best practices to use these technologies appropriately as instructional tools. However, the problem remains that geography educators have not largely adopted GST in the classroom (Kerski 2003; Baker 2005; White 2008). The reason for this lack of use in the classroom may stem from educators' understanding of these technologies as instructional tools and the depth of their TPCK.

The world has gone through a rapid evolution, one could even say revolution, of online and mobile technologies over the last decade and a half. Thus, the United States needs a “fresh approach to public education” (The Partnership for 21st Century Skills 2008, 1), especially in geography education. Shelley (1999) cautioned geographers, “Education itself is undergoing profound change,” and stated that it is the professional geography community’s responsibility to develop and implement “an agenda of high-quality basic research on teaching and learning in geography” (592). In line with Nellis (1994), Hill and Solem (1999) stated that computer technology is changing geography education. Further, Meyer et al. (1999) explained the change in K-12 education by highlighting the increased use of and focus on technology, a sentiment that resonates with geographers who want to ensure the quality of geographic learning.

Today, teachers have a new responsibility; they must help young people understand the data on which maps depend so they can discover and comprehend the hidden relationships, patterns, and trends that exist within such maps (Wiegand 2006). Understanding the underlying data is also practical for students to evaluate maps critically. From a basic navigation exercise to evaluating an emergency response route given a set of criteria, students who use GST learn to be analytical, question data sources, and not take data—and, thus, maps—at face value.

Geospatial technologies afford teachers the wherewithal to create effective learning environments. Furthermore, since the advent of the Internet, the explosion of new Web 2.0 applications, and the evolution of mobile devices capable of robust functions, educators have an array of technologies available to them that require little or no software or memory space on their computers (Bull, Hammond, and Ferster 2008;

Unwin et al. 2012). Another advantage of learning to use GST is the growing rate of job opportunities in this area, which is outpacing the ability to fill these jobs. The American government, education leadership, school officials, professional associations, and other key stakeholders in academia must work to ensure that teachers are equipped with the appropriate training and support to educate young citizens in the twenty-first century.

Unprecedented Support: U.S. Government Funded Technologies

The advent of computers in education fundamentally changed the use of instructional technology, and computers were no longer used merely to support instruction. Technology has quickly become the expected tool to equip students with the knowledge and skills they need both personally and professionally to succeed in the twenty-first century. According to Lemke and Coughlin (1998), the key element for teachers is to produce authentic learning experiences by applying technologies to extend a student's intellectual capabilities within the respective discipline. For example, assignments in an English class should expand computer use from its word processing function to writing papers, to performing various functions such as gathering and verifying data, finding images, engaging experts, working across platforms and networks, etc. (Lemke and Coughlin 1998). In other words, technology can no longer be used only for simplistic tasks or in a supportive role. Rather, tasks must mirror what students encounter in real-world settings. Therefore, teachers must build a myriad set of skills that can be translated in various settings to address multiple content areas and demands.

Since the introduction of computers, the federal government has devoted significant funding and pushed a national agenda to equip schools with technology (EdWeek 1997; Lemke and Coughlin 1998; Culp, Honey, and Mandinach 2005). Reports in the 1990s, such as the Milken Exchange on Education Technology (Lemke and Coughlin 1998); the Internet Access in U.S. Public Schools and Classrooms: 1994–2005 (Wells and Lewis 2006); and the DOE (2004, 2010) NETP report have documented that U.S. schools lack sophisticated uses of technology. Reports in the 1990s and early 2000s were unique in that students would "face significantly different and more complex challenges and opportunities than previous generations" (Lemke and Coughlin 1998, 15) as they prepare to be a part of the twenty-first-century economy in which technology knowledge and skills are essential (DOE 2004; Wells and Lewis 2006; DOE 2010). This realization began the unprecedented support for technology in education (EdWeek 1997; Lemke and Coughlin 1998).

Because of support from the federal government and industry, the technology infrastructure increased dramatically in schools. Federal reports provide evidence of such change. For example, Wells and Lewis (2006) conducted an annual study through the NCES that "gauge[d] the changes in computer and Internet availability" (1) in schools nationwide. This report addressed other emerging issues such as "the use of Internet access to provide various opportunities and information for teaching and learning" (1). Additionally, the report illustrated a picture of growth of technological offerings and use in U.S. public schools. For example, from 1994 to 2005, the student-computer ratio increased from an average of 12:1 in 1994 to 3.8:1 in 2005. Access to high-speed, broadband Internet nearly tripled from 34 percent of schools in 1994 to 97 percent in 2005 (Wells and Lewis 2006). High-speed Internet refers to "access [to] the Internet and Internet related services at significantly higher speeds than those available through 'dial-up' Internet access services" (DOE 2009, 9).

From 2005–2010, nearly 100 percent of public schools nationwide had Internet access (DOE 2004; Wells and Lewis 2006; DOE 2009; Gray, Thomas, and Lewis 2010a). Availability of wireless internet connections also increased; 23 percent of schools reported wireless connections in 2003 and 45 percent in 2005. Gray, Thomas, and Lewis (2010a) stated that 88 percent of public schools had wireless connections in all or in part of their campuses. Laying the foundation to equip schools with the ability to provide a technologically enhanced education and the staunch support of the federal government has continued over the past two decades.

Learners of a New Era

Since the early 1980s, labels for learners have exemplified reliance on technology and seamless engagement in the digital world. Some labels include the Millennials, Net Generation, Generation Y, digital natives, and the Google generation (Tapscott 1998; Howe and Strauss 2000; Prensky 2001; CIBER 2008; Creanor and Tinder 2010; Dziuban et al. 2010; Hardy and Jefferies 2010). Learners in the new era are like no other (Oblinger and Oblinger 2005; De Freitas and Conole 2010), and teachers and other key stakeholders must understand these learners and learning environments to support and prepare students in the twenty-first century.

Post-1980s learners have grown up in a time when information has been free, fast, abundant, and available through a variety of sources (De Freitas and Conole 2010). Such information is not always provided by experts, and it can be transmitted instantaneously through texts, microblogs (e.g., Twitter), social media (e.g., Facebook), blogs, and instant messaging. Young people today use a suite of digital tools to meet their information needs. Additionally, many of their interactions with these technologies are sporadic because of multi-tasking and multi-communicating, which cause their minds to shift topics, settings, and thought processes constantly (De Freitas and Conole 2010). Today's students are not only digitally literate, they are also fluent in a language that is second to most educators. Furthermore, they expect technology to change and expect that they will have the wherewithal to embrace new technologies.

Much speculation exists as to how the new digital environment directly changes students' expectations and academic outcomes (Brown 2000; Prensky 2001; Creanor and Trinder 2010). Some researchers have described these students as resourceful, resilient, collaborative, independent, graphically oriented, active, cynical, questioning, opinionated, technologically skilled, willing to experiment online, skilled with multi-modal communication, and flexible as they seek information using multiple strategies (Tapscott 1998; Prensky 2001; Howe and Strauss 2000; Higgins et al. 2005; Twenge 2006; De Freitas and Conole 2010; Dziuban et al. 2010; Sharpe and Beetham 2010). However, teaching these learners is challenging because of their short attention spans and eagerness to forge forward in the world of technology to seek answers rather than focus fully on the teacher.

Preparing Students for the Future

Today, technology skills for learners are essential. Teachers need to guide students, often times in the role of facilitator, to prepare them to face the expectations of the twenty-first-century workforce. To develop these skills, students and their teachers need to be digitally literate. *Digital literacy*, a growing popular concept, refers to "how effective learners work with information and knowledge" (Beetham and Oliver 2010, 155; see also Martin and Grudziecki 2006; Lea 2009). Beetham and Oliver (2010) described information and digital literacy as requirements of learners in the Digital Information Age. Specifically, *information literacy* is the "most widely recognized and defined capacities" of twenty-first-century learners and is the ability "to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information" (Beetham and Oliver 2010, 156; see also Spritzer, Eisenberg, and Lowe 1998; CILIP 2005). Digital literacy is also a "highly relevant term for exploring learners' experiences of learning, and the directions in which learning may evolve in the near future" (Beetham and Oliver 2010, 157). Interestingly, in Europe, digital literacy is being required more for future citizens and economic growth and is defined as more than having technical skills to include critical thinking, judgment, and other forms of literacy that require higher levels of analysis (European Commission [EC] 2009; Beetham and Oliver 2010). In terms of this dissertation, digital literacy refers to the ability to use technologies appropriately to facilitate higher order thinking and analysis of various issues and situations.

Many teachers in the Digital Information Age were born before the commencement of this era. Therefore, teachers can no longer learn to use these technologies alongside students; rather, they need to be knowledgeable about these technologies before they enter the classroom. Teachers need to be taught what it means to be a twenty-first-century educator. However, few federal reports have focused on the needs of effective educators who can prepare their students successfully. Existing reports have described available technologies and training opportunities for teachers, demanded innovative learning environments, and recognized the lack of teacher knowledge regarding modern technologies. However, little guidance exists for teachers and teacher preparation programs that explain how to transform existing educators into savvy teachers who are well-equipped to groom students for the future. Therefore, teachers must be prepared to evolve with the culture of the Digital Information Age.

History and Use of Geospatial Technologies in American Education

As evidenced by the history of instructional technologies in the classroom, many digital tools that have shaped the present and that will continue to shape the future were developed in the mid-1990s with the most influential technologies evolving over the last few years. These advances also influenced the development of GST. Geospatial technologies emerged with the advent of GIS and remotely sensed images; soon thereafter came the use of GPS. Like most instructional technologies, GST were born either in the military or business sectors, and were later adapted into education.

Geospatial technologies have traditionally been referred to as GIS, remote sensors, and GPS (Brunn, Cutter, and Harrington 2004; Baker 2005; Oberle, Joseph, and May 2010) and include all online variations of these technologies such as virtual globes, GIS-based applications (e.g., the United States Geological Survey (USGS) mapping tool, National Atlas), and online GIS applications that are similar to their desktop software counterparts. Although data layers for analysis have been in use since the 1920s, the military and business sectors have used GIS since the early 1960s when mainframe computers became more readily available (Clarke 2011).

By 1974, the International Geographical Union published a mapping software inventory, the Complete Geographical Information Systems, and GIS was accepted as the generic term for software that allowed data layers and data queries to analyze relationships, patterns, and distributions (Clarke 2011). After the advent of personal computers by Apple and IBM in the late 1970s and early 1980s, respectively, GIS use and development increased dramatically. Now, smaller GIS companies abound and a more widespread global GIS audience exists (Clarke 2011).

As educational technology infrastructures mature, K-12 educators have begun to take notice and software packages have become more readily available. However, by the end of the 1990s, less than two percent of secondary teachers used GIS in the classroom (Kerski 2003). This fact is understandable given the historical patterns of instructional technology implementation in schools that introduce new technologies into K-12 education at least a decade or more following the debut of these innovations into mainstream society.

Lee and Wizenreid (2009) supported Cuban (1986) who repeatedly proclaimed how slow the school system is to change, especially when it comes to adopting new technologies. These researchers noted that it could take another ten years or more following the release of technology before widespread use is seen in K-12 schools. In all fairness, when GIS software was released for public use, the technology was still too new and evolving too quickly for teachers to see its value and understand how to incorporate it into their daily curricula. As the 1980s and 1990s saw an increase in the use and attention of desktop GIS, the world was introduced to the World Wide Web.

The conditions for GIS software and other GST use in schools improved with the dawn of Internet-based GIS (Baker 2005; Milson and Earle 2007; Kerski 2008; Milson and Kerski 2012). During this time, GIS applications were revolutionized to keep up with the new online demands. Key government agencies, such as the USGS and the Census Bureau, offered data and digital interactive mapping online. Digital maps, such as

MapQuest, quickly made mapping more popular. By the beginning of the twenty-first century, online GST became commonplace to the average citizen (Clarke 2011).

The arrival of mobile devices added to the need for advances in GIS software and other related technologies as the demand for “geo-anything” increased (Johnson, Levine, and Smith 2009). Thus, a new era for geographic technologies began in large part from the growth of personal computers and the Internet. Today, GST are no longer only for the military, business, or educational sectors; they are woven into the very fabric of citizens’ personal lives in the digital Informational Age.

Teachers have used remotely sensed images since they were made available to the public. Initial images were aerial photographs taken by airplanes, while, more recently, pictures tend to come from airplanes, satellites, the space shuttle, and the international space station using a variety of online sites (e.g., NASA’s Earth Observatory). Increasingly, students are required to analyze data and images from different sources. For example, in Texas, a new high-stakes test in geography, the World Geography End of Course exam, uses remotely sensed images, a 20-year-old technique, as one way to assess students’ abilities to analyze and understand geographic data. Now that computer technology has evolved to support digital images, educators can more readily use and incorporate remote sensing images into their instruction.

Use of GPS has also increased because of recent advances in technology. This technology has changed from hand-held devices that were used by a few to being part of daily life with this technology in cars and cell phones. For example, smart phone apps allow individuals to mark where their car is located in a parking lot so they can find their way back to it later in the day. Some apps even allow one to find friends through the GPS in their phones. A map of the world displays where they are located using social networks, such as Facebook, and individuals can mark where they are for friends to see. More importantly, remotely sensed images and GPS are now integrated fully into GIS software, so these technologies can be used simultaneously to allow for robust data analyses (Clarke 2011).

Pioneering educators in science and geography used GST in schools during its infancy in the late 1980s and 1990s (Kerski 2003; Milson and Kerski 2012). These early innovators saw the value of developing an inquiry-rich, exploratory learning environment where learners collaborated as they analyzed data. Teachers shared their successes at state and national conferences, such as the National Science Teachers Association (NSTA), the International Society for Technology Education (ISTE), and the National Conference for Geographic Education (Baker 2005).

As teachers saw evidence that GST can work in the classroom, more educators were willing to try these technologies. Today, the use of GIS software continues to increase in geography education. Science educators remain the primary users of GIS in classroom instruction (Milson and Kerski 2012). While, GST are not required in the curricula of most states, a growing cadre of innovative educators are applying these technologies in their classrooms (Gatrell 2001; Milson and Roberts 2008; Milson and Kerski 2012).

The New Millennium and the Adoption of GST in Education

To capture the influence of the growing interest in technology in geography classrooms, Kerski's dissertation in the 1990s, which was later published in 2000 and 2003, measured the use of GIS among high school teachers. He administered a national

33-item survey to 1,520 high school educators who had purchased a GIS personally or via their schools (Kerski 2000, 2003). This seminal study was the first to measure the use of this technology at this scale. Kerski (2000, 2003) reported a slow rate of diffusion of GIS in secondary geography education, and noted that less than two percent of American high school teachers had adopted GIS as a tool for instruction.

White (2008) also found that K-12 educators were slow to accept geospatial technologies in the classroom. Both Kerski (2000, 2003) and White explained the diffusion of GIS as an instructional technology by applying Rogers' (1995, 2003) Diffusion of Innovations theoretical framework. In doing so, these researchers established the framework as a legitimate lens to evaluate the diffusion of GST. They also determined that changes in digital technologies and the virtual world could influence GST diffusion.

Since Kerski's (2000) study, many low- to high-tech geospatial applications have become available on the Internet, which is now available in nearly all schools nationwide (DOE 2004; Fuhrmann et al. 2005; White 2008; DOE 2010; Gray, Thomas, and Lewis 2010a). Additionally, many students and teachers alike own smart phones that offer instant access to various technologies. Because of the availability and global use of GST, secondary educators need to do a better job of embracing their value to remain competitive with world markets.

Geospatial Technologies: Diffusion and Barriers to Use

Even though there is a clarion call for change in American secondary geography education, the diffusion of GST has been very slow (Nellis 1994; Audet and Paris 1997; Bednarz and Audet 1999; Donaldson 2000; Kerski 2000, 2003; Wigglesworth 2003;

Baker 2005; NRC 2006; White 2008). Historically, the absence of these technologies may have resulted because of the undeniable barriers of GIS software and other geospatial technological applications in the classroom. These barriers include the following: limited GST awareness; prohibitive costs; limited availability of hardware and software; inconsistent access to computers; limited availability of pre-processed data; little or no technical support; lack of training, teacher collaboration, and lesson planning time; disproportionate demands on teachers' time; limited instructional support; and lack of pedagogy, instruction, and assessment strategies regarding GST (Meyer et al. 1999; Kerski 2003; McClurg and Buss 2007; Bednarz and Bednarz 2008).

Common GST training consists of imparting technology knowledge with very little pedagogy, as evidenced by the number of educators who teach about these technologies rather than those who teach with these technologies (Kerski 2003; Baker 2005; White 2008). However, educators teach the way they were taught (Frank 1990; Barnhart, Brooks, and Etkina 2003; Kerski 2003). Therefore, training needs to include not only technical aspects, but also appropriate pedagogical techniques for these technologies within the context of a discipline (e.g., geography). These barriers mirror challenges traditionally found with the implementation of general instructional technologies and stem from a lack of resources, effective technology training, and knowledge of appropriate ways to teach using available technologies.

Justification for this Study

Kerski (2000) and White (2008) addressed the adoption rate of GST within secondary education. Kerski (2000) provided a baseline for GST adoption in secondary education, which served as a basis for comparison in this research. Technology and the virtual community have experienced a phenomenal evolution since the birth of the new millennium. Kerski (2000) focused on secondary educators who owned geographic information system software in the 1990s. His investigation included educators who engaged technology in varying degrees and who exhibited characteristics that reflected a willingness to accept and integrate innovative ways to teach geography. Kerski suggested that these teachers may be more willing to accept and integrate GST into their geography education curricula with the influx of easy-to-use applications on the Internet and the decreased need to learn specific software programs. Geography education (Table 1.1) includes both stand-alone geography and social studies courses with a strong geography component for most states in the United States.

No previous study has measured the progression of GST in the classroom on a national scale since Kerski in the late 1990s. Therefore, the present investigation analyzed the use of GIS and new GST that encompassed visualization and GIS-based tools by high school geography teachers. This research contributes to the body of literature concerning the place of GST in high school geography education in the twenty-first century. Further, Kerski's (2000) study did not address online GST applications or mobile technologies because they were just entering the scene at the time of his study. Thus, this study captured new information because of the explosion of Web 2.0 applications on the Internet over the past ten years.

Similar to Kerski (2000) and White (2008), the current study also applied Rogers' (1995, 2003) Diffusion of Innovations framework to evaluate the current progression of desktop and online GST in high school geography instruction. The results from the study add to the literature by extending the current understanding of GST diffusion. Because of a paucity of research on the influence of training for GST in K-12 geography education regarding TPCK, the findings from this study fill gaps in this area as well.

Because of the exceptionally fast evolution of the Internet and Web 2.0 tools and the growth and acceptance of GST personally and professionally, the world has changed significantly since Kerski's (2000) study on the use of GIS software in secondary education. For example, national and state governments in the United States have worked to ensure computers and the Internet are available to all students (NETP 2010). To plan for future educational and professional development adequately, an update of the assessment of the diffusion of GST in K-12 education was timely and necessary.

It was imperative that this study not only ascertained GST use among teachers, but also determined factors that spur geography teachers' past impediments and barriers to seeking opportunities to incorporate these technologies into their learning environments. Addressing this new, but vital, angle offered insight into whether teachers with more exposure to GST and pedagogical strategies for implementation, through training and other experiences, were more likely to engage these technologies frequently as instructional tools in geography classrooms.

Further, it was not enough to assess only patterns of use, but it was also necessary to understand why certain teachers have been more successful in integrating GST into their classrooms. Therefore, participant data analysis provided information to clarify the profiles for different stages of the Innovation-Decision Process to better comprehend the needs of geography teachers as they interacted with and decided whether to use these tools.

Definitions

Table 1.1 Definitions of Terms

Term	Definition
Compatibility	The "degree to which [technology] is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (Rogers 2003, 240).
Complexity	The "degree to which an innovation is perceived as relatively difficulty to understand and use" (Rogers 2003, 257).
Content Knowledge (CK)	A thorough understanding of one's discipline (Shulman 1986).
Confirmation Stage	The stage "when an individual seeks reinforcement of an innovation decision already made" (Rogers 2003, 169).
Decision Stage	The stage when individuals engage "in activities that lead to a choice to adopt or reject the innovation" (Rogers 2003, 169).
Diffusion	"The process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 2003, 5).
Digital Information Age	A period of significant growth in computing capacity, the prevalence of various forms of digital tools and application, the dramatic growth and demand for information processing and information-based industries, and the rapidly evolving online applications and trends (Lindeman and Vastag 2011).
Digital Literacy	The effectiveness of "learners [to] work with information and knowledge" (Beetham and Oliver 2010, 155).

Table 1.1. Continued.

Term	Definition
Digital Native	A person who belongs to "the first generation raised using technology" and who is typically "consumed with (or immersed in) technology outside the classroom and want the same in school" (Rosen 2010, 172, 24).
Early Adopters	Individuals who accept an idea relatively early in the process, but who are well integrated into a system and play a vital role in the diffusion of an innovation. These individuals are also well-respected opinion leaders and role models who are expected to tryout and evaluate new technologies while working through the challenges and risks of implementing these innovations (Rogers 2003, 283).
Early Majority	Individuals who provide links and "interconnectedness in the system's interpersonal networks" (Rogers 2003, 284), although they are not opinion leaders.
Geography Education	The teaching and learning about relationships between and among places, cultures, and physical systems within or between regions that can be taught in standalone geography courses or within geography strands in the social studies discipline.
Geospatial Technologies (GST)	"Geographic information systems (GIS), [and] its supporting science, geographic information science (GIScience), and related spatial visualization tools such as remote sensing (RS)" (Bednarz and Bednarz 2008, 249).
High-Speed Internet	"Access [to] the Internet and Internet related services at significantly higher speeds than those available through 'dial-up' Internet access services" (DOE 2009, 9).
Implementation Stage	The stage when the "individual puts a new idea into use" (Rogers 2003, 169).

Table 1.1. Continued.

Term	Definition
Information Literacy	The "most widely recognized and defined capacities" of twenty-first-century learners. Individuals have"[the ability] to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information" (Beetham and Oliver 2010, 156).
Innovation	"An idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers 2003, 12).
Innovation-Decision Process	Time-ordered, sequential "process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to formulating an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision" (Rogers 2003, 171).
Instructional Technologies	"Any device available to teachers for use in instructing students in a more efficient and stimulating manner than the sole use of the teacher's voice. Hardware and software, the tool itself, and the information the tool conveys define the technology" (Cuban 1986, 4).
Knowledge Stage	The stage when an individual is made aware of the existence of the innovation initially "and gains an understanding of how it functions" (Rogers 2003, 169).
Laggard	Individuals who are the last to change, who make decisions based on "what has always been done," and who are suspicious of change and those who bring change (Rogers 2003, 284).
Late Majority	Individuals who are cautious, skeptical, and slow to adopt an innovation and may do so under duress from others in the system (Rogers 2003).

Table 1.1. Continued.

Term	Definition
The Network of Alliances for Geographic Education	"The Network of Alliances for Geographic Education is a group of educators united to support geographic literacy. Alliances are partnerships between university faculty and K-12 educators. These state-based organizations connect educators, provide world-class professional development and promote educational innovation at the state, district, and local levels. Since 1986, National Geographic and the Alliance Network have worked to catalyze 'geo-education' reform across the United States, District of Columbia, Canada and Puerto Rico" (National Geographic Society 2014, para. 1). Also referred to as State Geographic Alliances or Alliances.
Observability	The evaluation of consequences of the innovation to determine whether an individual wants to adopt it (Rogers 2003).
Pedagogical Knowledge (PK)	The understanding of different strategies to teach a wide array of learners in a given classroom (Shulman 1986).
Pedagogical Content Knowledge (PCK)	The understanding of pedagogical strategies specific to a certain discipline (Mishra and Koehler 2006).
Persuasion Stage	The stage when "a favorable or an unfavorable attitude toward the innovation" (Rogers 2003, 169) is develops.
Rogers' Diffusion of Innovations Theoretical Research	A theoretical model that explains the processes and rates at which a population adopts an innovation and includes the internal and external factors that influence the decision-making process (Rogers 2003).
Relative Advantage	The "degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers 2003, 229).

Table 1.1. Continued.

Term	Definition
Technology Knowledge (TK)	General knowledge of technology that can be used to teach any subject matter (Mishra and Koehler 2006).
Technology Content Knowledge (TCK)	The knowledge of technology that relates to a specific discipline (Mishra and Koehler 2006).
Technological Pedagogical Knowledge (TPK)	The "knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies" (Mishra and Koehler 2006, 1028).
Technological Pedagogical Content Knowledge (TPCK)	The knowledge of "what technology is best to teach specific content and how to implement that technology so all students learn" (Bednarz and Bednarz 2008, 262).
Triability	An individual's ability to try out the innovation on a limited basis (Rogers 2003, 258).
Web 2.0	Online applications that make it possible for users to create and share information with multiple "communities of users, resulting in various forms of user-driven communications, collaborations, and content (re)creation" (Facer and Selwyn 2010, 32).

CHAPTER II

LITERATURE REVIEW

Two frameworks further the understanding of high school geography teachers' decisions to use geospatial technologies (GST) as pedagogical enhancements: Rogers' (2003) Diffusion of Innovation and Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPCK). Although originally used to explore decisions to adopt new agriculture technologies, since the 1960s, many researchers have used Rogers' (2003) Diffusion of Innovation framework to comprehend how and why a given population accepts an innovation. In education, researchers have applied Rogers' (2003) framework to aid in the diffusion of a variety of innovations for education communities such as K-12 education, higher education, and counseling (Berger 2005; Jacobsen 1997; Sahin 2012). This framework also aids in understanding the GST adoption progression among high school geography teachers (Kerski 2000; White 2008).

The second framework used in this study is Mishra and Koehler's (2006) TPCK, which allows further exploration of teachers' decisions to accept and use GST as instructional technologies. The TPCK framework was designed to explain teachers' levels of knowledge and understand their abilities or willingness to use technology in certain educational situations. Evolving from Shulman's (1986) research on content and pedagogical knowledge in teacher preparation, Mishra and Koehler (2006) included technological knowledge to reflect education in the new millennium.

Setting the Stage: Assessing Geospatial Technologies Awareness and Use

White (2008) suggested that the Internet could provide the vehicle to diffuse GST into K-12 education. Dynarski et al. (2007) suggested that Web 2.0 applications allow the flexibility to incorporate technology productively in the learning environment. Rogers' (2003) Diffusion of Innovations framework, a combination of adoption and diffusion theory, was applied to the data analysis in the current study to provide a lens to examine the progress of GST diffusion among high school geography educators.

According to Straub (2009), adoption theory describes individuals and their choices to accept or reject an innovation. In contrast, diffusion theory explains the spread of an innovation and measures individuals' behavioral changes. To illustrate the combination of these two concepts, Rogers (2003) proposed the Innovation-Decision Process, a model within the Diffusion of Innovation framework, to illustrate the manner in which a population adopts an innovation.

In the current study, this model was used to analyze the progression of GST in high school geographic instruction. A brief explanation of Rogers' (2003) terms for the diffusion of an innovation and the Innovation-Decision Process is necessary to provide background knowledge on the characteristics of different types of adopters, influences on decision-making, and processes for accepting or rejecting an innovation. These descriptions applied to participants in the current study to understand the adoption process of GST among high school geography teachers.

Understanding Types of GST Adopters

Understanding behaviors can help predict how individuals accept or reject innovations (Straub 2009). Rogers (2003) asserted that those who accepted an innovation could be placed into one of five categories: *Innovators*, *Early Adopters*, *Early Majority*, *Late Majority*, and *Laggards* (Figure 2.1). Rogers based the criterion for each category on the degree to which an individual adopted a new idea or technology compared to other members of his or her social system.

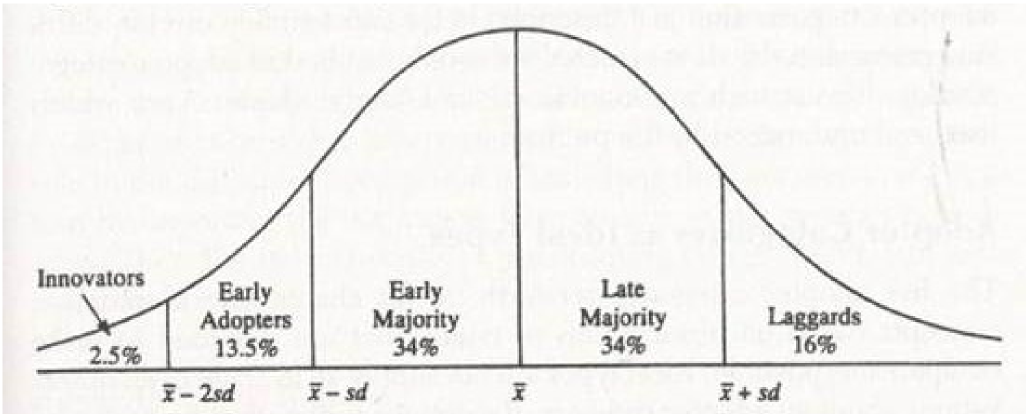


Figure 2.1. Adopter categorization based on innovativeness. Source: Rogers (2003)

According to Rogers (2003), Innovators make up 2.5 percent of the population, serve as gatekeepers, and launch innovations into an existing system. These individuals believe in the potential of new technologies, are vitalized by new ideas, and seek other like-minded individuals who accept a high degree of risk or uncertainty and setbacks when adopting an innovation (Rogers 2003). Early Adopters make up 13.5 percent of the population and are well-respected opinion leaders and role models who vet and evaluate new technologies while working through the challenges and risks of implementing the innovation (Rogers 2003). These individuals accept an idea relatively early in the process and play a vital role in the diffusion of that innovation. Innovators and Early Adopters represent a very influential 16 percent of the population positioned at the forefront of change.

The overwhelming majority of the population forms the final three categories of adopters. The Early Majority and Late Majority each represent 34 percent of the population, while the Laggards make up 16 percent. Individuals in the Early Majority category adopt an innovation thoughtfully and deliberately. Although members of these groups are not opinion leaders, they do provide links and "interconnectedness in the system's interpersonal networks" (Rogers 2003, 284). The Late Majority includes individuals who are cautious, skeptical, and slow to adopt an innovation; members of this group may only do so under duress from others within the system (Rogers 2003). For this study, the term *majority* refers to the combination of Early Majority and Late Majority populations. Finally, Laggards make decisions based on "what has always been done" (Rogers 2003, 284) and are suspicious of change and those who bring change. Combined, these three groups represent 84 percent of the population who is tied to cultural norms and slower to change than the 16 percent who represent Innovators and Early Adopters.

Deciding Factors for GST Adoption

Individuals will adopt an innovation after they have evaluated its *relative advantage*, *compatibility*, *complexity*, *triability*, and *observability* (Rogers 2003). The "relative advantage is the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers 2003, 229). Rogers proposed that a community accepts an innovation depending on its compatibility, or the "degree to which [it] is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (240).

Cuban (1986) also discussed the idea of compatibility by stating that change is slow in the education community. However, if an innovation could be included easily in teachers' daily tasks, it would be more readily accepted. Cuban (1986) also emphasized the need for an innovation to be relatively easy to use. Lee and Wizenreid (2009) supported this idea; for example, teachers quickly adopted the innovation of the chalkboard, and it remains in use today. The next element is complexity, which "is the degree to which an innovation is perceived as relatively difficulty to understand and use" (Rogers 2003, 257).

Educators want to incorporate an innovation easily (triability) and observe its benefits in teaching and learning (observability). Rogers (2003) referred to triability as the individual's ability to try out an innovation on a limited basis. Further, he defined observability as the opportunity to evaluate the consequences of an innovation and to determine whether to adopt the technology. According to Straub (2009), Rogers' work is arguably "the most influential…in the area of understanding how an innovation infiltrates a population (or not)" (629). Additionally, Cuban (1986) stated, "Teachers are gatekeepers for instructional technology. Teachers must open the classroom door" (37). Thus, understanding the process whereby a geography educator makes a decision to accept or decline GST is imperative to aiding the diffusion of these technologies into high school geography classrooms.

Rogers' (2003) Innovation-Decision Process

Rogers (2003) referred to the process of deciding to accept or reject an innovation as the Innovation-Decision Process. This model, as shown in Figure 2.2, illustrates the "information-seeking and information-processing activity in which an individual obtains information in order to decrease uncertainty about the innovation" (Rogers 2003, 21). In this model, the individual moves from the "initial knowledge of an innovation, to forming an attitude toward the innovation, to making a decision to adopt or reject, to implementation of the new ideas, and to confirmation of this decision" (Rogers 2003, 168). Although an individual forms basic awareness when introduced to an innovation, he or she constantly gathers and uses information (knowledge) to refine attitudes, decisions, and actions. This cycle consists of various iterations of choices and actions coupled with ongoing practices and evaluations of those choices and actions. Ultimately, an individual determines whether a new idea or action is an alternative to the former idea or action. A distinct part of moving through these phases involves addressing the uncertainty associated the innovation. Rogers (2003) also noted that the steps, or stages, of the Innovation-Decision Process “usually occur in a time-ordered sequence” (21).

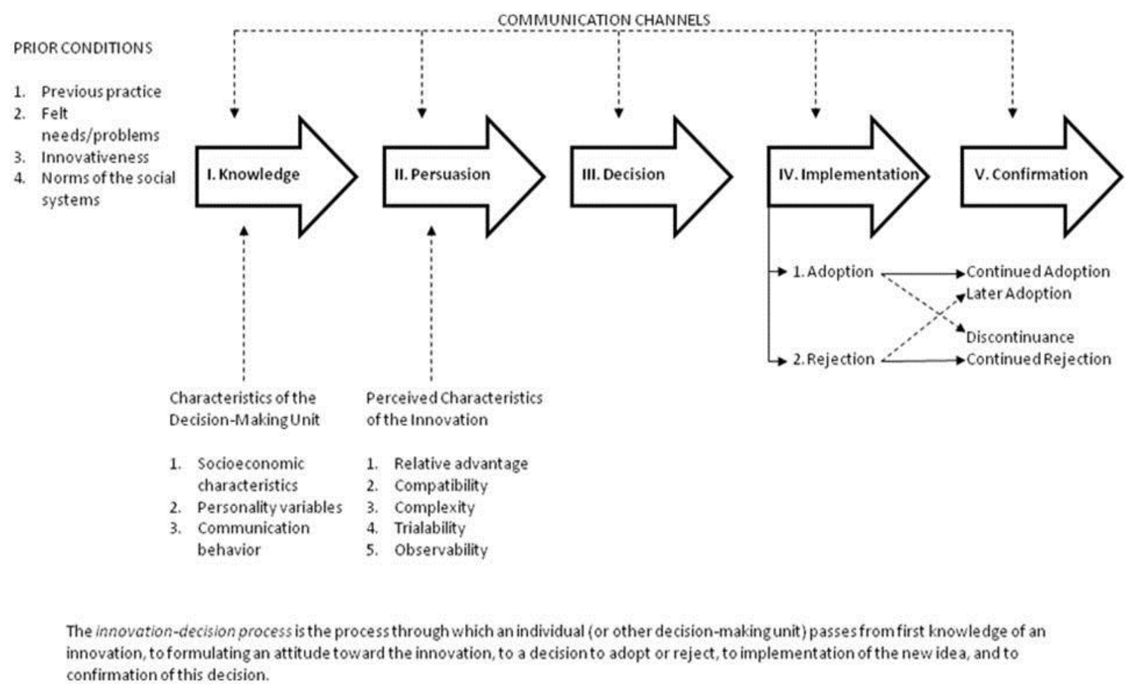


Figure 2.2. Rogers’ (2003) Innovation-Decision Process Model. Source: Rogers (2003, 170)

Although Rogers explained the Innovation-Decision Process as stages (or phases), which he purported were consistent with findings of other diffusion researchers, individuals progress at their own pace over time. Specifically, the Innovation-Decision Process consists of five stages: *Knowledge*, *Persuasion*, *Decision*, *Implementation*, and *Confirmation*. This model sheds some light on geography educators’ decisions on the acceptance and use of GST in high school geography education, which, in turn, can inform policy makers, key education decision makers, pre-service educators, and professional development designers of new inroads for this situation.

The Knowledge Stage occurs when the individual is made aware of the existence of the innovation, “and [then] gains an understanding of how it functions” (Rogers 2003, 169). The Persuasion Stage transpires when an individual “forms a favorable or an unfavorable attitude toward the innovation” (169). The Decision Stage includes individuals engaging “in activities that lead to a choice to adopt or reject the” new technology (169). This stage leads to the Implementation Stage, which occurs when the “individual puts a new idea into use” (169). Finally, the Confirmation Stage occurs “when an individual seeks reinforcement of an innovation-decision already made” (169). Although it is possible that an individual changes his or her mind after receiving conflicting messages regarding an innovation, most individuals who reach the final stage confirm their decisions to use the innovation.

For clarification and support, Rogers (2003) compared his five stages of the Innovation-Decision Process with McGuire’s (1989) Hierarchy of Effects and Prochaska’s Stages of Change (Prochaska, DiClemente, and Norcross 1992) (Table 2.1). In the current study, Table 2.1 was used as a guide to determine participants’ acceptance of GST as tools for instruction. Throughout this document, when describing the stages in general, this researcher simply calls the stage using Rogers’ (2003) terms (e.g., Decision Stage); however, when a stage relates to a specific technology, the innovation is referred to first then stage (e.g., GST Decision Stage).

Table 2.1. Stages in the Innovation-Decision Process

Table 5-1. Stages in the Innovation-Decision Process The Hierarchy-of-Effects and the Stages-of-Change Correspond to Stages in the Innovation-Decision Process

Stages in the Innovation-Decision Process	*Hierarchy-of-Effects*	*Porchaska's Stages-of-Change*
I. *Knowledge Stage*		I. Precontemplation
	1. Recall of information	
	2. Comprehension of messages	
	3. Knowledge or skill for effective adoption of the innovation	
II. *Persuasion Stage*		II. Contemplation
	4. Liking the innovation	
	5. Discussion of the new behavior with others	
	6. Acceptance of the message about the innovation	
	7. Formation of a positive image of the message and the innovation	
	8. Support for the innovative behavior from the system	
III. *Decision Stage*		III. Preparation
	9. Intention to seek additional information about the innovation	
	10. Intention to try the innovation	
IV. *Implementation Stage*		IV. Action
	11. Acquisition of additional information about the innovation	
	12. Use of the innovation on a regular basis	
	13. Continued use of the innovation	
V. *Confirmation Stage*		V. Maintenance
	14. Recognition of the benefits of using the innovation	
	15. Integration of the innovation into one's ongoing routine	
	16. Promotion of the innovation to others	

Source: Based on McGuire's (1989, p. 45) hierarchy-of-effects, as modified by Population Communication Services at Johns Hopkins University, and with the addition of Prochaska's stages-of-change (Prochaska, DiClemente, and Norcross, 1992).

Source: Rogers (2003)

A Model of Five Stages in the Innovation-Decision Process

Researchers have reported that high school educators are slow to accept GST as viable instructional tools for geography education (Kerski 2003; Bednarz 2004; Baker 2005; White 2008). Since the late 1990s, Rogers' (1995) Diffusion of Innovation framework has helped explain trends in adopting these technologies among secondary educators in terms of innovative adopter categories (Kerski 2000, 2003; White 2008). For example, at the dawn of the new millennium, Kerski (2000) contended that Geographical Information Systems (GIS) adopters reflected the category of Innovators. However, few secondary educators were in the infant stages of adopting desktop GIS software, as evidenced by Innovators who dared to bring these technologies into their classrooms and share their successes with other educators (Kerski 2000).

White (2008) explained the correlation between Rogers' (2003) Diffusion of Innovation theoretical framework and geography educators' adoption of various technologies; specifically, GIS software. She suggested, "GIS in education is in the earliest stages…of adoption and the users…are most likely considered Early Adopters" (172). She also estimated that only five to ten percent of educators had adopted GIS, thus identifying these adopters as GIS Early Adopters. White (2008) suggested that, although additional users might have existed at the time of her study, many geography teachers had not embraced these technologies as tools for instruction. Paraphrasing Rogers (2003), White (2008) explained, "There must be a 'perceived need' of the innovation and a match to the goals" (172) of a given group of people. In other words, if teachers do not identify a perceived need to infuse GST into their instruction, then implementation will likely continue to be slow. Thus, approval by Early Adopters can encourage others to try out and apply these technologies in the classroom.

Applying Rogers' (2003) Diffusion of Innovation as a lens to understand the adoption process in K-12 education earned its place in the literature by researchers such as Kerski (2000) and White (2008) as well as other education and instructional technology researchers (e.g., Jacobsen 1997; Berger 2005; Sahin 2012). Researchers have demonstrated that this model is viable to understanding the processes and stages of behavior and decision-making regarding new innovations. Although the current investigation also addressed GST adopter categories, it was a unique study because it sought to explain the stage of adopters when they made the decision to accept GST in their teaching, and to further the understanding of teachers' knowledge during the Innovation-Decision Process. Comprehending participant action or inaction will go a long way toward understanding the slow rate of GST diffusion into K-12 geography education.

Addressing the "Why, Where?" Question of Geospatial Technologies in Instruction

Diffusion of GST for over the past two decades has been slow to infiltrate high school geography education; therefore, it was necessary to examine ways in which professional development designers, pre-service teachers, and education and political leaders can address this problem. It was not enough to simply know where geography teachers were in the process of deciding to accept or reject GST as tools for instruction. This researcher also recognized the importance of understanding why these teachers were at specific stages in the process. In other words, it was necessary to understand the "why and where" of geography educators' GST decision-making processes.

Preparing educators in the past focused on content and pedagogical knowledge. More recently, this practice began including technological knowledge; however, with little or no attention paid to knowledge of technological content and pedagogical strategies (Hughes 2005; Koehler, Mishra, and Yahya 2005). Therefore, it is asserted that the phenomenon would be especially true for GST in geography education.

Mishra and Koehler's (2006) TPCK theoretical framework was used to examine high school geography educators' GST preparation processes to determine what knowledge assisted in the adoption, in Rogers' (2003) terms, to fulfill a "perceived need" of teaching with these technologies. This study also highlighted current characteristics of geography educators' content, pedagogy, and technology knowledge. Mishra and Koehler (2006) expounded on the work of Shulman (1986) who suggested that teacher preparation programs should incorporate both an understanding of pedagogy and content into teaching training programs with a special focus on where they overlap to form pedagogical content knowledge, or the extent to which they understand teaching strategies specific to a content area.

By the end of the millennia, Hughes (2005) had added technology knowledge as a vital part of pre-service training. Mishra and Koehler (2006) further suggested that teachers needed TPCK to be effective. Following Shulman (1986), content knowledge (CK) is the thorough understanding of one's discipline; whereas, pedagogical knowledge (PK) is the understanding of different strategies to teach an array of learners in a given classroom. Shulman determined that the relationship between the CK and PK was the most important, and when combined, pedagogical content knowledge (PCK) could offer a new level to teacher preparation. For example, in geography education, it is not enough to understand geography content or general pedagogy; educators must also know the appropriate teaching strategies for the array of geography content, skills, and analysis.

Since the 1980s, the teaching environment has changed to include instructional computers in the classroom and access to the Internet (Fuhrmann et al. 2005; Mishra and Koehler 2006). Mishra and Koehler (2006) contended that technology content knowledge and the appropriate pedagogy provided a much needed update to Shulman's (1986) often-cited framework (Figure 2.3). By adding technology to Shulman's PCK framework, Mishra and Koehler (2006) provided a new dimension to comprehend teachers' core knowledge, which explains the complex and vital relationship among content, pedagogy, and technology.

Simply put, Technological Content Knowledge (TCK) is knowing the technology related to one's subject matter. Further, Mishra and Koehler defined Technological Pedagogical Knowledge (TPK) as, "Knowledge of the existence, components, and capabilities of various technologies as they are used in teaching and learning settings, and conversely, knowing how teaching might change as the result of using particular technologies" (1028). Technological Pedagogical Content Knowledge combines these types of knowledge as "an emergent form of knowledge" (1028) that "is central to teachers' work" (Mishra and Koehler 2006, 1029). Bednarz and Bednarz (2008) defined TPCK as knowing "what technology is best to teach specific content and how to implement that technology so all students learn" (262). Learning to implement GST appropriately into secondary geography education is critical, and geography educators must recognize that geography education is changing, as are their future students (Nellis 1994; Hill and Solem 1999; Shelly 1999).

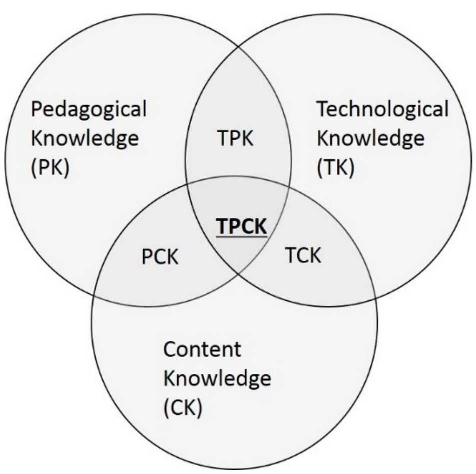


Figure 2.3. TPCK. Source: Mishra and Koehler (2006)

Generic use of technologies to teach content might be a barrier to appropriate use of Web 2.0 tools that stem from earlier periods in educational technology (Bull, Hammond, and Ferster 2008). Recognizing that each discipline has its own culture, traditions, and pedagogical goals, strengthens the ability to diffuse innovative technologies (Bull, Hammond, and Ferster 2008). Additionally, developing appropriate TPCK for one's discipline is vital. Because of the prolific nature of the Internet, Mishra and Kohler (2006) believed that it not only encourages, but forces educators to consider core pedagogical issues, thus drives educators' decisions about content and pedagogy, and geography is no different. Educators are now faced with the exciting possibilities various technologies have to offer, as well as daunting responsibilities to incorporate them in ways that may be new and foreign to the teachers, but that prepare students for the twenty-first century.

Researchers have recognized TPCK as an appropriate way to examine the incorporation of GST in geography education. Doering, Veletsianos, and Scharber (2008) extended the TPCK model by applying it to geography education (Figure 2.4). They argued that social studies teachers need "to have geography technological pedagogical knowledge (G-TPCK)" so they can "understand more than technology alone (e.g., Google Earth), more than pedagogical models alone (e.g., structured problem solving), more than content alone (e.g., cultural geography)" (220). When considered in combination, educators must understand the dynamic relationships and interplay among the three knowledge components (Doering Veletsianos, and Scharber 2008). Doering, Veletsianos, and Scharber advocated the use of TPCK (or geospatial TPCK [G-TPCK] in their case) as a "pedagogical, theoretical, and methodological framework to guide future social studies research" (219). Further, Bednarz and Bednarz (2008) explained that the ideas of PCK and TPCK were useful in understanding social studies teachers' slow acceptance of technologies such as GIS and other GST.

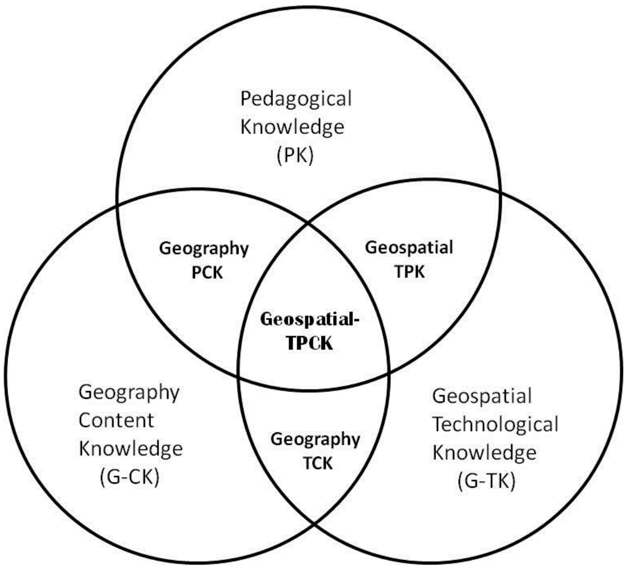


Figure 2.4. G-TPCK. Source: Adapted from Doering and Veletsianos (2007) and Rogers (2003)

Professional development and teacher preparation designers should provide training designed to develop K-12 geography educators' TPCK. Educators teach the way they were taught, and there is a call for "students [to] learn…with GST" (Doering, Veletsianos, and Scharber 2008, 216). Therefore, educators must be taught "to teach with GST and not about GST" (Baker 2005, 47; see also Kerski 2003). Developing teachers' TPCK is one way to ensure that educators not only teach using these tools, but that they truly understand how to apply these tools to geography education and the variety of strategies available to incorporate the array of online and desktop GST.

Altering the way geography educators teach requires epistemological and philosophical change (Doering, Veletsianos, and Scharber 2008). Those who train pre- and in-service geography teachers are responsible not only for providing content and pedagogical knowledge, but also for developing educators' habits of mind to think spatially and use GST to foster spatial thinking in their students. Likewise, key local, state, and federal decision makers are responsible for ensuring that teachers are equipped, supported, and encouraged to learn about these technologies and strategies to incorporate them into instruction, which is accomplished by providing teachers continual training, equipment, sufficient Internet bandwidth, and time to learn, experiment, and collaborate using these technologies.

Historical Geospatial Technologies: Barriers and Opportunities for Diffusion

Challenges with technology infrastructure and teacher technology preparation abound (Lee and Wizenreid 2009; DOE 2009; Gray, Thomas, and Lewis 2010b). Historically, barriers have included technologies designed for industrial rather than educational purposes, constant and rapid digital changes and development, time, smooth instructional implementation, lack of knowledge for appropriate pedagogical strategies, and underprepared pre- and in-service teachers. These barriers have impeded the acceptance of instructional technologies within education (Cuban 1986; Lemke and Coughlin 1998; Lee and Wizenreid 2009; De Freitas and Conole 2010). Technology use in geography education has experienced similar difficulties.

Access to computers and appropriate support can be problematic. While almost all schools have computers for student use, they may or may not be readily accessible to teachers outside of the Career and Technology Education (CATE) classes. When available, teachers must sign up to use computer labs or laptop carts (Kerski 2003; White 2008). Additionally, reading and science, technology, engineering, and mathematics (STEM) classes may be favored over social studies classes, which leads to an uneven use and availability of computers. As is typical with most instructional technologies, teachers must learn GST on their own time and, typically, do not have other educators with whom to collaborate, or they must obtain support from the instructional technology staff. However, such support is difficult because few, if any, are aware of technologies specific to the field of geography (Kerski 2003; Baker 2005; White 2008).

Although some researchers indicated that GST have become more accepted in recent years, little evidence exists to suggest its adoption by K-12 geography educators. Initially, "the geography education community appears [sic] to be ambivalent about the role of GIS in K-12 education" as evidenced by "the small number of teacher prep programs integrating GIS into the course of study" (Bednarz and Audet 1999, 62). Additionally, pre-service programs have changed little since the 1990s, which has limited exposure to GST prior to teaching. Although some have made efforts to train K-12 educators over the past decades, the education community as a whole has not set forth major initiatives with clear agendas and milestones. However, key entities within the geography education and business communities have worked diligently to bring GST to the forefront of K-12 education.

By the end of the twentieth and beginning of the twenty-first centuries, K-12 educators became increasingly aware of GST and their applications to geography education largely because of the commitment and efforts of private vendors such as the Environmental Systems Research Institute (Esri) and geographic education organizations such as the National Geographic State Alliance Network (Milson and Kerski 2012). In the early twenty-first century, geographic information system awareness at the K-12 education level increased dramatically nationwide through professional development, online training, and the publishing of curriculum materials (Baker, Palmer, and Kerski 2009; Milson and Kerski 2012). Additionally, GIS software became available to educators for free or at a low cost largely from the willingness of Esri to bring an industrial-strength technology (i.e., district and state GIS licenses). Other entities, such as My World GIS, have also worked to make GIS software more attractive to teachers in an effort to diffuse these instructional tools into schools. Further, easy-to-use interfaces allow teachers and students to engage data quickly rather than encounter cumbersome industrial-strength software.

The National Geographic Society Network of State Alliances also played a role in GST dissemination, and some Alliances have been especially instrumental. For example, one Early Adopter of GST in instruction, the Texas Alliance for Geographic Education (TAGE), was largely responsible for the awareness and use of GIS, remote sensing, and Global Positioning System (GPS) among geography teachers in the state of Texas. The TAGE increased awareness and use by offering educators workshops and summer institutes. Other Alliances have provided the same services for educators in their states to diffuse these technologies further.

The application of GST to education continues to grow in the United States. In addition to professional development opportunities, developers have published curriculum materials and resources that explain ways to incorporate these technologies into the classroom (Feaster and English 2002; Malone, Palmer, and Voigt 2005; Milson and Kerski 2012). Just as important, is the increasing body of literature that has examined the implementation of GST in K-12 education (e.g., Baker and White 2003; West 2003; Shin 2006; Milson and Kerski 2012). In addition to the efforts of private vendors and educational organizations, other factors have influenced the increased use and attention to GIS in American secondary education. Technology-driven fieldwork supports these technologies because of concerns of global climate change, environmental education, and reports on “the key role of outdoor education on human health and the environment” (Milson and Kerski 2012, 306; see also Louv 2005).

Online GST applications may also relieve some limitations to the use of these instructional tools. For example, the advent of the Internet and Web 2.0 applications provided fertile ground for programmers to develop universal GST programs. Advances in technology have also increased hardware capabilities and reduced costs, which has resulted in an exponential growth of affordable personal computers in both homes and schools that are capable of handling large software packages such as GIS (McClurg and Buss 2007). Additionally, software companies have begun offering educators affordable software bundles.

The increase in Web accessibility has also led to a “proliferation of user-generated media” and “a culture of sharing and remixing” information using text, photo, audio, and video applications (Bull, Hammond, and Ferster 2008, 277-278). Those who belong to this culture are sometimes called *digital natives* because they were born into an era that has only known computers and the Internet; therefore, they are accustomed to and expect technologies to be ever evolving in response to human needs and desires (Rosen 2010; Milson and Kerski 2012). Further, these digital natives grew up expecting that any information desired is readily available with a touch of their fingers and a click of the mouse. Therefore, they expect to find a map to any location and have the ability to look up information using geocoded data such as zip codes.

The Internet provides a safe, easy-to-use environment and is a "powerful way to expand any number of instructional activities" (Baker 2005, 45). Baker (2005), in support of Cheung and Brown (2001) and O'Dea (2002), reported that teachers and students find Internet applications easy to use and less time consuming during their lessons. In fact, as cited in Bull, Hammond, and Ferster (2008), Jones and Madden (2002) reported that students more commonly use the Internet than the library to obtain information and complete assignments. Carver, Evans, and Kingston (2004) mentioned that traditional instructional delivery has changed in response to "the rapid technological advances seen over the last 100 years; [from] photography [… to] computers, and most recently, the Internet" (425-426).

The U.S. government cited that, as of 2010, nearly 100 percent of schools and homes had computers and access to the Internet, and most had high-speed Internet connections (Gray, Thomas, and Lewis 2010a). However, teachers might not have the time necessary to use GIS software fully, but would, perhaps consider incorporating online GST to support a concept during class. Thus, the Internet is a viable medium for these technologies because it makes them readily available, easy to use, and requires fewer administrator constraints.

The growth of GST development and accessibility is made possible by the creativity and innovativeness of Web 2.0 applications. Educators today have many choices from simple Internet mapping, such as MapQuest, to more interactive ventures, such as Google Earth and online GIS applications such as Esri's AEJEE (ArcExplorer—Java Edition for Educators) and ArcGIS online. Understandably, some of these applications are not as powerful as desktop GIS software; however, most educators do not need to use full industrial-strength programs.

For example, the United States Geological Survey (USGS) website provides a low-level GIS mapping instrument that includes predetermined datasets that educators can click on and off to display to their students who can analyze these maps and the relationships among the data with the maps. Queries cannot be conducted as they can in a full-scale GIS program; however, these applications are highly useful for teachers because they are easy to use, highly functional, and allow discussions to ensue within minutes of opening the applications.

McClurg and Buss (2007) stated that fifth- through twelfth-grade educators use GIS and GPS because they are readily available. However, online GST are rapidly evolving, meaning some applications may only be available for a few years. Therefore, teachers may find adapting to the ever-changing technologies difficult, which could impede their integration into instruction. Considering the growth of GST and the accessibility of the Internet, it was necessary to reassess the current rate of GST use in secondary education.

Milson and Kerski (2012) reported that increased attention to the role of visualization and the availability and diversity of online mapping tools was influential. They cited national standards in geography and science that called for "inquiry-oriented problem solving about authentic issues" (Milson and Kerski 2012, 307) as well as increased attention on spatial thinking as cited in the National Research Council 2006 report and the focus on CATE and STEM research in secondary school reform (Baker and White 2003; Baker 2005). Additionally, "geo-anything" applications for mobile devices are in high demand as key tools for digital natives (Johnson, Levine, and Smith 2009). These factors were considered coupled with advances in and availability of digital technologies in the nation's schools; it was determined that it was necessary to encourage and foster the use of these technologies. To do so, future exploration into the adoption process regarding these technologies was necessary.

In the National Education Technology Plan 2010, Secretary of Education Arne Duncan began with a letter to members of Congress that stressed the vital role education plays in American economic "growth and prosperity" (Department of Education [DOE] 2010, iv). He described his technology plan, which called "for applying the advanced technologies used in our daily personal and professional lives to our entire education system to improve student learning, accelerate and scale up the adoption of effective practices, and use data and information for continuous improvement" (iv). His plan also demanded, "Engaging and empowering personalized learning experiences for learners" (iv).

When used appropriately, GST have the potential to support engaging, empowering learning environments that foster critical thinking skills, including analysis, problem solving, and prediction. Additionally, GST embody the very technologies that are in increasingly high demand in the Digital Information Age. These technologies are often used on "Smart" mobile devices, and they represent the new, cutting edge, advances in everyday personal and professional lives. These crosscutting, interdisciplinary tools are very much the wave of the future and learning how to engage them appropriately will go a long way toward securing the economic growth and prosperity of America. In fact, the GST industry experienced a 30 percent annual growth rate over the past decade (Palmer and Baker 2013). Considering this growth, examining teacher awareness and use of these technologies was critical to add to the efforts of preparing learners for the world that Secretary of Education Duncan envisioned.

Geospatial technologies can provide authentic learning environments that will have far-reaching implications beyond the classroom and into students' personal and professional lives. Understanding the historical and ongoing challenges and successes of GST use in K-12 education is critical to facilitate the diffusion of these technologies in geography classroom environments. Although the Internet may help diminish logistical and infrastructural barriers (Baker 2005), it was important to explore the constraints that individual teachers place on using technology in the classroom. With time, training, and ongoing professional development, teachers can rise to the challenge "to leverage the learning sciences and modern technology to create engaging, relevant, and personalized learning experiences for all learners that mirror students' daily lives and the reality of their futures" (DOE 2010, ix). Thus, reassessing high school teachers' awareness and use of these technologies was necessary to provide a clearer picture of the true nature of twenty-first-century geography education and furnish information to geography educators to evolve and meet the needs of their students. To discuss how educators can move forward, equipped with twenty-first-century skills and teaching strategies, this researcher 1) examined current GST practices of American secondary geography educators and 2) evaluated geography teachers' knowledge of GST as instructional tools.

CHAPTER III

RESEARCH QUESTIONS

This study addressed the following questions:

1. Using Everett Rogers' (2003) Diffusion of Innovations theoretical framework, how do teachers conform to Rogers' five stages of the Innovation-Decision Process with respect to the acceptance of geospatial technologies (GST) as pedagogic techniques for teaching high school geography?
2. Using Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPCK) framework, do high school teachers who exhibit more Technological Pedagogical Content Knowledge use geospatial technology more frequently than other teachers?

CHAPTER IV

RESEARCH DESIGN

An exploratory two-phased QUANT-QUAL mixed methods research design was used in this study (Figure 4.1). Increasingly over the last decade, mixed method designs have become widespread, and some researchers even consider them the norm (Biemer and Lyberg 2003; Dillman, Smyth, and Christian 2009). Technological and cultural changes were the main causes for the change in design. Digital technologies have made it possible to use accessible, low-cost Internet or interactive voice response (IVR) devices to collect data. Prior to the advent of computers, a mixed method design typically entailed a mailed quantitative survey followed by telephone or in-person qualitative interviews (Dillman, Smyth, and Christian 2009). With technology, research designs can take many forms. The four main types of mixed methods, or mixed mode, research design include 1) use of one mode to contact participants and another mode to encourage responses; 2) use of two different modes to collect responses from the same participants for specific questions using a questionnaire; 3) use of different modes for different participants in the same survey period; and 4) use of different modes to survey the same participants at two data collection periods (Dillman, Smyth, and Christian 2009). This researcher applied the fourth type of mixed method design using an online survey instrument and telephone interview protocol.

Typically, this method is used for longitudinal studies or when participants move geographically, which may require different modes of data collection. In this study, two different modes were used with the same sample at different times during data collection. Initially, participants answered an online survey (Phase I) from which some indicated their willingness to participate in telephone interviews (Phase II). When conducting interviews, it is assumed that individuals have intimate and distinctive knowledge about the phenomenon being studied and, when used with another form of data collection, this information can be used to triangulate data, which increases the validity of a study (Hesse-Biber and Leavy 2006).

For both phases, a purposeful sample of geography educators was selected. Selection criteria included being a member of one of the five state Geographic Alliance organizations that requires geography education for high school graduation and being a geography teacher. Concerning the former criterion, states were selected based on research by the Gilbert M. Grosvenor Center for Geographic Research in 2010 that documented those states requiring geography education for high school graduates. Researchers at the Grosvenor Center contacted each state Department of Education (DOE) to determine, among other information, which states required a geography course for high school graduation. The findings revealed that Mississippi, Minnesota, South Dakota, Texas, and Utah were the only ones to include geography as a requirement for graduation.

It must be noted that, in a 2012 study, the Grosvenor Center determined that a miscommunication occurred with the Minnesota Social Studies Supervisor; the state reported student choice for geography at the high school level as a required course. After investigating the strength of geography education in Minnesota with key individuals in the geography education community, it was decided that Minnesota had a strong state geography education program; therefore, remained in the current study.

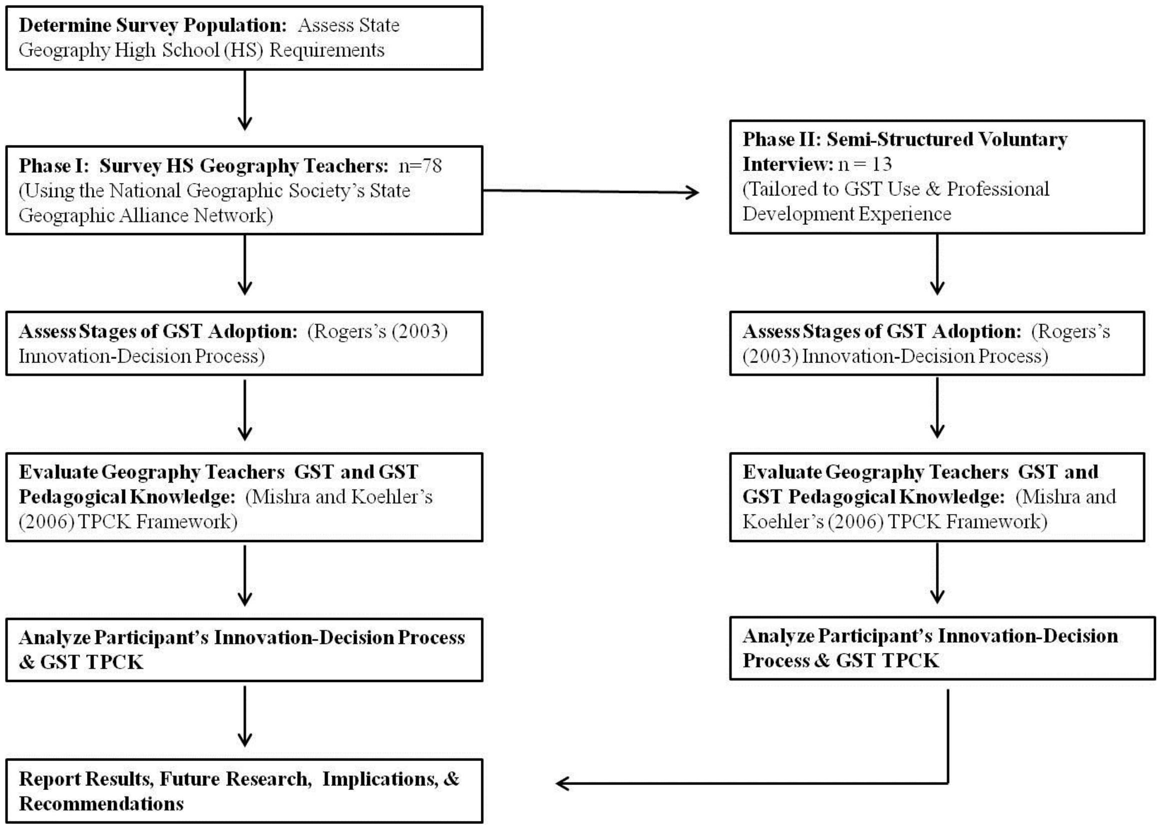


Figure 4.1. Research design flowchart.

Phase I was the quantitative portion of this study, which consisted of administrating a questionnaire to current high school geography teachers. The instrument aimed to investigate geospatial technologies (GST) in terms of educators' awareness, use, and attitudes toward; pedagogical knowledge as tools for instruction; support in the classroom; and teacher training for the use of these technologies (both as instructional and pedagogical enhancements).

Surveys were distributed to geography educators through Geographic Alliance Coordinators from each of the five selected states via their membership listserv or email databases. The only exception was the South Dakota Geographic Alliance, which did not have a membership listserv; however, the Alliance Coordinator, took steps to ensure contact with the state DOE Social Studies Supervisor who allowed access to the state

Social Studies listserv. All communications, including the initial survey invitation and subsequent reminder emails, were sent via these listservs; therefore, some participants may have fallen outside the scope of this study. In these cases, only data from high school geography educators were included in the analysis. A high school geography teacher was defined as an educator who taught World Geography, Pre-AP World Geography, or AP Human Geography. The survey was disseminated via the Internet using the SurveyMonkey service, and addressed past informal or formal GST training experiences.

During Phase I of this study, instrument items were coded using both Rogers' (2003) Diffusion of Innovations research and Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPCK) framework to explain teachers' decision processes to accept GST. The Innovation-Decision Process includes five stages: Knowledge, Persuasion, Decision, Implementation, and Confirmation.

The components of TPCK addressed in this study includes GST knowledge and technological, pedagogical, and content knowledge. Geospatial technologies knowledge included awareness of various forms of GIS software and online GST applications as well as other geospatial tools. Because of the sampling method used, it was assumed that participants already knew geography content and pedagogy. Analysis of the survey responses yielded clarification regarding profiles of geography teachers in each adoption stage.

After all surveys were compiled, educators who volunteered to participate in the phone interviews were contacted, which marked the beginning of Phase II (the qualitative portion) of this study. Guided by Mishra and Koehler's (2006) framework, phone interviews were conducted to obtain qualitative data to explain the common traits of educators who use GST as instructional tools. Of interest was information such as barriers, support, attitudes, and training experience related to GST. The phone interviews provided dedicated time to examine educators' training and experiences and determine whether these experiences, together, formed a compilation of content, technology, and pedagogical strategies specific to technology use in geography education. In conducting these interviews, reasons for teachers' use and success with these technologies were determined. Participants' decisions to accept or reject GST as instructional enhancements were also assessed. If participants accepted these technologies, they were asked how they employed them when they taught geography.

Phases I and II examined geography educators' knowledge and decision-making to determine their levels of TPCK at a given stage in the Innovation-Decision Process. This study is unique in that no previous study has sought to combine these two frameworks in such a manner. The findings from this study can provide education policy makers, pre-service educators, and professional development providers with insight into using advanced technologies, specifically GST, to enhance geography education.

CHAPTER V

METHODS

Mixed Methods Research Design

The aim of this study was to examine the current patterns of high school geography teachers' uses of geospatial technologies (GST) and to determine why some educators engage these innovations more frequently despite barriers to their use. The research was timely and essential because teachers are required to prepare students for twenty-first century college and workforce demands. Over the past decade, the American workforce has experienced a 30 percent annual growth rate in the geospatial industry, which has generated new revenue totaling $1.6 trillion over the past 15 years (Palmer and Baker 2013). Twenty-first century education includes technology as a core element because students and adults are expected to access, analyze, manage, and use vast amounts of data to make critical decisions and predictions (Department of Education [DOE] 2004; Ertmer and Ottenbreit-Leftwich 2010; An and Reigeluth 2011).

The two levels of technology that educators commonly use, low-level or no technology, are no longer acceptable or sufficient (Ertmer and Ottenbreit-Leftwich 2010). Additionally, simple technology in lecture-based classrooms deprives students of an enriching and engaging education required in the Digital Information Age (Zemelman, Daniels and Hyde 2005; Lawless and Pellegrino 2007; Partnership for 21st Century Skills 2008; Ertmer and Ottenbreit-Leftwich 2010). One way to ensure that students' needs are met and to manage the increasing information in the Digital Information Age is with information and communication technology (ICT), such as GST, which exemplifies technology in geography education.

A mixed methods research design was chosen as the best approach for this study because it provided a comprehensive means to analyze data using both quantitative and qualitative approaches. Although these research designs are common methods to the field of research, deliberate mixing of the two methodologies has been an acceptable research practice for about 20 years. According to Creswell (2003), since the mid-1990s, "mixed methods research has come of age" (4). Creswell and Plano Clark (2007) defined mixed methods, also referred to as multi-modal design, as follows:

> Mixed methods research is a research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the directions of the collection and analysis of data and the mixture of qualitative and quantitative approaches…Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone. (5)

The use of multi-modal designs to study a phenomenon is a purposeful attempt to emphasize the strengths of both quantitative and qualitative research. Applying only one approach might weaken a study because it would rely only on that method of acquiring data and could bias the results. Multi-modal research studies reveal a continuum in which one approach is central while the other plays a supportive role or in which both approaches are equal in status (Newman and Benz 1998; Creswell 2003). In this study, a sequential, mixed methods design was used to collect and analyze data in two phases, a dominant quantitative procedure and a supportive qualitative procedure. Data were collected using an online survey instrument during Phase I and a telephone interview during Phase II.

This chapter first explains the appropriate inquiry and considerations for a mixed methods study. Next, the research design is divided into descriptions for Phase I and

Phase II procedures, which is followed by caveats for data collection and possible limitations of the study. The chapter concludes with an explanation of the collection and coding of the data to address each research question.

Determining Appropriate Inquiry Approaches

Different perspectives influence researchers as they seek to understand the world. Research design is influenced by three elements of inquiry that, when used together, can form a multi-modal approach to a study. The elements of inquiry include alternative knowledge claims, strategies of inquiry, and methods. These elements have underlying principles and processes that help inform those who employ the multi-modal research approach.

Alternate Knowledge Claims

Alternate knowledge claims influence qualitative and quantitative research designs separately and consist of four primary schools of thought: postpositivism, constructivism, advocacy and participatory, and pragmatism (Creswell 2003). Postpositivism dates back to the 1800s, and reflects a deterministic philosophy that examines cause and effect issues using a quantitative approach, and employs careful observations, measurements, and tests (Smith 1983; Creswell 2003). Social constructed knowledge claims explore individual experiences qualitatively based on the assumptions that people seek to understand their worlds and to develop subjective meanings. Constructed knowledge is typically shaped through interactions and discussions with participants. Thus, researchers tend to "address the 'processes' of interaction among individuals" (Creswell 2003, 8).

The advocacy and participatory schools of thoughts seek to give a voice to marginalized participants. Finally, the pragmatic school of thought focuses on the research problem rather than a particular method, and is concerned with applications and solutions to problems. This focus allows for the use of pluralistic research approaches, which forms the "philosophical underpinnings for mixed methods studies" (Creswell 2003, 11; see also Patton 1990; Tashakkori and Teddlie 1998).

The scientific community has come to accept mixed methods research designs. In 1997, the National Science Foundation (NSF 1997) wrote the *User-Friendly Handbook for Mixed Methods Evaluation* and actively encouraged researchers to use this approach. Combining quantitative and qualitative approaches provides statistical data about patterns and correlations. This information can lead to a deeper understanding of the tenets and precepts of the data that, otherwise, could only be shared by individuals with intimate knowledge of key issues and situations.

This study followed the pragmatic knowledge model in that a pluralistic, or mixed methods, research approach was used to answer the research questions. In other words, the research design was influenced, to some degree, by both quantitative (postpositivism) and qualitative (constructivism) approaches. As such, the strengths of postpositivism were used by developing measures of observations to study geography teachers' behaviors and to reduce their identifying traits to a few key characteristics that represented their levels of GST use. Constructivism was also applied using participants' views and experiences to shape meaning from their work environments, trainings, and expectations of their teaching decisions.

Some high school geography teachers may feel marginalized and bound by constraints beyond their control; therefore, the qualitative phase of this research offered a forum for geography educators to voice their concerns regarding the use of GST as tools for instruction. This provided a venue that allowed secondary educators to speak, advocate, and engage in a participatory school of thought (Creswell 2003). Alternate knowledge claims are but one of three elements of inquiry that inform a mixed methods research design; two other elements include strategies of inquiry and research methods.

Strategies of Inquiry and Research Methods

Strategies of inquiry influenced the method chosen for the research design. Quantitative and qualitative research designs use different approaches. Dating from the 1800s, quantitative inquiries employ experimental designs that use treatment conditions and non-experimental designs that use instruments, such as surveys, to collect data (Babble 1990; Keppel 1991; Creswell 2003). Qualitative inquiries, more clearly defined since the 1990s, employ various methods based on need. This multi-modal study benefited from the influences of both the qualitative and quantitative forms of inquiry.

The mixed methods approach is less known than is either of the former types of inquiry; however, it uses a purposeful strategy to collect and analyze quantitative and qualitative data using a sequential, concurrent, or transformative procedure. A sequential procedure involves the dominant-supportive relationship between quantitative and qualitative research design in which is determined the best strategy. A concurrent procedure allows the collection of quantitative and qualitative forms of data simultaneously. Finally, a transformative procedure applies a theoretical lens to examine quantitative and qualitative data using either a sequential or concurrent design.

Researchers must consider all three elements of inquiry to determine the best possible strategy for their multi-modal research designs. In the present study, a QUANT-QUAL approach was used whereby a quantitative online survey was the dominant method and the qualitative telephone interviews extended and supported the survey data.

Bracketing Researcher Experience

Both postpositivist quantitative and constructivist qualitative research cultures recognize that a researcher's preconceptions, dispositions, and experiences could influence the results of a study. Where a quantitative researcher seeks to *bracket* influences on his or her investigation, a qualitative researcher may identify the *lens* for the research (Morrow and Smith 2000; Hoyt and Bhati 2007). Thus, the term bracket is widely used in qualitative research as a way to identify experiences and biases regarding the phenomenon under investigation. For the current study, the researcher's experiences teaching high school geography, working with Geographic Information Systems (GIS) professionals and academics, training teachers, and researching geography education influenced her perception of GST as valid instructional tools and the willingness of high school teachers to use them. Therefore, it is appropriate to share this background and possible bias (Appendix D).

Ethical Considerations

Ethical considerations for any study include a research plan presented to and reviewed by the university Institutional Review Board (IRB), informed consent and sponsorship, confidentiality and anonymity of participants, a reciprocal relationship between researcher and participants, and permission from authority figures at the research site (Creswell 2003). These ethical considerations were addressed by submitting a proposal to the IRB at Texas State University-San Marcos. In February 2010, the IRB issued a waiver indicating that the proposed study was exempt from a full review (Appendix C).

Participants during each phase were informed of the research goals and were reminded that all information would remain confidential and they would remain anonymous. Participants received this information in a variety of ways, including an introductory email prior to the study, a letter attached to the survey, and verbally before and during the telephone interviews. Participants who volunteered for the survey and telephone interviews are referred to anonymously in this report.

A reciprocal relationship with the sample population was developed during the pilot for the survey, as teachers were invited to comment, edit, and add to the survey items. Additionally, participants were told they would be informed when the study was completed should they wish to read the dissertation. Finally, Alliance Coordinators in participating states granted permission to administer a survey to their members, and these professionals willingly sent messages to their membership requesting their participation.

Statistical Analysis

Data were analyzed using quantitative and qualitative approaches. The Statistical Package for the Social Sciences (SPSS) software was used to evaluate the descriptive and inferential statistics from the online survey. Additionally, participants' responses to the qualitative phone interviews were coded and evaluated.

Caveats for Data Collection

Caveats for mixed methods research stem from the research method design, selection bias, response rate, and response bias. According to Creswell (2003), analysis can be limited because approaches used may yield results that are difficult to compare. Although generally not the case, in the current study, it was possible that the weakness of the designs were enhanced, which may have biased the results. Steps were taken to ensure the reliability and validity of the data collected for analysis.

The research design capitalized on the strengths of quantitative and qualitative data collection techniques using an online survey and telephone interviews. Although surveys can seem limited and prescribed, participants in the pilot tests stated that they felt satisfied with the breadth and depth of the survey. One concern with online surveys is that they can be biased toward individuals with access to computers and the Internet. In the current study, this was not a concern because teachers in public schools have access to both computers and the Internet (DOE 2004; Wells and Lewis 2006; DOE 2009; Grey, Thomas, and Lewis 2010a).

The phases of research worked in tandem to produce a clear understanding of current geography education practices. The digital listservs and email databases from the Geographic Alliances provided contact information about their membership. The telephone interviews allowed free response opportunities, which provided a forum for participants beyond the scope of the online survey.

Selection bias may have occurred because of purposeful sampling of the target population. The initial pilot studies included only teachers from the Texas Alliance for Geographic Education, which limited input from geography teachers from other states. Therefore, obtaining comments from only Texas teachers' perspectives may have biased the development of the survey. This issue was addressed by including survey and professional development experts from other regions of the United States in the review of the survey instrument. The final survey administered to geography educators in the five selected states resulted in answers that were consistent with those by Texas Alliance teachers.

Data from these surveys and the subsequent interviews were coded and analyzed. This study was not grant-funded, thus, external evaluators and other analysts could not be paid; however, external coders aided in recoding survey items. A number of experts were also asked to review the survey instrument and telephone interview protocol to ensure reliability.

Measures were taken to limit bias during the interview transcription process by using an external, third party transcription service that was unaware of the study. Because researcher-coded transcripts could bias the results, an external reviewer evaluated portions of the transcripts to ensure consistency in coding. Additional funding for trained professionals could have provided the means to ensure that researcher bias did not influence the findings; however, such funding was not available. Responses to the telephone interviews reflected primarily Texas geography teachers' views because few educators volunteered from other state Geographic Alliances. The telephone interview results did not unduly influence the study because the qualitative phase aimed to support and refine the survey results and to gain insight into commonalities among teachers who used GST.

Phase I of the study used an online survey, which raised two areas of concern: response bias and response rate. Response bias was not calculated because the Geographic Alliances from the selected states did not have a common way of defining membership. For example, some may have included only active members, while others may have included all teachers on their listservs. Additionally, some may not have kept updated email databases of their constituents; therefore, calculating response bias was not possible.

To ensure a high response rate, participants' state Geographic Alliance Coordinators, with whom they had established relationships, sent emails informing members about the study that included a link to the online survey instrument. Participants also had the option of completing a paper and pencil version of the survey that they could email or fax back upon completion. All participants completed the survey online.

South Dakota was the only state in which participants were not recruited from the Geographic Alliance because it did not have an up-to-date email membership list. As a result, the Alliance Coordinator provided contact information for the Social Studies Supervisor for the South Dakota Department of Education (DOE), which was acceptable because he had contact with a range of geography educators in the state.

To increase the response rate, reminder emails were sent to each state Geographic Alliance Coordinator who forwarded them to their constituents. Texas participants had a higher response rate than the other participating states, possibly because participants felt a greater affiliation with the researcher who was a member of their Alliance. This higher response rate could also have been because Texas employs more geography teachers than any other state in the United States, and the response rate simply reflected this difference.

Many variables can influence teachers' perspectives on education. The views of school district administrators, school leaders, and educators concerning appropriate tools for learning may change from year to year. Additionally, support for teacher professional development, beyond what school districts provide internally, fluctuates. Pressures on teachers, such as state assessments, also define and refine teachers' views.

Limitations: A Review of Research Design and Data Collection

This investigation was an exploratory study of high school geography teachers' decisions to adopt GST as pedagogical enhancements in the classroom. While the findings of this study were deemed sufficient to identify the current state of GST in geography education, the need for a larger sample size, even representation, and more robust statistical survey items is recognized if the implementation of these tools to the broader portion of the teaching population is to be effective.

In general, a large sample population was preferable in this study for the telephone interviews to reflect the five selected states equally. Additionally, personal experience with the Texas Alliance for Geographic Education may have skewed the results as more Texas teachers participated. Therefore, it would have been advantageous to include someone who was equally networked with each state Alliance to encourage higher participation among teachers from other states. This strategy would have been particularly beneficial for South Dakota, as no teacher from this state qualified for the study.

Additionally, a shorter questionnaire and shorter time span between the survey administration and interviews may have yielded more interview participants. Nine months passed between survey administration and interviews; therefore, participants may have lost interest in completing the interview phase of this study. Furthermore, the development of more statistically sophisticated questions may have allowed a more robust statistical analysis using interval and scale-level data.

In addition to making changes to the survey instrument, future researchers could enhance a study of this nature by adding focus groups to the research design. Focus groups would provide an intimate and informal conversation among educators and offer additional insight into the inner workings of the geography education population. Regional meetings with geography teachers could also provide a varied and holistic accounting of their thoughts regarding GST as tools for instruction. Teachers who participated in this study may have been from similar areas, and their perceptions could have reflected the strongholds for their state Alliances. In other words, responses may have been regionally biased; therefore, focus groups would have aided in ensuring such biases were minimized.

Research Design

Using a QUANT-QUAL sequential strategy, the two-phased mixed methods approach informed the research design. In the first phase of the investigation, high school geography teachers from five states with strong geography programs were asked to take a survey that assessed their awareness (knowledge), decisions, and actions regarding the use of GST as tools for instruction. The sample criteria included teachers who taught World Geography or Human Geography courses at the high school level in one of five states: Minnesota, Mississippi, South Dakota, Texas, and Utah. Participation was voluntary, and teachers were informed of the purpose of the survey and were assured that all information would be kept confidential. Using self-reported data, survey responses were analyzed to determine whether any associations or statistically significant differences existed among geography teachers at and across varying stages of adoption of

Rogers' (2003) Diffusion of Innovation and Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPCK) frameworks.

Participants volunteered for Phase II by providing their contact information on the Phase I questionnaire. Phase II aimed to explore experiences with and perceptions of GST as tools for instruction. Kerski (2000) and White (2008) asserted that current GST users in K-12 schools resemble Innovators and Early Adopters as described by Rogers (2003). As such, these change agents serve as leaders and role models. Therefore, participants were recognized as being uniquely situated to observe and comment on other geography teachers' behaviors and attitudes concerning the use of technology in geography classrooms.

During the phone interviews, participants were asked to describe observations and perceptions of their colleagues' decisions to adopt GST as tools for instruction as well as the levels of knowledge (technological, pedagogical, content) their colleagues exhibited. Responses were examined for unifying trends to support Phase I data analysis. The research questions guided and structured each phase. Table 5.1 displays the timeline for both phases of this investigation. Data for each research question were examined within the context of the instrument used to collect the data, and then were combined for the final analysis.

Table 5.1. Data Collection and Analysis Timeline

Phase of Study	Data Collection	Dates
Phase I	Develop survey instrument	Spring 2010
	Pilot survey	Summer 2010
	Revise survey	Fall 2010
	Deliver survey	Spring and Summer 2011
	Data analysis	Fall 2012
Phase II	Develop interview protocol	Spring 2012
	Confirm participant volunteers	Spring 2012
	Conduct interview	Spring 2012
	Transcribe interviews	Fall 2012
	Analyze interviews	Fall 2012

Phase One: Online Survey Design

This research builds on Kerski's (2000) seminal study that measured, for the first time, the use of GIS by secondary science and geography teachers on a national scale. When Kerski conducted his study, online GST were in their infancy and many applications that exist today had not yet been developed. As such, his study is dated and does not provide a true representation of current twenty-first-century geography educators. However, researchers in the early twenty-first century noted that the barriers and concerns with GST that Kerski reported were still problematic (Kerski 2003; Bednarz 2004; Baker 2005; Milson and Kerski 2012). Therefore, Kerski's original survey items are of value and should be used in research. The majority of the survey instrument in Phase I stemmed from Kerski's original questionnaire, which was used with his permission. A copy of Kerski's questionnaire is located in Appendix B.

The survey design, in part, replicated Kerski's study in that it examined geography teachers' use of GST and extended his study to encompass desktop and online

GST in general, including GIS software. The specific survey instrument and design in Phase I were derived foremost from Kerski's (2000) study as well as from research on instructional technology and teachers' attitudes based on guidelines set forth by Dillman, Smyth, and Christian (2009) and other expert advice.

Survey Use

Surveys are effective tools for collecting quantitative data and learning about behaviors, attitudes, opinions, and overall trends, especially when the sample population is large (Creswell 2003; Desimone and Le Floch 2004; Dillman, Smyth, and Christian 2009). Until the 1990s, most surveys were conducted in person, by mail, or by phone. However, beginning in the 1990s, researchers began using the Internet to administer surveys.

According to Dillman, Smyth, and Christian (2009), early in the Digital Information Age, researchers recognized the potential of web surveys, mainly because of the financial benefits and convenience for both researchers and participants (e.g., easy and fast to develop and complete). Computers also helped standardize surveys and made data entry more efficient. Some challenges with web surveys include a possible lack of access to computers and the Internet, lack of knowing how to use computers, inability to obtain email addresses from the general public, and lack of a "systematic list of Internet users" (Dillman, Smyth, and Christian 2009, 9). The latter two challenges limit Internet surveys to specific populations with computer skills and an understanding of the Internet.

Of utmost importance is designing a survey instrument that will yield valid and reliable responses and offer insight into key participants' perceptions and experiences (Fink 2006). In general, researchers must consider the length of the survey, frequency of similar questions, and the time it takes to complete a survey (Asiu, Antons, and Fultz 1998). Although shorter surveys are recommended because of their perceived ease, longer surveys can be designed visually to appear shorter, thus, are less burdensome (Asiu, Antons and Fultz 1998; Bourque and Fielder 2003; Dillman, Smyth, and Christian 2009).

The order and types of questions also influence participants' responses (Fink 2006, Dillman, Smyth, and Christian 2009). For example, placing demographic information toward the end of the instrument can relax the participant and encourage survey completion because these questions are easy and familiar. Additionally, items were written as short and concise questions, making them clearer and quicker to answer.

A final consideration in survey development is conducting a pilot test to ensure reliability, validity, and a smooth consistent flow of the survey instrument. This researcher went to great lengths to ensure that the survey instrument design followed appropriate, well-researched guidelines. Additionally, the sample population aimed to best represent quality geography teachers in the United States.

Sample Teacher Population

The key to any good research is the careful selection of the study population. Although a randomly sampled population is ideal, in some cases, purposeful sampling or samples of convenience may be appropriate (Creswell 2003; Dillman, Smyth, and Christian 2009). Using a purposeful sampling method, participants were recruited based on geography (location), which is a common method when using phone surveys (Bourque and Fielder 2003). The aim of this method was to recruit participants from a targeted pool of geography educators from selected states based on specific criteria.

Kerski (2000) focused on teachers in schools that had purchased GIS software to examine the extent to which this technology was incorporated into instruction. To measure teacher technology use in the current study, the scope was widened to include all GST (online and desktop software applications) that featured an array of dynamic visualization and analytical tools. The population of interest was teachers in states where geography education was strong and supported by each selected state's DOE, as evidenced by state social studies graduation requirements.

The participants selected for this study represented a range of geography teachers—from those with strong geography backgrounds to those with little knowledge and experience. States with less robust geography programs may not have educator requirements or certifications specific to geography courses. Therefore, sampling from these states would have lessened the likelihood of engaging a good representation of geography teachers. According to Dillman, Smyth, and Christian (2009), concentrating on a target population when using an online survey is appropriate largely because a pool of email addresses from which a sample may be drawn is not available to the public.

The sample teacher population for this research was determined by state geography graduation requirements and affiliation with state Geographic Alliance organizations. A 2010 study conducted by the Gilbert M. Grosvenor Center for Geographic Education was used to determine the states selected for this study. The 2010 research identified states that required geography as a course for high school graduation through direct communication with the social studies supervisors for each state's DOE. States that met this inclusion criteria included Minnesota, Mississippi, South Dakota, Texas, and Utah.

Each state in the United States has a Geographic Alliance that is a part of the National Geographic Network of Geographic Alliances, which provides professional development and materials to enrich and extend K-12 educators' geographic content knowledge, skills, and pedagogy. Granted, those teachers who were not members of an Alliance could not participate in this study. However, Alliance members represented teachers who were likely to seek out additional training for content and pedagogical improvement. Additionally, surveying all teachers in these states might have involved educators who were not interested in enhancing their teaching and learning environments; therefore, those teachers were beyond the scope of this study.

Working with state Geographic Alliances helped limit the population for this investigation to a manageable size that could be easily accessed. Alliance members are representative of the general teaching population in that they reflect experts and novices in geography content knowledge as well as users and non-users of technology, especially regarding GST. Because of their proclivity for enriching their learning and teaching environments, they were likely candidates for this research because they were expected to be knowledgeable about the classroom environment; the approved curriculum and teaching standards; technology challenges; and the possibilities, resources, and available support for using technology. These teachers also had access to computers and the Internet. A benefit of this target population was the availability of a pool of email addresses from which to sample (Dillman, Smyth, and Christian 2009). The Alliance Coordinators were the gatekeepers of teachers' contact information and were willing to communicate with their membership. Their participation was invaluable.

The South Dakota Geographic Alliance was an exception, as the Alliance did not have an established listserv. The Coordinator provided contact information for the Social Studies Supervisor at the South Dakota DOE who provided the contact information of social studies teachers using its listserv. Although this situation was less than ideal because communications did not include an introduction from an Alliance Coordinator, it was an efficient means to contact teachers in this remote state. Furthermore, the Alliance was smaller than others included in this analysis; therefore, the South Dakota DOE may have had greater access to a larger sampling of geography teachers in this state.

Survey Instrument and Design

The survey instrument, Geospatial Technology in High School Geography Education, was administered online in Phase I to collect data regarding teachers' usage of and knowledge about GST. Dillman, Smyth, and Christian (2009) was used as a guide to format the survey, which was uploaded into SurveyMonkey, an internet survey distribution and tracking service. This service was selected because it was low-cost and user friendly.

When selecting an online survey, it is important to ensure that one's audience has the capability to use and access appropriate technology. In this study, participation was limited to high school geography educators. Schools have increased their technology resources rapidly, including Internet access, over the last decade; therefore, participants in this study were very likely to have Internet access (DOE 2010). However, participants were given the opportunity to complete a paper and pencil version of the survey, which they could return by fax, email, or mail. All participants decided to respond via the online questionnaire. This section details the survey instrument design, followed by a discussion of the pilot study, data collection, coding process, and data generation.

Survey design is vital to ensure participation and completion of a questionnaire with reliable and valid responses. The development of the survey for the current study followed the guidelines set forth in *Internet, Mail and Mixed-mode Surveys: The Tailored Design Methods* (Dillman, Smyth, and Christian 2009). This work was selected because Dillman is a well-respected and oft-cited researcher in survey design. The survey was also influenced by *How to Conduct Telephone Surveys* (Bourque and Fielder 2003) and *How to Assess and Interpret Survey Psychometrics* (Litwin 2003). A web-based survey was selected because of its relative ease of use, low cost, and quick response time. Additionally, an incentive was offered to entice participation and survey completion; specifically, participants had a chance to be one of five chosen for a prize.

Survey design involves an array of details beyond content and layout to include such things as tools for easy reading, participant directions, key terms, types of questions, and question design. The content of this instrument was centered on teacher use of and training for GST as instructional tools in high school geography education. Consideration for item layout and arrangement ensured that the page length remained short to minimize scrolling. Standalone questions were also developed; therefore, participants did not rely on prior questions. Each Internet page of the survey included titles for topics of questions, a copy of the survey directions, and the definitions of key terms to facilitate participants' understanding of the questionnaire.

Item arrangement also expedited survey responses. Therefore, easier questions, such as those using a Likert scale or demographic questions were placed at the beginning and end of the survey. Following the advice of survey and research experts, the more difficult questions, such as open-ended and multiple-choice, were placed in the middle of the questionnaire. The online SurveyMonkey web application provided consistency in form and ease of access and use. SurveyMonkey was selected because the researcher had experience with this service and knew that a number of educators were also familiar with this service. In designing this survey about technology, it was also essential to include participants' attitudes toward the technologies being discussed.

Teachers' attitudes regarding GST

The researcher's experience with and research about instructional technologies informed the survey items regarding teachers' attitudes and perceptions. Mohan's (2009) study, which used a survey to examine the affective domain of geography educators who traveled to determine their attitudes toward other cultures, guided the question design structure. A few general items were also included to determine participants' attitudes toward technology, which could influence their perceptions of and willingness to use GST as instructional tools.

A complete analysis of current GST use requires an understanding of teachers' attitudes toward these innovations. According to Holden and Rada (2011), "User acceptance, satisfaction, and perceived usability of innovative technologies are crucial to the diffusion of those technologies" (343). Teachers may perceive digital technologies as useful, personally and professionally, but may be hesitant to use them because they change rapidly. Therefore, teachers may lack appropriate knowledge, be uncomfortable with these technologies, have conflicting belief systems, or experience institutional constraints that influence their decisions negatively (Ertmer 2005; Lawless and Pellegrino

2007; Hew and Brush 2007; Roehrig, Kruse, and Kern 2007; Subramaniam 2007; Mueller et al. 2008; Somekh 2008; Straub 2009; Ertmer and Ottenbreit-Leftwich 2010).

Logically, it would follow that, if a technology were perceived as highly usable and helpful, it would be widely accepted by a population (Ertmer and Ottenbreit-Leftwich 2010). This assumption is not always accurate, especially when technological innovations are designed without adequate consideration for classroom implementation (Dillon 2001; Holden and Rada 2011). Geospatial technologies, as with many instructional tools, were first intended for industrial and military purposes; therefore, the target population of high school geography educators was never considered specifically the original development of GST.

Few researchers have attempted to combine the usability of an innovation with users' characteristics into a unified theory for design and implementation purposes (Dillon 2001; Holden and Rada 2011). This study did not seek to develop a theory about teacher GST use; rather, it attempted to identify factors (i.e., technological knowledge, pedagogical knowledge, and content knowledge) that influence geography teachers' decisions to use these technologies to enhance instruction. Data garnered from the study instruments may help key education decision-makers, stakeholders, pre-service educators, and in-service and professional development providers make informed decisions about appropriate and sustainable ways to implement GST into geography education. As such, the survey used in this study included some items that inquired into educators' affective domains regarding their perceptions of technology in general, and GST, specifically, which could influence their self-reported data.

Survey Instrument Sections

Seven sections comprised the research survey, Geospatial Technology in High School Geography Education (Appendix A). The first section, “Awareness and Experience with Technology in Geography Education,” gathered information about the basic awareness of, attitudes (including comfort levels) toward, and experiences with (including use and training) GST. A few baseline questions determined basic use and attitudes toward technology in general. The second section, “Training and use of Geospatial Technologies in Geography Education,” further examined the level of GST use and interest in and awareness of professional development opportunities concerning these technologies. Questions were designed to capture how actively teachers pursued the learning and use of GST as instructional tools. Sections 1 and 2 used Likert scales to structure responses.

In the two subsequent sections, the survey included semi-closed-ended questions to explore teachers’ knowledge, training, support, and perceptions of GST. The response option of “other” allowed participants to provide additional information. The third section, “Available Geospatial Technologies, Use, and Support,” provided details about the awareness of these technologies, including length of time, type of technology, benefits of use, challenges to use, and support at the district and school levels. The fourth section, “Geospatial Technologies Training and Experience,” included questions designed to specify the types of training experiences and to explain expectations of current users. In the qualitative section, “Tell Your Story: What is Your Experience with Geospatial Technologies,” participants were given the opportunity to describe their technology use, training, and support in their own words. The sixth section, “Technology and Geography Education," asked questions to gain an understanding of the geography teachers and the technology available to these teachers in general.

Survey experts from the National Geographic Society and Texas State University advised that the "Demographic Data" section should be placed toward the end of the survey (See also Dillman, Smyth, and Christian 2009). The advice from these experts guided the development of this section. Demographic information provided critical facts about participants' schools, backgrounds, and available computer resources. These data were especially important when performing descriptive analysis.

Refining the Survey: Review, Pilot Testing, and Coding

Expert review of the survey instrument

Before administering a survey to the target audience, it should be reviewed and piloted. Dillman, Smyth, and Christian (2009) suggested that a screen shot of the survey be shared with reviewers because it makes it less difficult to repost reviewers' corrections to the online instrument. This issue was not a concern for the current study as the SurveyMonkey web application allowed for easy review and edit of the instrument. Dillman, Smyth, and Christian (2009) and other researchers (e.g., Newman and McNeil 1998, Creswell 2003, and Litwin 2003) strongly advised that experts evaluate questionnaires to ensure the form and content of the instrument are appropriate and will yield valid responses.

In keeping with best practices, four groups of experts were asked to review and suggest revisions to the survey. Five geography education experts reviewed the survey for content validity, clarity, and form. Two survey measurement and design experts evaluated the survey for clarity, appropriate use of scales, and instrument design. Three professional development experts assessed the content validity of the questions regarding training, types of available GST, and associated benefits and challenges (Figure 5.1). Current geography teachers also evaluated the survey for content and form. Experts conducted the final survey reviews to evaluate the online SurveyMonkey instrument to ensure it was consistent, uniform, clear, and easy to read, and technically sound. Significant adjustments were made over multiple phases of this review process.

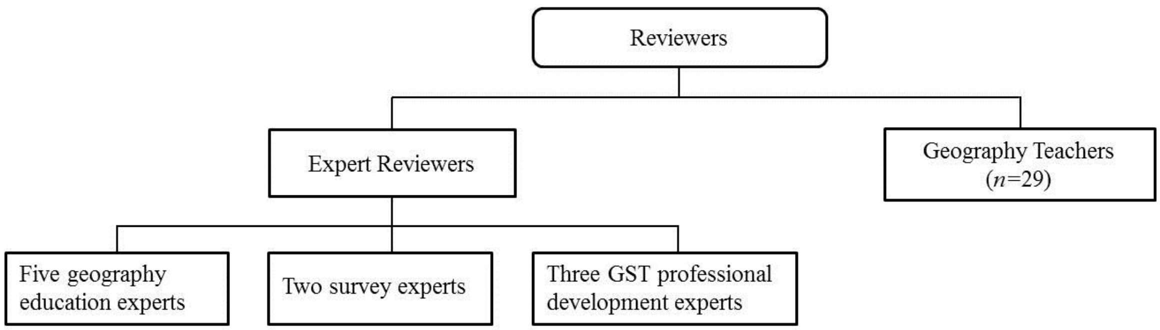


Figure 5.1. Design of survey review.

Table 5.2 provides an example of one revised survey item based on advice from the expert reviewers. Specifically, the reviewers suggested that an open-ended question be changed to an item with response choices to aid participants in answering the question and providing consistent answers for the item analysis.

Table 5.2. Revision to Survey Example

Review Phase	Sample Question
Before Review	What is the total number of hours of training you have in GST (online or desktop)?
After Review	Approximately, how many hours of training in GST have you had over the past 10 years (online or desktop software)? o I have had no training for GST o 3-6 hours o 9-12 hours o 15-18 hours o 21 or more hours

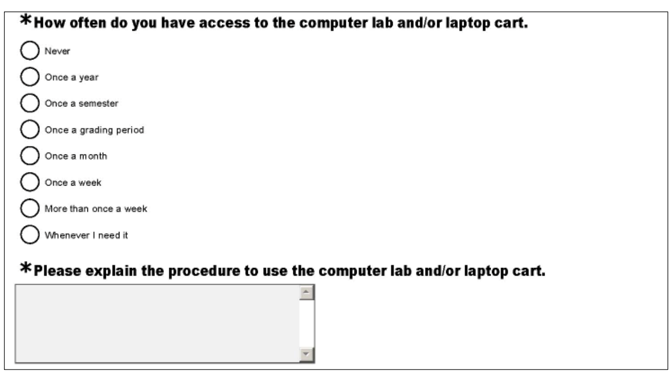
Pilot testing the survey instrument

Pilot testing was a critical stage in survey development and took place prior to the distribution of the instrument (Creswell 2003; Litwin 2003; Somekh and Lewin 2008; Dillman, Smyth, and Christian 2009; Fink 2009). Pilot testing provided a forum for current high school educators to comment and suggest changes to the survey. This survey was piloted twice with two different samples of geography teachers who were members of the Texas Alliance for Geographic Education (TAGE) and who represented both novice and expert teachers.

The researcher was present when participants completed the survey. The first pilot test consisted of 15 mostly novice geography educators, some of whom were new to TAGE. The second pilot test included 14 expert geography educators who were in training to be TAGE teacher consultants. Teacher consultants are experienced geography teachers who train other educators in geography concepts, skills, and pedagogy. The survey was piloted using a paper form because the online survey was not yet available. Therefore, participant feedback focused on the survey directions; key terms; and item content, order, and clarity. When the online survey was available, at least one expert from each group previewed the instrument for technical or form concerns.

Teachers who participated in the pilot clarified the questions, assessed the intent versus response of the items, and addressed technical concerns. The sample size was too small to conduct inferential statistics; however, their comments addressed the content validity, clarity, and form of the questionnaire. On average, participants completed the first pilot test in 8 minutes and 26 seconds and the second pilot test averaged 12 minutes and 36 seconds. The timing discrepancy occurred because participants in the second pilot test were very knowledgeable and excited about the topic, and they tended to discuss various matters while completing the survey. However, participants were redirected to complete the survey before asking questions or discussing survey items. Many participants also took notes as they completed the survey. Only one of the 29 teachers stated that the survey was too long. All other geography teachers and content experts were adamant that the survey was an appropriate length.

Each group of teachers provided feedback regarding the form and wording of items. In feedback discussions, pilot study participants expressed deep concern that future participants be allowed to explain that they were constrained by the educational institution rather than their lack of knowledge or willingness to use GST. In addition, both groups suggested items that would allow educators to provide more detail regarding the cumbersome process of accessing computer resources for social studies education. Figure 5.2 illustrates an example item added based on teachers' recommendations.


***How often do you have access to the computer lab and/or laptop cart.**

- Never
- Once a year
- Once a semester
- Once a grading period
- Once a month
- Once a week
- More than once a week
- Whenever I need it

***Please explain the procedure to use the computer lab and/or laptop cart.**

Figure 5.2. Revision to survey instrument.

Data Collection

The survey was hosted on the SurveyMonkey website. This online application allowed for the development of complex, extensive instruments that use a variety of qualitative and quantitative questioning techniques. To use SurveyMonkey, a one-year subscription was purchased, the training manual on creating surveys was read, and good survey questions were written. These questions were created in concert with expert survey designers and, when necessary, the SurveyMonkey customer service.

The 103-item survey was designed, tested, and distributed using the link provided by SurveyMonkey. SurveyMonkey collected participants' responses and provided data in an Excel spreadsheet. A codebook was developed to guide the analysis of the survey results (Appendix F); details of the codebook are discussed later in this chapter. The online survey link and email letter to participants was reviewed for any functional errors before the link was sent to Alliance Coordinators. When the Coordinators received the draft email, they sent it to their constituents.

Participants received the email for the survey in four phases. First, a letter was sent to the selected state Geographic Alliance Coordinators asking for their participation in sending the initial survey and subsequent reminders to their members. Next, Coordinators were asked to forward the link for the survey and a letter of introduction to the research to members on their listservs. A suggested introduction to the email was provided to facilitate Coordinators' efforts. Using their Alliance listservs, the selection of high school geography educators who were members of the Alliance was more likely to occur. A reminder email was sent to Alliance Coordinators to forward to their members to complete the survey approximately two weeks after the initial email. Another email was sent after an additional two weeks that informed participants of an extension due to technical difficulties with the link experienced by one of the Coordinators. States with low response rates received an additional reminder.

As spring academic testing approached, all survey reminders were suspended until after this annual testing period. One Coordinator requested that data collection wait until summer when teachers gathered for training events; therefore, the survey was open for responses from the end of January 2010 to the beginning of August 2010. In August 2010, the survey link was closed, and the data were retrieved and downloaded into an Excel spreadsheet. Upon downloading the data from SurveyMonkey into the Excel file, an initial review for partial and missing data was conducted before data were prepared and imported into SPSS.

Demographic data were assessed to determine whether participants met the criteria for this study. It was essential that participants completed the entire survey; any incomplete responses were eliminated. Survey responses from 153 participants were collected; 116 (76 percent) completed all survey items. Of those, 78 participants were high school geography teachers.

Variables were coded according to SPSS protocol and imported into the software for statistical analysis. Each variable, or survey question, was assigned a code, and each condition within the variable was assigned a value. Codes are "tags, names or labels, and coding is therefore a process of putting tags, names or labels" on data, such as survey items (Punch 2005, 199). All questions using the Likert scale were assigned the following codes: "1" = Strongly Disagree, "2" = Disagree, "3" = Neutral, "4" = Agree, and "5" = Strongly Agree. Survey items that allowed participants to "check all that apply" were divided into separate questions that represented each response.

The conditions assigned used a binary code "0" for unselected responses or "1" for selected responses. For example, the item "The use of GST in geography education is supported by my: (Check all that apply)" had five possible choices: Department Head/Chair, Principal, Social Studies Supervisor, Instructional Technology Specialist, and Other. Each choice was coded as a separate variable with the value of "0" (unselected answer) or "1" (selected answer).

Questions that required participants to select only one answer represented a variable with values that ranged from "0" to the number of response choices. For example, the survey item, "Currently, I use geospatial technologies (GST) to teach geography" was assigned the following codes: "0" = Never, "1" = Once a semester, "2" = Once a grading period, "3" = Once a month, "4" = Once a week, and "5" = Two or more times a week. Demographic data were coded and assigned values in the same fashion. These data were used to group participants into different levels of the independent variable.

Open-ended questions were qualitative in nature, thus coding required a different strategy. Ultimately, these items did not lead to themes that would support the Phase I analysis as it was designed. Therefore, the analysis conducted in Phase I examined data from only the quantitative items mentioned previously. Appendix I lists the codes used for each survey item. Descriptive and inferential statistics were used to analyze the data, which is discussed in detail in Chapters VI-IX.

Data were coded two more times to group participants to address the research questions. Variables were coded for each of Rogers' (2003) five stages of Innovation-Decision Process and Mishra and Koehler's (2006) components of the TPCK framework. External reviewers were used as appropriate. The coding process is discussed in detail in the data generation section of this chapter and in the discussion on the analysis of the survey data in later chapters.

Phase Two: Telephone Interviews

Phone Interview Use

Telephone interviews allow researchers to access larger population samples (Bourque and Fielder 2003). Participants are often receptive to a personal interview design and are more willing to answer questions because they are not required to write out their responses (Bourque and Fielder 2003). However, limitations to telephone interviews include "the use of answering machines, caller ID, call-blocking devices, fax machines, computer modems, and cell phones" (Bourque and Fielder 2003, 1). These limitations did not apply to the current study because participants volunteered by providing their contact information on the survey and scheduling times for their interviews.

The phone interviews were conducted nine months after the close of the Internet survey. The delay between the survey data collection and the interviews was necessary based on suggestions from educators who indicated that they had more time in the spring to participate in the interviews. An interview question protocol was used to guide participants to provide information in regard to their awareness of and decisions to use GST, thoughts on their geospatial TPCK (G-TPCK), and observations of other high school geography teachers' behaviors concerning their awareness and knowledge of these technologies (Appendix J).

Participants and Setting

Geography teachers volunteered for Phase II of this study by indicating their interest in participating in the interviews and providing their contact information. Of the 78 high school geography teachers who completed the survey, 32 initially agreed to be interviewed. Twenty-one of these participants positively responded to an email invitation to participate that followed the survey administration. Concerning the difference in interview participants, it is possible that, by the time of the interviews, some educators had changed teaching positions or felt that it had been too long between the completion of the survey and the phone interview. Of the teachers ($n = 21$) who agreed to a telephone interview, only 14 were able to make their scheduled meetings. However, one teacher taught at an alternative learning center where grade levels and courses were merged depending on the student population each year; therefore, he/she did not solely teach geography at the high school level. Ultimately, 13 participants were interviewed for Phase II of the study. All participants received the interview questions via email for their review and selected times that best fit their teaching schedules. Some interviews were conducted during the day, while other teachers preferred to be contacted at night.

The 13 interviewees varied in their degree of education, experience using GST, and years of teaching experience. All agreed that technology should be used when teaching and were familiar with some of these technologies, including GIS. At the time of the interviews, one teacher had retired and one had become an administrator. These participants responded to the interview questions based on their experiences from the previous year. Appendix K summarizes participants' demographic profiles and descriptive statistics. Teachers' responses are discussed in the analysis discussion in Chapters VI through IX.

Data Collection Procedure

Based on an analysis of the survey data, interview questions were developed to explore teachers' decisions to use GST as instructional tools. The interviews were conducted in May 2012 and were transcribed in the summer and fall of 2012. A semi-structured format was used, which included broad questions that focused on three main areas: barriers to implementation, GST pedagogical training, and reasons why teachers use GST. Bourque and Fielder (2003) advocated using open-ended questions to guide telephone interviews, which allows participants to respond freely in a structured question sequence.

Generally when using a semi-structured, open-ended interview format, participants may feel more comfortable asking for clarification throughout the conversation. Additionally, this format provides the liberty to probe participants when their answers are limited or unclear. In the current study, semi-structured interviews guided the discussion with specific questions and provided an opportunity for participants to expand their answers to include other information they found important. To practice interviewing skills and improve question clarity and design, the interview questions were piloted with two seasoned secondary educators.

Field notes were taken and all interviews were digitally recorded for later transcription with participants' consent. Experienced transcribers completed the transcriptions of the recorded interviews, including pauses, laughs, coughs, etc. One interview was transcribed by a former Texas State University student who was referred by the Department of Student Services because of her experience in transcribing voice recordings and video. Casting Words, a transcription service referred by another researcher, conducted all other transcriptions. Casting Words was selected to transcribe the remaining interviews because it was a cost effective option.

Each interview yielded slightly different challenges to data collection. For example, on two occasions, participants provided rather lengthy responses, which made it difficult to control the pace of these interviews. However, providing research questions ahead of time helped facilitate the interview process and alleviate some concerns between orally and visually presented questions (Creswell 2003). During the interviews, participants were reminded of their previous survey answers to pertinent questions to ensure their answers had not changed. Finally, prompts helped situate participants to answer the interview questions.

Qualitative Data Generation

Interview responses were coded according to each question and common themes among the answers. Yin's (2011) five-part framework was followed to generate the qualitative data, which includes 1) compiling, 2) disassembling, 3) reassembling and arraying, 4) interpreting, and 5) concluding. Part 1 of the qualitative data generation process involved compiling the data, which occurred with the phone interviews (Yin, 2011). Part 2, disassembling, included reviewing the field notes and coding and sorting the data. Yin (2011) considered this method Level 1 coding, meaning it is the initial coding phase in which labels closely resemble the wording of the text. The term *open coding* also represents this process (Yin 2011), and many of the Level 1 codes relate to one another. Ultimately, the goal is to reorganize the codes and group them into like categories to provide Level 2 coding, which refers to reassembling and arraying codes (Part 3 of Yin's framework). Part 4, interpreting, is akin to analysis, which is discussed in the next four chapters. Part 5, concluding, includes final thoughts, which are offered in Chapter X.

The interview protocol established most Level 2 coding using the interview questions (Appendix J). Initially, the open-coded method was used to look for themes during the first and second readings of the transcripts (Strauss and Corbin 1998; Yin 2011). This analysis provided many categories in which to cluster and identify data using Level 2 codes. Although the researcher may have influenced some topics discussed in the interviews based on her line of questioning, additional themes were formed as the codes were further reduced.

Reliability and Validity

Litwin (2003) defined reliability as "a statistical measure of the reproducibility or stability of the data gathered by the survey instrument" (6). Conversely, validity was defined by how well the survey items "measure what they are intended to measure" (Litwin 2003, 31). Fink (2006) stated that reliability measures consistent information and validity measures the accuracy of the information (7).

The purpose of the mixed methods design was to use the strengths of both quantitative and qualitative data to improve reliability and validity. This research method used triangulation, or multiple methods, to verify data. The reliability and validity of this study's data were addressed by 1) assessing the internal consistency of survey items, 2) using experts to review the survey instruments and code data, 3) triangulating data from two sources (surveys and phone interviews), and 4) comparing current findings with previous research.

Reliability

Some reliability tests, such as test-retest reliability or alternate-form reliability, require multiple surveys administered to the same groups of participants. These tests were beyond the scope of this study. In both phases of this research, reliability of the instruments and analysis were checked using reliability tests that assessed single survey items and evaluator assessments.

Internal consistency was also assessed regarding survey items for specific variables. Internal consistency is an assessment applied to a group of items rather than single items "as an indicator of how well the different items measure the same issue" (Litwin 2003, 20). This verifies that all survey items identified as measuring one variable actually report a similar result. The responses to the Likert Scale questions indicated a strong internal consistency (Cronbach $\alpha = .95$), providing evidence that the survey was very reliable.

Codes regarding the phases of participants' innovation-decisions to use GST were more subjective in nature. Therefore, an interrater reliability test was conducted using two additional reviewers. Interrater reliability measures the consistency of agreement between two or more evaluators regarding "their assessment of a variable" (Litwin 2003, 26) and the correlation coefficient between data collectors. Researchers only use this test when the measurement of an external variable is subjective. In this study, the interrater reliability was moderate (.54) to high (.73); therefore, the researcher was confident in her assessment.

Assessing technological knowledge and technological pedagogical knowledge were more concrete because of the nature of the survey questions; therefore, the researcher's knowledge and expertise were sufficient to code these items. However, an external reviewer supplied an additional check of the coding. Expertise was used to code the Phase II telephone interview responses. An external reviewer provided an additional check for reliability by coding a portion of the interview transcripts using the final code schema to ensure confidence in the data analysis.

Validity

Survey instruments must yield valid responses. The reviewers who evaluated the survey to ensure validity had the following qualifications: subject area expertise, intimate knowledge of the technological capabilities in a typical high school, and membership with Texas Alliance for Geographic Education. Typically, researchers use multiple methods to address validity. In this study, face and content validity were used to ensure the accuracy of responses (Litwin 2003). Face validity involves a casual assessment of the look and feel of the survey. Surveys developed based on intuitive understanding, knowledge, or expertise typically use this type of validity assessment (Walker 2001). Content validity allows trained, experienced evaluators to review and assess the accuracy of an instrument (Newman and McNeil 1998; Plevyak et al. 2001; Dillman, Smyth and Christian 2009). These reviewers established face and content validity of the survey during the pilot test, which resulted in significant changes to the instrument design, including changing open-ended questions to lists, rewording some statements for clarity, and adding questions to elicit more detail.

Triangulation

One of the most popular and familiar approaches of mixed methods research includes triangulation (Creswell 2003, 217). According to Briller et al. (2008), mixed methods refer to a useful strategy to describe “multiple approaches to the study of a phenomenon” (245). Other researchers agree (Denzin 1978; Jick 1979; National Science Foundation 1997; Denzin and Lincoln 2000; Creswell 2003). In other words, the data from two or more different research techniques are used to corroborate and cross-validate results by offsetting the innate weaknesses in individual quantitative and qualitative models by focusing on the strengths of these methods (Greene, Speizer, and Wiitala 1989; Steckler et al. 1992; Morgan 1998; Creswell 2003).

Triangulation can take many forms, including methodological, theoretical, interdisciplinary, communication, and collaborative (Briller et al. 2008); however, it is ultimately the researcher’s choice to decide what multi-mode design is best for the study at hand. Triangulation can occur within an instrument using different types of items and between or across instruments using various data collection techniques (Denzin 1978; Jick 1979). All forms of the current research approach compared different types of data to provide a complete, holistic understanding of the phenomenon. Both the online survey and the supporting telephone interviews enriched the validity of the results and triangulated the data. Triangulation was salient to this study. Quantifying data that revealed the awareness and use of GST was equally significant to gaining insight into educators’ first-hand accounts regarding their decisions to use innovative technologies.

Data Generation: Addressing the Research Questions

Data in Phases I and II of this study were coded in several ways to allow for effective analysis. First, survey items were coded to reflect participants' levels of decision-making regarding GST as instructional tools using Rogers' (2003) stages of Innovation-Decision Process as variable names. Second, participants' answers were recoded to reflect their technological content knowledge (TCK) and TPCK regarding these technologies.

External reviewers coded survey items for each stage of the Innovation-Decision Process as some items were dual coded and complex in nature. It was assumed that participants' content knowledge, pedagogical knowledge, and pedagogical content knowledge were, at least, at a basic level; therefore, these constructs were not measured in this investigation. The geospatial knowledge variables (G-TCK and G-TPCK) were dependent on how participants answered their surveys. External reviewers coded survey items for each stage of the Innovation-Decision Process as some items were dual coded and complex in nature. External reviewers did not code TCK and TPCK variables. Rather, these variables were assigned survey questions by the principal researcher. This coding process was more simplistic in nature—an item reflected either technology knowledge, technological pedagogical knowledge, or neither variable. Variables in Phase II were also coded. The qualitative data gathered were first transcribed and then analyzed for common themes. The final step was recoding in which each variable was assigned a code that reflected Rogers' (2003) Innovation-Decision Process and Mishra and Koehler's (2006) TPCK.

Research Question 1: Data Generation to Explain Stages of GST Decision-Making

Participants were clustered, or categorized, according to their levels of GST awareness (knowledge), decision-making, and action (use). This analysis addressed Research Question 1: Using Everett Rogers' (2003) Diffusion of Innovations theoretical framework, how do teachers conform to the five stages of the Innovation-Decision Process with respect to accepting GST as pedagogic techniques to teach high school geography? Both Phases I and II yielded unique data that illustrated participants' conformity to this framework.

Phase I: Using Quantitative Data to Identify GST Innovation-Decision Stages

To group participants according to their decisions to use GST in the classroom, the survey items were recoded into new variables. The following codes were assigned to Rogers' (2003) Innovation-Decision Stages: "1" = Knowledge Stage, "2" = Persuasion Stage, "3" = Decision Stage, "4" = Implementation Stage, and "5" = Confirmation Stage. Participants' responses were then evaluated to determine whether their answers reflected attainment of a given stage ("1" = a positive response for a given stage and "0" = a non-positive [i.e., neutral, disagree, strongly disagree, etc.] response for a given stage).

A frequency table, by participant, was used to assess whether each participant had 50 percent or more positive responses. When this criterion was met, each participant was assigned to the stage being evaluated. It was possible that participants were assigned to more than one stage. For example, a participant assigned to the Decision Stage would also be assigned to the two subsequent stages, Knowledge and Persuasion. External reviewers recoded survey items according to the appropriate stage of the GST Innovation-Decision Process.

Innovation-decision external coding process

Content analysis involves the reading of texts, or other documents, to determine meaning. Krippendorff's (2004) approach to interpretative content analysis guided the coding protocol to determine participants' stages of the Innovation-Decision Process. This approach typically addresses the particulars of one type of data or document are compared to those of another type of data. Logically, neither type of data implies the other; therefore, further analysis of the data is required. Content analysis is not central to deductive or inductive research (Krippendorff 2004).

This investigation was deductive in its approach in that general stages of one's decision to use an innovation were presented initially, and survey and interview responses provided details that supported or refuted these generalities. Although content analysis, as described by Krippendorff (2004), was beyond the scope of this study, its principles were sound and provided direction to use with external reviewers. Coders' knowledge and experiences can enrich a study as they examine and interpret data for latent content and meaning. Additionally, when variables are subjective in nature, it is suitable to use reviewers to determine the appropriate codes for each variable. Because the nature of Rogers' (2003) Innovation-Decision Stages was subjective, two reviewers, in addition to the researcher, assisted in determining the codes for each survey item.

External coders

According to Krippendorff (2004), "Coders need a level of familiarity with what they are looking at that usually cannot be made explicit by any instruction" (128), and they need to be familiar with the vernacular of the topic studied to interpret the content properly. He also noted, "*Familiarity* denotes a sense of understanding that coders must bring to a content analysis. But the sharing of similar *backgrounds*—similar histories of involvement with texts, similar education, and similar social sensitivities—is what aids reliability" (128). All coders for this study, including the researcher, had significant background in the geosciences and experience with GST. One reviewer was a secondary science educator with a Master's degree in Science Education in Physics and Astronomy who had expertise in earth science and environmental education. The other reviewer was a doctoral student in geography education who had experience providing professional development for K-12 educators. At the time of this study, the researcher was a doctoral student in geography education with experience in developing science and geography secondary lessons, worked as a high school geography teacher, and provided professional development for geography content and GST. The coders employed for this study did not know each other, and they worked independently.

Codebook and coding sheet

A codebook and coding sheet were created to train the reviewers and ensure a consistent, reliable evaluation of the survey questions (Appendix F). The coders did not evaluate participants' responses. Rather, their purpose was to examine the text of the survey items and assign appropriate variable names to reflect participants' stages of GST adoption (Rogers 2003). Definitions were applied for each adoption level to code survey items accordingly and to identify participants who represented different stages in the Innovation-Decision Process.

The codebook explained the objective of the exercise, defined the categories and levels of participants' decisions to use GST, and provided explicit details for coding. Each reviewer was furnished with a document that specified knowledge levels exhibited in each stage of Rogers' (2003) Innovation-Decision Process (Appendix H). Reviewers were asked to examine the survey items and think about what knowledge and abilities were required to answer the questions. Great care was taken to ensure the coders did not assume any additional knowledge, rather focused only on each question independent of the other survey items. The codebook was available to coders for reference throughout the coding process.

A coding sheet (Appendix G) accompanied the codebook for the reviewers to record their evaluations of the survey items. This document included the following four columns: survey items, primary code, secondary code, and notes. Reviewers were asked to assign variable names with one primary code. Thus, reviewers were required to assign one stage of the Innovation-Decision Process that best fit a given survey item. It was expected that some items would be dual coded; therefore, reviewers were allowed to use a secondary code to reflect another stage represented by a question. The notes section furnished coders space to make comments. Reviewers also used this section to provide justification for coding or for questions. Reviewers received these via email prior to training.

Training coders

Each reviewer participated in an individual one-hour training during which time they were given background information on Rogers' (2003) Innovation-Decision Process and were informed of the coding terms, procedures, documents, and expectations. Examples of each stage and explanations of the reasoning behind each decision were provided, and the documents were reviewed. The training took place face-to-face with one reviewer and via phone with another. The reviewers were asked to record their evaluations digitally using a specific file-naming protocol and return the documents via email.

Ideally, reviewers relied on only their training experience and coding materials to complete their analyses. However, additional training is sometimes necessary (Krippendorff 2004). When the initial coding sheets were returned with few dual-coded items, reviewers received additional training and examples that included defining the stages, providing new examples, and questioning coders to ensure understanding. The final codes of the survey items were assessed for reliability, which yielded moderate (.54) to strong (.73) reliability among reviewers.

Generally, agreement of either two or all three reviewers determined the code used. When the two external coders did not agree, the researcher determined the appropriate code. This decision was sufficient because both coders were largely consistent with the researcher who had greater expertise and knowledge in this area of research. After the coding process, each variable was assigned to an Innovation-Decision stage.

Analyzing stages of GST decisions using coded survey data

Survey data were used to form a general overview of participants' GST awareness; current and planned use; and perceived barriers, benefits, and potential of GST use (Table 5.3).

Table 5.3. Overview of Participants' GST Awareness

Survey Questions
1. I am aware of desktop Geographic Information Systems (GIS) software. (Likert scale)
2. I am aware of online Geospatial Technologies (GST). (Likert scale)
3. What forms of desktop GIS software are you aware of? (Check all that apply.)
4. What forms of Geospatial Technologies are you are aware of? (Check that apply)
5. I use GST to teach geography. (Likert scale)
6. Currently, I use Geospatial Technologies (GST) to teach geography. (Select the appropriate answer)
7. How do you use GST in your classroom? (Check all that apply)
8. I am willing to learn more about GST. (Likert scale)
9. In the future, I plan to use GST to teach geography (Select appropriate frequency)
10. Challenges (Check all that apply)
11. Benefits (Check all that apply)
12. Potential (Check all that apply)

To study these items further, the first seven questions were used to compare stages of participants' decisions to use GST as instructional tools. According to Rogers (2003), increasingly positive decisions toward an innovation reflect increased knowledge of, positive attitudes toward, and decisions to use the innovation. These questions reflected these characteristics.

Participants' responses were evaluated to determine whether their answers reflected characteristics that indicated their GST knowledge and decisions. As explained previously, a binary code identified individuals who answered survey items positively or non-positively. When all questions coded for a stage individually were positively answered 50 percent or more of the time, participants were associated with that stage. Those who responded with positive answers to all questions in each stage less than 50 percent of the time were identified as "Pre-Knowledge."

It should be noted that knowledge and knowledge levels were fluid and ever changing. As such, the data portrayed individuals with an array of knowledge and abilities. Therefore, this type of coding did not reflect a state of attainment per se; however, a best assessment determined by external review using a locally verified rubric. Because the researcher determined the criteria for stage attainment, some individuals could have been misidentified. Perhaps, with additional resources and financial support, a team of experts could determine a more exact way to identify participants' levels of knowledge and decision-making. However, the participant selection method used in the current study included those who engaged in the GST adoption process positively and on a regular basis (50 percent or more of the time).

Phase II: Using Qualitative Data to Identify GST Innovation-Decision Stages

Participants were asked to volunteer for telephone interviews to discuss the use of GST in secondary geography education. Thirteen agreed to be interviewed. The interview was designed to support and extend the quantitative data gathered during Phase I of the study and to assess participants' decisions to use GST as instructional tools.

According to Rogers (2003), Early Adopters are recognized as leaders in their social communities. Because participants indicated that they used GST in some way, they largely represented either Innovators or Early Adopters. Kerski (2000) and White (2008) supported the notion that educators who engage these technologies are one of the two aforementioned groups of adopters. Because earlier research (e.g., Kerski 2000 and White 2008) suggested that users of GST are Innovators or Adopters, it was assumed that participants were knowledgeable of the geography education community. Therefore, they were asked to comment on their observations of other geography teachers' awareness and use of GST in the geography classroom. These comments were used to convey information about other facets of the geography education community.

Participants' GST Decision Stages were determined using a series of questions, and participants confirmed their responses to the survey item "I use GST to teach geography." This item identified whether participants had made a decision to use GST, which helped determine the appropriate stage in the Innovation-Decision Process. Other questions included topics that targeted GST knowledge, teaching strategies (pedagogy), barriers to use, and decisions for continued use. Each topic was designed to address one or more of Rogers' (2003) stages of the Innovation-Decision Process.

Interview items about other geography teachers also were informative regarding their possible stages of GST decisions. Participants were asked three questions that inquired as to why other teachers did not use GST, what would compel them to use these technologies, and whether social studies or geography teachers valued such technologies. The data yielded from these questions addressed both GST awareness and use by other geography teachers.

These items were imperative because very little is known about the majority of geography teachers concerning technology use. As Rogers (2003) described, the Early and Late Majority populations are slower to accept an innovation and are tied to a greater degree to the status quo and rules governing their communities. In this study, the combined Early and Late Majority populations are referred to as the "majority," and it was anticipated that "other" geography teachers represented this majority. This majority is greatly influenced by Early Adopters who are willing to try something new and vet it for others. Because GST are slow to diffuse into the geography community, understanding the majority of geographers' characteristics and needs is a critical step to diffusing GST in the future. Thus, the interview questions were only an introduction to a conversation that must commence about motivating and enticing the majority of geography educators to use GST as tools for instruction.

Research Question 2: Data Generation to Explain G-TPCK

Both quantitative and qualitative data were used to identify participants' characteristics that suggest a certain degree of G-TPCK. Participants' teacher certifications and geography course assignments provided evidence for their basic geography content and pedagogical content knowledge; therefore, content knowledge (CK) was understood and included when discussing technological or technological pedagogical knowledge (i.e., TCK or TPCK). The analysis for Research Question 2 focused on assessing participants' geospatial technological knowledge (G-TCK) and G-TPCK. Participants were categorized as G-TPCK only when they exhibited signs of both knowledge and pedagogical (teaching strategies) knowledge specific to using these technologies when teaching geography. If participants did not display G-TCK or G-TPCK, they were considered to have "Limited G-TCPK."

Phase I: Using Quantitative Data to Identify G-TPCK

Research Question 2 was as follows: Using Mishra and Koehler's (2006) TPCK framework, do high school teachers who exhibit more TPCK use GST more frequently compared to other teachers? Answering this research question was less subjective than answering questions on participants' stages of the GST Innovation-Decision Process; therefore, it did not require the use of external evaluators. All survey items for these data were coded (see Appendix I). Basic participant geographic content knowledge was implicit because participants must have shown some competence to be assigned to teach geography by their school supervisors. Additionally, it was assumed that participants had general pedagogical knowledge because all were state-certified teachers. Therefore, this survey was designed for geography teachers to report their personal G-TCK and G-TPCK in their content areas.

Responses were evaluated to determine whether the provided answers reflected characteristics for technological knowledge and technological pedagogical knowledge; data were coded "1" for positive responses and "0" for non-positive response for G-TCK or G-TPCK characteristics. Participants were assigned to a category based on their average response scores. When participants responded positively 50 percent or more of the time to a TPCK coded question, they were assigned to the G-TPCK group. Participants who answered TPCK coded questions 30-49 percent of the time were placed in the G-TCK category. Finally, those with an average TPCK score below 30 percent were identified as "Limited G-TPCK."

Analyzing Participants' G-TPCK Using Coded Survey Data

Participants' G-TPCK was evaluated with respect to Rogers' (2003) Innovation-Decision Process using the first seven questions listed in Table 5.2 to analyze the data. The data served as a comparison among the three TPCK categories: G-TPCK, G-TPCK, and Limited G-TPCK. Finally, participants were assessed in each stage of decision-making regarding their TPCK characteristics to develop a complete profile of Rogers' (2003) and Mishra and Koehler's (2006) frameworks for a combined analysis.

Phase II: Using Qualitative Data to Identify Participants' G-TPCK

During the voluntary, semi-structured telephone interviews, participants answered a series of questions on topics regarding their current awareness and use of GST as well as their pedagogical knowledge for these technologies. The data gathered indicated the degree of their G-TPCK. They also commented on other teachers' decisions to use GST and possible reasons for their decisions. The information yielded from these questions addressed GST knowledge and G-TPCK by different teacher groups (participants and other geography teachers).

The following four analysis chapters explore the data generated during the quantitative and qualitative phases of this research. Chapter VI offers a general overview to provide a holistic profile of the sample population for this study. Chapter VII addresses the original research questions via Phase I and Phase II data to discuss the current diffusion of GST as tools for instruction using Rogers' (2003) framework. Chapter VIII reports on the evaluation of the quantitative and qualitative data and suggests elements of participants' G-TPCK to address the second research question using Mishra and Koehler's (2006) framework. Finally, Chapter IX compares G-TPCK at each stage of the Innovation-Decision Process.

CHAPTER VI

ANALYSIS: A QUANTITATIVE OVERVIEW

Kerski’s (2003) research, conducted in the late 1990s, served as the impetus for this investigation. He was the first researcher to examine national use of geographic information systems (GIS) among high school teachers. At the time, less than two percent of American high schools had adopted GIS as tools for instruction (Kerski 2003). Over a decade later, the current study aimed to measure the diffusion of geospatial technologies (GST) among high school geography teachers as evidenced by use and/or knowledge about these technologies in the classroom setting. Because of the length of time between studies and the influx of online technologies, it was expected that high school educators would view the use of GST more favorably as tools for instruction. Therefore, when appropriate, comparisons between Kerski’s work and the current research are examined in Chapter VI. The nature of the QUANT-QUAL study reflects that the quantitative phase is the more dominant method that describes detailed information for the entire sample population; therefore, an overview of the quantitative data was appropriate.

School Demographic Data and Sample Population Information

The sample population was selected from specific state Geographic Alliance memberships because they represented teachers who were committed to developing their content and pedagogical knowledge. The state Geographic Alliance Network has developed a culture of expectations for members to attend professional development events and increase their knowledge and skills as educators. As such, these Alliances represented teachers who were most likely to be exposed to GST in some way.

Five states were chosen for this study because they required geography for high school graduation as per conversations in 2010 with the Social Studies Supervisors of these states (i.e., Mississippi, Minnesota, South Dakota, Texas, and Utah). The State Geographic Alliance Coordinators received a link to the online survey to be distributed to members in their networks. The South Dakota Geographic Alliance did not have this infrastructure; therefore, the questionnaire was sent through the South Dakota Social Studies Department of Education (DOE) listserv with the permission of the State Social Studies Supervisor.

Participants represented public schools in either urban or suburban areas with large numbers of lower and middle socioeconomic students. Profile data provided background information about participants' teaching environments and knowledge bases from which to understand responses during the study. Of the 153 teachers who completed the survey, 78 high school geography teachers met the participation criteria. Largely representative of public institutions (97 percent), these teachers reflected mainly low- and mid-socioeconomic (41 percent and 45 percent, respectively) institutions. The remaining participants (14 percent) were from high-socioeconomic schools. Half of the participants (50 percent) were from suburban schools, while the others were mainly from urban schools (38 percent). A few (12 percent) participants were from rural areas (Figure 6.1).

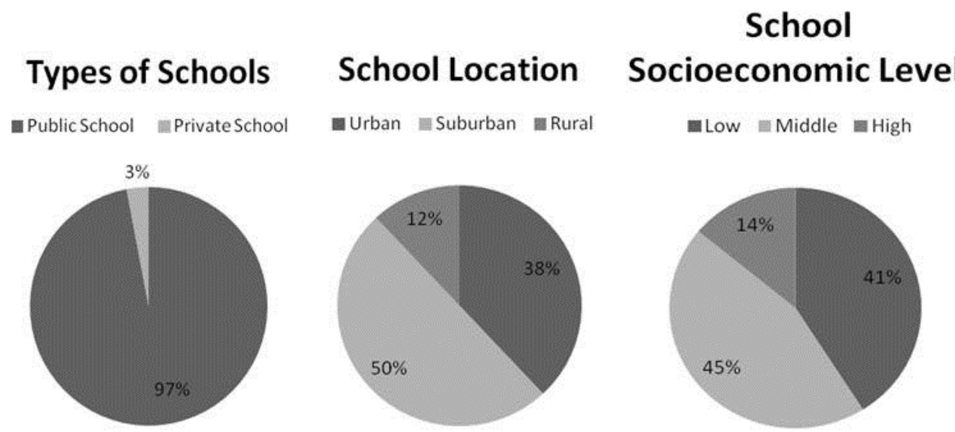


Figure 6.1. Participants' school demographics, n = 78

Participant Demographic Data

Participants represented all ages and years of teaching experience. Table 6.1 summarizes pertinent descriptive statistics from the total sample. The population of State Geographic Alliance members consists of early career to experienced teachers. Generally, Alliances have relatively few pre-service and new teachers; therefore, few new teachers participated in this study. Although the majority of participants were in their 50s (41 percent), teachers in their 30s and early 40s made up 45 percent of the sample population.

The two smallest groups of teachers were in their 20s (5 percent) and late 40s (9 percent). For this study, teachers were considered "new" (0-2 years of experience), "early career" (3-5 years of experience), "mid-career" (6-10 years of experience), or "experienced" (over 10 years of experience). The majority of participants were experienced teachers (62 percent); however, early (19 percent) and mid-career teachers (15 percent) were also included in the sample population.

Table 6.1. Participants' Demographic Data

Variable Description		Number of Participants (n = 78)	
		n	%
Teacher Age	20-25 years	1	1
	26-30 years	3	4
	31-35 years	10	13
	36-40 years	11	14
	41-45 years	14	18
	46-50 years	7	9
	51 years or older	32	41
Ethnicity	Caucasian	71	91
	Hispanic	5	6
	Asian	1	1
	African American	0	0
	Native American	1	1
Gender	Male	31	40
	Female	47	60
Highest Degree Earned	Bachelor's Degree	52	67
	Master's Degree	45	55
	Doctorate Degree	2	3
Teaching Experience	Pre-service teacher	0	0
	0-2 years	4	5
	3-5 years	14	19
	6-10 years	12	15
	11 years or more	48	62

Other key demographics included gender, ethnicity, and education. Nearly two-thirds of those surveyed were female (60 percent). The majority of participants were Caucasian (9 percent), and other ethnicities represented included Hispanic (6 percent), Asian (1 percent), and Native American (1 percent). No African Americans teachers participated in the study. This phenomenon may reflect the population of geography educators in general within the surveyed states or within the state Geographic Alliances specifically. Over half (n = 45) of the participants had master's degrees and two participants had doctoral degrees, which reinforced their proclivity to improve as educators.

Educators' Geospatial Technologies Awareness, Use, and Attitude: An Overview

Examining Participants' Awareness of Geospatial Technologies

General information about participants' GST awareness and use must be realized before addressing the stages of adopting these technologies in the classroom, which will be discussed in Chapters VII through IX. To appreciate participants' decisions regarding GST implementation, it was also important to address their pedagogical and content knowledge, which is referred to as Geospatial Technological Pedagogical Content Knowledge (G-TPCK). Here, the term *awareness* refers to basic knowledge about these technological innovations, while *use* refers to the intentional application of these technologies to enhance geographic learning. Awareness and use of an innovation indicated the level of progression of GST diffusion into the high school geography educator population. To assess participants' awareness, both Likert scale and multiple choice questions were included in the survey. Determining awareness included questions that specifically targeted desktop GIS, which has been actively included in educator professional development since the 1990s, and online GST, which has become widely available in recent years.

The questionnaire began with Likert scale items to assess teachers' knowledge, skills, and attitudes toward technology, in general, and toward GST specifically (Tables 6.2 and 6.3). Most participants agreed or strongly agreed that they were aware of GIS and online GST (80 percent and 66 percent, respectively). Alternatively, another survey item reflected that fewer participants were aware of online GST. This occurrence may be reflective of the newness of the term *geospatial technologies* rather than specific technologies as evidenced by the number of participants who identified using specific forms of desktop GIS and other GST.

Table 6.2. Desktop GIS Awareness Using Likert Scale Data

Variable Description		Number of Participants (n = 78)	
		n	%
I am aware of desktop Geographic Information Systems (GIS) software.	Strongly Disagree	4	5
	Disagree	8	10
	Neutral	4	5
	Agree	41	53
	Strongly Agree	21	27

Table 6.3. Online GST Awareness Using Likert Scale Data

Variable Description		Number of Participants (n = 78)	
		n	%
I am aware of online geospatial technologies (GST).	Strongly Disagree	4	5
	Disagree	13	17
	Neutral	9	12
	Agree	37	47
	Strongly Agree	15	19

Participants were given the opportunity to identify 11 forms of GIS and 10 forms of other GST. They were far more aware of the Esri desktop ArcView GIS than other forms of desktop GIS software (Table 6.4). Although more than half of the participants recognized Esri ArcView GIS (n = 56), only a quarter fewer participants recognized other similar software such as ArcVoyager (28 percent), ArcExplorer Java Edition for Educators (AEJEE) (26 percent), My World GIS (23 percent), Earth Resource Data Analysis System (ERDAS) Imagine (23 percent), and MapInfo (22 percent).

Between one and nine percent of teachers recognized the remaining six forms of desktop GIS. It was not surprising that the most popular GIS software programs were those designed or modified with the educator in mind and that included ancillary resources for teacher support. Additionally, Esri's ArcGIS software may fare better because of the strong marketing presence of this company at many education professional development events and its support staff who are dedicated to education. The lack of knowledge about the specific systems available to geography teachers represented a startling disconnect for those who initially agreed or strongly agreed that they were aware of GIS.

Table 6.4. Awareness of Desktop GIS Technologies

Types of GIS	Number of Participants (n = 78)	
	n	%
Esri ArcView GIS	44	56
ArcVoyager	22	28
ArcExplorer Java Edition for Educators (AEJEE)	20	26
My World GIS	18	23
Earth Resource Data Analysis System (ERDAS) Imagine	18	23
MapInfo	17	22
Geographic Resources Analysis Support System (GRASS)	7	9
IDRISI	6	8
MS MapPoint	6	8
SmallWorld	4	5
InterGraph GeoMedia	2	3
Manifold	1	1

On the other hand, more participants were aware of other forms of GST, ranging from visualization tools to GIS-based interactive applications to robust online GIS websites (Table 6.5). The most popular GST tool was Google Earth, which 97 percent of participants recognized, followed closely by MapQuest (87 percent) and Global Positioning Systems (GPS) (83 percent). Participants were also well aware of interactive maps (49 percent), remotely sensed images (49 percent), and mapping games (47 percent).

It would be interesting to know how much GST knowledge was obtained from exploring the Internet, playing games, word-of-mouth, professional networks, or professional development. However, this study did not explore these other methods of learning about GST. The most well-known forms were visualization tools, which could be very powerful in the hands of an educator who encourages and models geographic thinking using inquiry, spatial thinking, and reasoning to understand concepts, systems, processes, connections, and situations around the world.

Table 6.5. Awareness of GST Technology

Type of GST	Number of Participants (*n* = 78)	
	n	%
Google Earth	76	97
MapQuest	68	87
Global Positioning System (GPS)	65	83
USGS Interactive Map	38	49
Remotely Sensed Images (e.g., Aerial Photography, LandSat Photography, Earth Observatory)	38	49
Mapping Games	37	47
National Atlas	31	40
ArcGIS Explorer	29	37
ArcGIS Online	24	31
Globalis	11	14
FieldScope	4	5

Participants were even more aware of online GIS-based applications or online GIS applications than most brands of desktop GIS software. For example, participants identified applications such as National Atlas (40 percent), ArcGIS Explorer (37 percent), and ArcGIS Online (31 percent) more readily than most forms of desktop GIS. With the exception of Globalis, which was no longer available online at the time of this study, and FieldScope, which did not have a project in the surveyed states, over one-third recognized all other GST listed in the survey. When comparing GIS systems, the lack of knowledge for the desktop software versions was a concern.

Knowledge of desktop GIS software presents a very different story. Fifty-six percent recognized Esri's desktop ArcView GIS, while fewer than 25 percent were aware of most forms of GIS software. This fact directly contrasted the 80 percent of participants who agreed or strongly agreed that they were "aware of GIS," which indicates that participants may be more aware of the term GIS rather the actual software. Awareness for the term GIS may stem from the increasing number of secondary textbooks that include information about this specific technology. Although many textbooks offer information about GIS, few suggest ways to use this technology when teaching, thereby stagnating the adoption process.

ArcGIS online fared better than its desktop counterparts, as 31 percent of the sample recognized this technology. This finding is particularly significant because of the incredibly rapid development and awareness of the online application. Desktop ArcGIS (available to teachers since the early 1990s), while slow, is still gaining tracking, while ArcGIS online has increase quickly over its three years on the market. Specifically, 20 years after Esri introduced its desktop ArcView GIS in the early 1990s, only 56 percent of the sample recognized this software. Conversely, after just three years on the market, 31 percent identified Esri's ArcGIS Online.

The progression of GST awareness from simple and complex visualization tools (e.g., MapQuest and Google Earth) to online GIS-based applications (e.g., National Atlas) to full online GIS applications (e.g., Esri ArcGIS Online) may illustrate the path of technology diffusion among high school geography teachers from basic to advanced users. As trained social studies educators, participants were comfortable using static images (e.g., maps, pictures, and diagrams) to identify key concepts, engage in discussions, and elicit interest. Therefore, they may be more comfortable initiating their experiences with Google Earth, GPS, remotely sensed images, MapQuest, and similar technologies.

As computers have increased in popularity and the Internet has become more commonplace, educators' comfort and confidence with "surfing" the web is likely to increase. Common web skills include clicking on links to learn more, scrolling in and out of maps, and so forth. These skills are transferable to applications such as Google Earth and interactive maps. Teachers continually build skills, abilities, and confidence, which may lead to a natural interest in and graduation to more robust uses of GIS applications, such as National Atlas, ArcGIS Explorer, and ArcGIS Online.

Although 66 percent of participants reported that they were aware of GST, clearly they were more aware than they perceived themselves to be. Programs such as MapQuest (87 percent), GPS (83 percent), and Google Earth (97 percent) may be ubiquitous, and thereby, overlooked as forms of GST. Additionally, preconceived notions of the term *geospatial technologies* could have influenced responses. The generic use of the term may also have been intimidating and, despite the researcher's efforts to counter this effect, may have represented robust desktop versions, which could be viewed as too complex to incorporate into the classroom. Whether responding to Likert scales or multiple choice questions, a strong contingency of experienced high school geography educators were aware of GST.

Geospatial Technologies Use

The key to measuring growth in technology diffusion is recognizing the extent to which educators actually use certain technologies. Kerski (2000) initiated the discussion when he noted that only two percent of all high school teachers used GIS software. The geospatial technology industry quickly developed over the past 15 years to include many forms; therefore, GST are not defined solely by robust, industrial-strength desktop GIS. Rather, they are defined in this study on a continuum from easily accessed visualization tool, to applications with preset data layers to more complex modeling programs that are compatible with online and desktop GIS software (Figure 6.2).

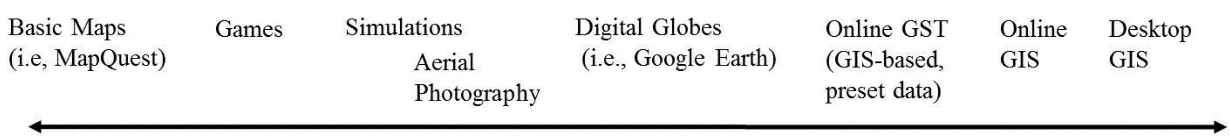


Figure 6.2. Geospatial technology progression of complexity.

Using both Likert scales and multiple choice questions, participants were asked to report how they engaged GST when teaching. Each method elicited a slightly different response. Although a clear majority of participants was aware of desktop GIS, other GST, or all technologies, only 42 percent responded positively to the statement, “I use GST to teach geography” (Table 6.6). Another 42 percent of participants provided a negative response, and the remaining 17 percent provided neutral responses.

Table 6.6. Use of GST to Teach Geography

Variable Description		Number of Participants (*n* = 78)	
		n	%
I use GST to teach geography.	Strongly Disagree	9	12
	Disagree	23	30
	Neutral	13	17
	Agree	26	33
	Strongly Agree	7	9

When asked about the frequency of GST use (Table 6.7), responses changed somewhat, and four chose not to respond. Of the remaining participants (*n* = 74), 32 percent stated that they never used these technologies to teach geography. Some geography educators only used them occasionally, once a semester (14 percent) or once a grading period (13 percent). On the other hand, 36 percent stated that they used these technologies more frequently, meaning monthly (18 percent), weekly (13 percent), or two or more times a week (5 percent). The finding that over two-thirds (68 percent) of the participants used GST on some level may indicate a change in the awareness and diffusion of GST within the high school geography education community.

Table 6.7. Current Frequency of GST Use

Variable Description	General Survey Population (*n* = 78)	
	n	%
Never	25	32
Once a Semester	11	14
Once a Grading Period	10	13
Once a Month	14	18
Once a Week	10	13
2 or More Times a Week	4	5
Missing	4	5

Reports of the use and current frequency of GST use may be due to the placement of the questions in the survey instrument. The initial Likert scale question was placed at the beginning of the questionnaire, while the question regarding frequency of use was located in the middle of the survey after different forms of GST were provided. Therefore, participant awareness and understanding of the breadth of applications may have been enhanced during the administration of the instrument. However, the data suggest that use of these technologies has increased from that reported in Kerski's (2000, 2003) study, which could be the result of more options available to current teachers.

More telling is the way in which participants engaged these technologies in the classroom (Table 6.8). Participants were asked to identify whether they used GST personally or professionally. This survey item required participants to mark all answers that applied; therefore, some may have selected multiple ways that reflected how they interacted with these tools. Nearly a quarter of participants (*n* = 18) selected "Do not use GST." On the other hand, 27 percent engaged GST on a personal level, while 42 percent integrated these technologies as part of their preparation for instruction. The majority of participants incorporated these technologies into instruction (53 percent), student activities (47 percent), or as part of student assignments (30 percent). The data showed both teacher and student engagement with GST, which illustrates a more integrated use of these technologies than Kerski found nearly 15 years ago.

Table 6.8. Geography Teachers' Uses of GST

Variable Description	General Survey Population (n = 78)	
	n	%
Do not use GST	18	23
Personal Use	21	27
Prepare for Class	33	42
Teach Geography	41	53
Student Activities	37	47
Student Assignments	23	30
Missing	0	0

*Note: Each variable was available for response. Participants were instructed to "check all that apply."

The discrepancy between the Likert scale item, "I use GST to teach geography," and the multiple choice question concerning how participants used GST may be explained through the word "use." The word "use" could be interpreted in various ways. Thus, clarifying questions were critical. Providing a list of different levels of GST integration may have resulted in each participant defining "use" differently. Differences in this definition could explain the 30 to 53 percent of participants who indicated that they used GST for student assignments, activities, or instruction. Additionally, participants could select choices that did not involve "teaching with" GST. In fact, personal use, which accounted for 27 percent of responses, may reflect a portion of the 32 percent who disagreed or strongly disagreed to the statement "I use GST to teach geography."

Intended Future Geospatial Technologies Use

A key to measuring the potential interest and diffusion of GST as tools for instruction in geography education was the teachers' willingness to learn about these technologies and their intentions to use them as tools for instruction in the future. Initially, participants were asked to indicate their willingness to learn more about GST.

Overwhelmingly, 93 percent agreed or strongly agreed that they were interested in learning more. Only two participants disagreed (Table 6.9).

Table 6.9. Willingness to Learn More about GST

Variable Description		Number of Participants (n = 78)	
		n	%
I am willing to learn more about GST.	Strongly Disagree	0	0
	Disagree	2	3
	Neutral	2	3
	Agree	26	33
	Strongly Agree	47	60

On a related survey item, participants were asked to choose the level of frequency with which they planned to incorporate GST into their instruction (Figure 6.3; Table 6.10). One participant stated that he/she never expected to include these technologies in the classroom. A few participants (14 percent) indicated that they only occasionally planned to use GST, meaning once a semester or grading period. However, the majority (65 percent) planned to use these technologies at least once a month or once a week. Almost one-fifth (18 percent) expected to include them in instruction two or more times a week. Sixty-five (83 percent) participants recognized the importance of these technologies as tools for instruction and intended to incorporate them into geography learning environments on a regular basis.

Table 6.10. Future Plans to Use GST as Instructional Tools

Variable Description	General Survey Population n = 78	
	n	%
Never	1	1
Once a Semester	3	4
Once a Grading Period	8	10
Once a Month	18	23
Once a Week	33	42
2 or More Times a Week	14	18
Missing	1	1

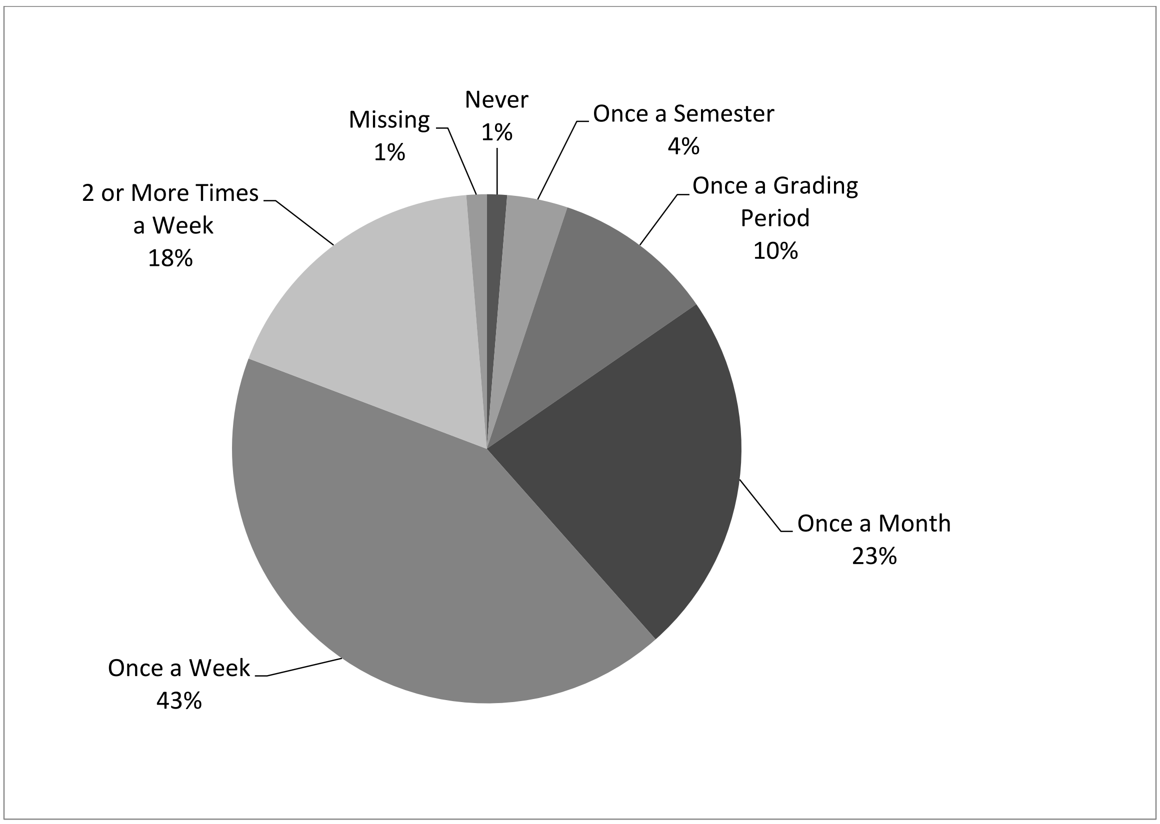


Figure 6.3. Future plans to use GST as instructional tools.

Geospatial Technologies Attitude: Addressing Comfort and Confidence Levels

In addition to understanding motivating factors for incorporating GST when teaching, establishing comfort and confidence in using and teaching with these technologies may be vital for their longevity as instructional enhancements. The difference in the number of teachers who indicated using these technologies for instruction, activities, assignments, or lesson planning is evidence of progress between Kerski's analysis and the current study. For over a decade, some Alliances, professional developers, and members of the geography education community have led a concerted effort to build awareness of GST among K-12 educators and this may account for this change in thinking.

A critical part of developing awareness of and willingness to try an innovation is establishing a strong comfort level and confidence in one's abilities to employ technology (Ertmer and Ottenbreit-Leftwich 2010). In the current study, more teachers reported using GST compared to those who reported having adequate knowledge of these technologies (Table 6.11). In other words, the data suggested that geography educators who used GST were not always comfortable with their knowledge of these technologies. For example, 33 percent agreed and nine percent strongly agreed that they used GST to teach geography; conversely, only 24 percent and six percent, respectively, were comfortable with their knowledge of GST. These findings may indicate geography teachers' willingness to test a technology prior to fully developing a sound understanding of how that technology operates or how educators apply it to instruction.

Table 6.11. Comfort and Confidence with GST

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
I use GST to teach Geography.	9	12	23	30	13	17	26	11	7	9
I am comfortable with my knowledge of geospatial technologies	7	9	24	31	23	30	19	24	5	6
I am confident in my ability to use geospatial technologies to plan geography lessons.	5	6	21	27	20	26	24	31	8	10
I am confident in my ability to use geospatial technologies When teaching geography.	6	8	21	27	16	21	28	36	7	9

It was possible that participants undervalued their GST knowledge and comfort, which may stem from an introspective assessment. For example, participants might have compared themselves to where they thought they should be and did not fully appreciate their current levels of knowledge and skills, thereby biasing the results. However, when asked to apply their technology knowledge to instruction, participants were more likely to report being confident in their abilities. Knowing where to employ and how to integrate technology into the curriculum may seem less intimidating as teachers consider the scope and sequence of their curriculum and feel more confident when constructing lessons. It is also possible that questions regarding participants' specific technological knowledge were intimidating, which made them feel ill equipped and, overall, undervalue their actual abilities.

Participants' confidence of their abilities to teach and develop lessons more closely reflected their GST usage patterns (Table 6.11). Thus, educators' emotions toward an innovation may be very influential to diffusing that innovation. It is essential that future research differentiate the influence of geography educators' confidence with desktop and online GST.

Implementing Geospatial Technologies: Challenges, Benefits, and Potential

The geography community has long recognized the importance of acknowledging the impediments and benefits of incorporating GST into geography education (i.e., Kerski 2000, 2003; Bednarz 2004; Baker 2005; Milson and Kerski 2012). These elements should be investigated to explain possible teacher behaviors and decision-making processes. These elements also serve to document the development of GST and the changing needs of educators as they grow to meet the evolution of these technologies.

Challenges Implementing Geospatial Technologies in a Secondary Classroom

A list of challenges regarding GST as a pedagogical enhancement was derived from the barriers identified in Kerski (2000) and other literature (e.g., Baker 2005; Milson and Kerski 2012). Not all barriers listed in Kerski's study were included in the current study as they were no longer relevant or had been addressed thoroughly in the literature. Additional items were provided in the current study to reflect barriers recognized in other studies such as Baker (2005) and Milson and Kerski (2012). For example, participants were asked to identify all challenges to implementing GST in the classroom; multiple responses were permitted (Table 6.12). All of the original barriers aligned with challenges noted in the current study.

Table 6.12. Challenges to Using GST: Past and Present

Barriers Identified by Kerski	Barriers to Current GST Use	Number of Participants (n = 78) *n*	%
Lack of access to computers*	Available computer time	43	55
Need GIS-based lessons/Lack of local data	Lack of resources	38	49
Lack of technical support**	Lack of technical support	38	49
Lack of awareness**	Awareness of available technology	37	47
Software problems*	Software	37	47
	Time in the curriculum	36	46
Need training*	Lack of available professional development	33	42
Short class periods**	Instructional time	31	40
Preparation time too long*	Planning time	31	40
	Do not know teaching strategies to incorporate GST into a geography classroom	30	39
Lack of awareness**	Do not know how to use GST	27	35
Difficult to implement*	Time it takes to learn the technology before teaching students	24	31
Lack of other teachers**	Few others use this technology in my school	22	28
	Internet availability	21	27
Hardware problems*	Hardware	20	26
	Lack of colleague support	14	18
Lack of administrative support**	Lack of administrative support	12	15

* Top six challenges reported by Kerski (2000).
** Challenges identified by one or two participants in Kerski (2000).

Of participants surveyed, 46 to 55 percent identified the following six challenges: available computer time (55 percent), lack of technical support (49 percent), lack of resources (49 percent), software (47 percent), awareness of available technologies (47 percent), and time in the curriculum (46 percent). Although the lack of available computer access was a key concern (n = 43), 31 percent indicated that they had access to computers via a laptop cart or computer lab more than once a week (10 percent), at least once a week (14 percent), or once a month (14 percent) (Table 6.13).

For some participants, computers were occasionally available once a grading period (15 percent) or once a semester (8 percent). Six participants had no access to computer labs or laptop carts. The 55 percent who cited computer access as a problem on a previous item may have been part of the 69 percent who did not have access to computers "whenever they need it." Availability may also be a loaded term that needs to be unpacked in future studies. Software concerns and the need for training continued to be perceived as an issue to incorporating technology into geography instruction.

Table 6.13. Plugged In: Access to Computer Labs and/or Laptop Carts

Variable Description	Number of Participants (*n* = 78)	
	n	%
Never Available	6	8
Once a Year	0	0
Once a Semester	6	8
Once a Grading Period	12	15
Once a Month	11	14
Once a Week	11	14
More Than Once a Week	8	10
Whenever I Need Computers	24	31

Although Kerski (2000) did not identify a lack of technical support or GST awareness as key problematic barriers, 49 percent of participants in the current study recognized the lack of technical support as a major area of concern (Table 6.12). Today, much technology is provided online and the lack of availability of a strong Internet connection could be a problem for educators. In addition, classroom projectors could be misaligned or unable to project the teacher's desktop. Forty-seven percent of participants recognized that the lack of awareness of available technology was a challenge, which may be reflective of the rapidly evolving times. The lack of resources, time in the curriculum, instructional time, and planning time also remained critical factors. The Digital Information Age has brought a level of expectation for technological functionality and an awareness of evolving online capabilities. Thus, educators may know that these technologies exist, but not know how to access them.

As with all new tools, GST present challenges, benefits, and potential rewards. The geography education community has long recognized barriers to using these technologies (Kerski 2000, 2003; Bednarz 2004; Baker 2005; Milson and Kerski 2012). However, the story of the diffusion of GST is not complete without understanding the other side of this coin; specifically, understanding the benefits and potential of GST.

Benefits of Geospatial Technologies

Recognizing factors that encourage secondary teachers to use GST is imperative to motivating educators to employ GST as instructional technologies. Despite the disparity in use, all participants (n = 78) agreed on the benefits to employing these technologies as pedagogical enhancements (Table 6.14). For the most part, educators are resourceful individuals who can figure out how to incorporate instructional tools they perceive as important. Understanding educators' perceived benefits of GST as instructional tools and their motivations for using them can go a long way to helping educational leaders, pre-service educators, and professional development providers offer meaningful learning experiences for geography teachers to implement in the classroom.

Participants were asked to identify the benefits of using GST based on a list derived from Kerski (2000), a review of the literature, and the researcher's experiences in teaching and providing professional development for educators. Table 6.14 illustrates benefits to using GST that participants reported as meaningful. In general, the results indicated little change regarding motivations for implementing these technologies in instructional practice. Specifically, participants identified student motivation, learning, and geographic thinking skills over content and approved learning standards.

Table 6.14. Benefits of Using GST

Benefits Identified by Kerski	Benefits to Current GST Use	Number of Participants (*n* = 78)	
		n	%
	No Benefits	0	0
	Develops spatial skills	64	82
Enhances learning*	Enhances learning	63	81
Enhances motivation and student interest	Enhances motivation and student interest	54	70
Provides real-world relevance to subjects*	Provides real-world relevance to subjects	54	69
Provides an exploratory tool for data analysis*	Provides an exploratory tool for data analysis	53	68
	Enhances critical thinking	52	67
	Prepares students to be a 21st century student	48	62
	Enhances the understanding of relationships	47	60
	Offers opportunities to understand spatial data	45	58
Helps to teach national, state, or district standards**	Helps to teach national, state, or district standards	40	51
Offers a team learning environment	Offers a cooperative learning environment	40	51
Provides employment skills**	Provides employment skills	36	46
Provides integration of different subjects	Provides integration of different subjects	36	46
Provides opportunities to partner with community**	Provides opportunities to partner with the community	28	36

*Top benefits identified in the Kerski (2000) study.
**Least frequently identified benefits in the Kerski (2000) study.

In the current study, two of the top three benefits identified the importance of student engagement: “enhances learning” (82 percent) and “enhances motivation and student interest" (70 percent). Geographic thinking skills led the responses at least 60 percent or more of the time with the exception of "develops spatial skills," which participants recognized 82 percent of the time. Fifty-one percent reported "teaching content as approved by national, state, or district learning standards" as a benefit. Participants seemed more inspired and motivated by student interest; specifically, if students were engaged, the content would follow. This pattern also generally held true in Kerski (2000).

The main difference between Kerski (2000) and the current study was that learning standards ranked fifth from the bottom in the current study, whereas this benefit ranked last as in Kerski's (2000) study. It is important to note that Kerski's study was conducted when the standards movement was just gaining momentum, and they were not yet fully institutionalized. National, state, and local learning standards have formed the backbone of the education environment since the dawn of the new millennium, and they are very much a part of today's teaching culture and expectations. Therefore, it was anticipated that participants in the current study would view learning standards as more important than did those in Kerski's study.

The benefits "provides integration of different subjects" and "offers a team learning environment" were ranked fifth and fourth from the bottom in Kerski's study and were viewed as slightly less important in this investigation. "Provides opportunities to partner with the community" remained one of the lowest ranking benefits to using GST—signaling that geography educators still may not be ready to engage community partners with GST in meaningful ways. The highest-ranking benefits were those that addressed student motivation, exploration, and learning in real-world environments, which remained key incentives for implementing GST today (Kerski 2000).

The benefits identified in Kerski's (2000) and the current study may be similar because both studies reflected the wishes of Innovators and Early Adopters. Educators in the Early or Late Majority might select other benefits that reflect their need for more deliberate approaches in addition to student interest, geographic thinking, and geographic content. Exploring this phenomenon was beyond the scope of this study and should be part of a future research agenda.

The Potential of Geospatial Technologies as Pedagogical Enhancements

Geospatial technologies as tools for instruction were highly recognized from the perspective of high school geography educators. However, the benefits to using GST may not always be key motivating factors. Participants were asked to identify what inspires them to use GST. The list reflected a compilation of previously identified benefits and barriers and the researcher's experiences (Table 6.15). Multiple responses were permitted.

Understanding factors that drive educators to overcoming barriers is paramount to understanding how GST can diffuse among the geography education community. As for benefits, 50 percent or more identified the key motivating factors as student learning, interest, and spatial thinking skills; 40 percent of participants chose "student reasoning skills development." Interestingly, 41 percent cited "knowledge of teaching strategies to better incorporate GST in geography education" as a motivating factor. With the exception of "access to the Internet" (39 percent), the next two major motivators for teachers were related to enhancing classroom performance, including "student performance" (37 percent) and "professional development" (35 percent). Software, hardware, personal benefits, or other teachers using GST motivated less than one-third of participants in the current study.

Table 6.15. Potential of GST

Encourages GST Use	Number of Participants (*n* = 78)	
	n	%
Enhances learning	48	62
Student interest	41	53
Develop spatial skills development	39	50
Knowledge of geospatial technologies	37	47
Knowledge of teaching strategies to better incorporate GST in geography education	32	41
Student reasoning skills development	31	40
Access to the Internet	30	39
Student performance	29	37
Professional development	27	35
Appropriate software	25	32
Appropriate equipment	23	30
Administrative support	19	24
Personal benefit	16	21
Other teachers use GST	14	18
Available planning time	6	8

The data revealed that participants were more likely to use an innovation if it inspired students to learn, think, and analyze at a higher level than if they were simply given software and equipment for their classrooms. Furthermore, participants recognized the need for more training to help them refine their approaches and execution of GST as pedagogic enhancements. Interestingly, only eight percent of those surveyed selected "planning time" as a key motivation, whereas 40 percent of the sample population cited this factor as a barrier. These factors identified what "hooked" educators and enticed them to use these technologies. Furthermore, these factors provided insight into what may be required for GST to diffuse among high school geography teachers and serve as fodder for future research.

Understanding the benefits of GST contrasts prior research, which seems to focus more heavily on barriers to using these technologies as a way to determine why they are not used on a grander scale. Granted, the benefits and potential of GST have been noted, but they have not been heavily pursued. There is much untapped power in recognizing and harnessing the perceived benefits and motivating potential of GST, which might be an essential force for the diffusion of these technologies in the future. Thus, the question should not be "What impedes a teacher from using GST?" Rather, the following questions should be asked: (1) "What motivates a teacher to overcome barriers to integrate GST into instruction?" and (2) "What factors are compelling enough to encourage geography educators to problem solve and figure out how technologies can become a reality for their instructional and learning environments?" These questions were beyond the scope of this study; however, they may prove fertile ground for future research.

Professional Development as a Tool: A Geospatial Technologies Teaching Culture

The diffusion of GST depends on "getting the word out," so to speak. Educators must be made aware of these technologies and their abilities to engage learners. According to Bednarz and Audet (1999) and Kerski (2000), most teachers learn to use classroom technologies through in-service professional development. Almost a decade and a half later, this continues to be the case. When comparing participants who agreed or strongly agreed that they used GST when teaching to those who attended professional development or who believed that professional development was available, the results were remarkably similar (Table 6.16). In fact, the data implied a relationship between those who teach with these tools and those who seek and attend related training. Online professional development may provide an alternative mechanism for teachers to gain expertise in and practice with incorporating GST when teaching geography. This specific form of professional development was beyond the scope of this study, but it warrants further research regarding its potential influence on geography teachers' decisions to use GST as pedagogical enhancements.

In the current study, 42 percent of participants stated that they used GST when teaching. Forty-one percent also reported attending related professional development, and another 41 percent recognized that training was generally available, which indicates a possible relationship between "use" and "attending professional development" and "awareness" of other professional development opportunities. However, fewer participants (36 percent) believed professional development that teaches pedagogical strategies for GST use was available. This finding supports the notion that educators may learn about an innovation and test or implement it in the classroom without a fully developed understanding of that innovation as a pedagogical enhancement.

The decision to exclude GST in geography instruction may be related to not attending professional development, which could also influence participants' knowledge of available training. For example, 42 percent of participants did not use GST to teach geography. Similarly, 37 to 40 percent of participants did not believe professional development was available—either to learn how these technologies work or how to teach with them. These data were reflective of the 41 percent who did not attended GST training. Participants represented teachers who were more likely to engage in training to increase their pedagogical and content knowledge. It would be interesting to know why 37 percent or more either did not attend GST training or did not know that such training was available. Garnering educators' attention and awareness may lead to greater diffusion of GST among high school geography teachers.

Table 6.16. GST Attendance and Perceived Availability

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
I use GST to teach Geography.	9	12	23	30	13	17	26	11	7	9
I attend professional development workshops to learn more about online geospatial technologies.	7	9	25	32	14	18	27	35	5	6
There are professional development opportunities available to me that teach me how to use online GST.	8	10	21	27	17	22	24	32	7	9
There are professional development opportunities available to me that teach pedagogical strategies for the use of online GST in geography education.*	6	8	25	32	18	23	25	32	3	4

* One response is missing.

Summary

Chapter VI provided a general overview of the survey data to provide a basic understanding of the demographics and key characteristics of the sample population in preparation for a more in-depth analysis of participants in accordance with their stages of adoption or levels of TPCK. The survey data revealed that, although participants initially believed they were more aware of GIS, they more readily identified specific GST. Interestingly, two-thirds of the sample population used these technologies either personally or professional. Additionally, at least half indicated that they engaged these tools when instructing learners. Further, most (93 percent) participants wanted to learn more about these tools. Various forms of professional development, such as online trainings, should be explored to evaluate their potential to diffuse GST to a wider audience. Participants' interests in learning more about GST gives hope that the diffusion of these technologies is on the rise.

The analysis of the perceived benefits and potential of these digital tools suggests the existence of compelling factors that drive high school geography educators to push through or work around barriers to their use. Understanding the benefits and motivations that encourage educators to embrace these technologies can help leaders, pre-service educators, and professional development providers to create authentic experiences. For example, participants considered capturing student interest as critical to delivering content. Additionally, some participants identified GST as viable tools for engaging students in high-level discussions and analyses of geographic processes.

Understanding factors that drive educators to use GST will be paramount for aiding the diffusion of these technologies in pre-collegiate education in the future. The key to supporting high school geography educators is determining whether they are Innovators or Early Adopters who will explore and continue to employ GST in creative ways, or whether they are among the majority of geography educators who may require concrete examples of infusing these technologies into the expected World Geography curricula. With the recent proliferation of online GST, it may be prudent to focus on the different types of technologies available online as they relate to the scope and sequence of high school geography courses. There is much untapped power in harnessing motivational factors that should be explored.

The next chapters explore participants' responses in detail as they relate to Rogers' (2003) Innovation Decision Process, Mishra, and Koehler's (2006) TPCK frameworks. Chapter VII explores the quantitative and qualitative data as it relates to Rogers' (2003) Innovation Decision Process model and offers data that highlights the diffusion of GST among current geography educators. Chapter VIII addresses elements of participants' G-TPCK by evaluating data from the Phase I survey and Phase II interview. Chapter IX compares participants G-TPCK among each stage of the Innovation-Decision Process. Finally, implications of these findings are discussed in Chapter X.

CHAPTER VII

EVALUATING THE GEOSPATIAL TECHNOLOGIES ADOPTION PROCESS: ADDRESSING RESEARCH QUESTION 1

Research supports the notion that K-12 geography teachers are slow to adopt geospatial technologies (GST) as tools for instruction (Kerski 2003; Bednarz 2004; Baker 2005; Milson and Earle 2012; Milson and Kerski 2013). Rogers (2003) suggested that people move through a series of stages when adopting a new technology, or innovation, which he calls the Innovation-Decision Process. In this study, the process is referred to as the GST Innovation-Decision Process. This research aimed to determine where high school geography educators are in the progression of the GST Innovation-Decision Process. Specifically, data from this study were used to address the following research question: Using Everett Rogers' (2003) Diffusion of Innovation theoretical framework, how do teachers conform to Rogers' five stages of the Innovation-Decision Process with respect to the acceptance of GST as pedagogic techniques for teaching high school geography? Here, the term *conformity* denotes the ability to identify participants by Rogers' (2003) stages, the sequential progression of adoption, and evidence of decisions to use these innovations.

This study included two phases to gather data: quantitative Phase I and qualitative Phase II. In Phase I, an online survey instrument was administered to 153 participants, of which 78 met the participation criteria. Initially, 32 participants from Phase I volunteered for the Phase II qualitative telephone interview. Ultimately, 13 participants were eligible and available for this part of the investigation. Chapter VII explores the data generated from Phases I and II of this study as it pertains to addressing Research Question 1. The quantitative data yielded from the survey instrument are discussed followed by a discussion on the supportive qualitative data analysis. The second research question is addressed in Chapter VIII.

Phase I: Analyzing Research Question 1 Using Survey Data to Explain Geospatial Technologies Adoption

Understanding Types of Geospatial Technologies Adopters

When analyzing the adoption process, it is helpful to keep in mind the different parts of a population who do or do not embrace an innovation. Rogers (2003) contended that the five categories of adopters in the Innovation-Decision Process are Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. Serving as gatekeepers, Innovators believe in the potential of a new technology and accept a high degree of risk, while Early Adopters accept an idea relatively early in the process and play a vital role in the diffusion of that innovation because they are well-respected opinion leaders and role models (Rogers 2003). Combined, these individuals represent a very influential 16 percent of the population who are at the forefront of technological change. The literature accepts that geography teachers who use GST fall into one of these two categories (Kerski 2000, 2003; White 2008). Generally, the Early Majority and Late Majority account for 68 percent of a population (Rogers 2003). These individuals are referred to as the “majority” because sufficient literature does not exist on the dynamics of the population beyond Innovators and Early Adopters. Laggards were not the focus of this study, and therefore, are not discussed.

Determining Stages of Adoption

As discussed in Chapter V, initial survey data were recoded into numbers that represented the string data provided by SurveyMonkey. Likert scale data were assigned numbers from “1” to “5” to represent strongly disagree to strongly agree. Multiple choice questions that allowed for multiple answers were recoded using a binary system of “1” and “0” for each answer choice. Other multiple choice answers were assigned nominally to reflect a specific answer choice. Open-ended questions were not recoded for the quantitative phase of this study. A few questions were dual coded when the information applied to more than one stage, which was seldom the case. After the data were coded, participants were grouped by adoption stage using the Statistical Package for the Social Sciences (SPSS) software.

The Phase I online questionnaire was developed based on Rogers’ (2003) Innovation-Decision Process. Additionally, survey items were recoded to identify each stage of adoption and analyze data according to participant awareness (knowledge), decision to use GST, and action taken (use). According to Rogers (2003), the stages of adopting an innovation are Knowledge, Persuasion, Decision, Implementation, and Confirmation. When the innovation refers to GST in this discussion, the stages include “GST” and the name of the stage (e.g., GST Knowledge Stage).

Rogers (2003) asserted that adoption occurs in a time-ordered sequential progression that includes the awareness of an innovation (knowledge), the development of a favorable or unfavorable opinion (persuasion), the acceptance or rejection of the innovation (decision), the action or use of an innovation (implementation) and, the evaluation of the implementation decision (confirmation). Rogers (2003) expected that the initial phases would be populated more heavily than the latter stages of the Innovation-Decision Process. With this understanding in mind, the survey items were designed to address awareness, decision-making, and action in the technology adoption progression.

Participants were assigned a score that represented the percentage of items answered positively for each stage of the Innovation-Decision Process. Specifically, participants were assigned to a stage when their scores represented an average of 50 percent or more positive responses to the items for a given stage. Participants could be assigned to more than one stage. For example, if an individual had a score of 52 percent for the Knowledge Stage, 62 percent for the Persuasion Stage, and 42 percent for the Decision Stage, he or she would have entered the Knowledge and Persuasion Stages, but not the Decision Stage. Conversely, a participant could be assigned to no stage in the Innovation-Decision model when he or she answered items for each stage positively less than 50 percent of the time. This instance occurred with 18 participants who were coded as "Pre-Knowledge."

Rogers (2003) recognized three types of knowledge present in the Knowledge Stage: awareness-knowledge, how-to knowledge, and principles-knowledge (underlying functioning principles of the innovation). He also stated that most change-agents, those who want to bring change, tend to focus on awareness and how-to knowledge. Thus participants were placed in the Knowledge Stage when they answered questions positively about basic awareness-knowledge (i.e., the simplest form), such as "I am aware of desktop Geographic Information Systems (GIS)." See Appendix I for the survey item-coding scheme. The principle knowledge resembles awareness as evaluated by Koehler and Mishra's (2005) Technological Pedagogical Content Knowledge (TPCK) framework, which is addressed in Research Question 2 in Chapters VIII and IX.

No assumptions were made in the current study about the distribution of the data; therefore, nonparametric statistics were appropriate. The data collected were mainly descriptive in nature and were nominal- or ordinal-level. According to Somekh and Lewin (2005), the Chi-square test is a nonparametric test that evaluates the association among variables. This test can only be used if there is "one case or person" in each cell of the contingency table. In other words, each category of participants must be in a separate category with no participants classified in more than one group.

The Chi-square test for either "goodness of fit" or independence could not be performed in this study because the stages of Rogers' (2003) Innovation-Decision Process were designed to be overlapping, not independent. Therefore, only descriptive statistics were used to analyze the stages of participants' decisions to adopt or not adopt GST as tools for instruction. Recoding the survey items according to Rogers' (2003) framework proved useful in the data analysis. Participants were grouped for further analysis, and stages were examined for trends regarding participants' knowledge, use, and frequency of use. Data were then compared to identify the development, or maturity, of GST knowledge and decision-making among the members in each group.

Addressing the Sequential Progress of Adoption

Rogers' (2003) model suggests that the process of deciding to adopt an innovation is sequential (Figure 7.1). Therefore, it was expected that at least as many participants in the GST Knowledge Stage would be as aware of these technologies as participants in the GST Decision and GST Implementation Stages. Rogers (2003) asserted that most individuals are in the Knowledge Stage because simply being aware of an innovation does not connote that one is persuaded to use, has made a decision to use, or has begun to employ said innovation. Consequently, each subsequent stage of the Innovation-Decision Process has fewer members, as illustrated by smaller concentric circles Figure 7.2. It was anticipated that the progress through these stages would also be true for the adoption of GST among high school geography teachers.

Knowledge Stage → Persuasion Stage → Decision Stage → Implementation Stage → Confirmation Stage

Figure 7.1. Sequential progression of the Innovation-Decision Process (Rogers 2003)

Conformity to Rogers' (2003) framework also required examining whether the Innovation-Decision Process model was meaningful to knowing participants' progression of GST knowledge and action at each stage of adoption. Figure 7.2 illustrates the number of participants for each stage when measured individually. The size of the circle represents the number of participants in each category. Therefore, the outer circles represent more participants and the inner circle represents fewer participants, which suggests the outer stages may be the initial step in a teacher's acceptance of GST. The adoption process is discussed in more detail later in this chapter.

Populating Stages of Adoption for Analysis

In this study, 28 of the 78 participants were identified as being "aware" of GST based on the original research design. Ideally, participants from the initial Knowledge Stage moved to the subsequent stages based on their levels of knowledge and experience with the innovation. Applying Rogers' (2003) model, substantially fewer participants were in the subsequent stages of GST adoption. However, geography educators did not appear to follow this process sequentially. Participants may also have undervalued their knowledge or responded to a “knowledge” question according to their personal definitions of “awareness” despite clear direction.

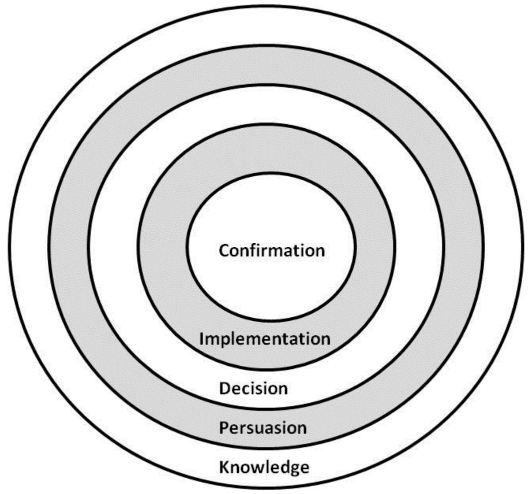


Figure 7.2. Relationship of the number of people in Rogers’ Innovation-Decision Process**.**

Considering these issues, participants were assessed on their levels of Knowledge, Persuasion, Decision, Implementation, and Confirmation individually. In other words, instead of identifying members of the GST Persuasion Stage from only those in the GST Knowledge Stage, participants were identified for each stage from the original 78-member sample population. Although participants were likely to be categorized at multiple levels of adoption, the results were more meaningful to the study overall. The only participants who were not identified in these stages of adoption were those labeled “Pre-Knowledge.”

Participants’ survey responses were evaluated using the coding system previously described. Table 7.1 identifies the number of participants in each stage of GST adoption. Most participants were identified in the GST Decision Stage rather than the GST Knowledge Stage, which was not expected based on Rogers’ (2003) prediction of the general linear adoption process. Almost three-fourths of participants positively answered the items coded “decision” 50 percent or more of the time. This finding suggests that these decisions may be part of the initial adoption process. The GST Implementation and GST Persuasion Stages, respectively, yielded the next largest participant groups.

The GST Knowledge and GST Confirmation Stages had the fewest number of participants. This finding could be due partially to the coding of multiple choice items at the GST Knowledge Stage such that each choice was a separate variable that influenced the average score for this stage. Additionally, the number of questions coded for each stage might not have been equal in number, which could have biased the sample. This finding could also be because participants may not have been aware of the term *geospatial technologies*, despite the definitions provided on the survey. As anticipated, the fewest number of participants were identified in the GST Confirmation Stage.

Table 7.1. Participants in the Stages of Rogers (2003) Innovation-Decision Process

Stages	*n*	%
Pre-Knowledge Stage	18	23
Stage 1: GST Knowledge	28	36
Stage 2: GST Persuasion	33	42
Stage 3: GST Decision	57	73
Stage 4: GST Implementation	41	52
Stage 5: GST Confirmation	27	35

Figure 7.2 illustrates the number of participants in each stage when measured individually. The size of the circle represents the number of participants in each category. Therefore, the outer circles represent more participants and the inner circles represent fewer participants, suggesting the outer stages may be the initial steps in a teacher’s acceptance of GST. The adoption process is discussed in detail later in this chapter. Conformity to Rogers’s (2003) framework also required examining whether the

Innovation-Decision Process model is meaningful to knowing participants' progression of GST knowledge and action at each stage of adoption. The following diagram represents participants' responses that indicate a possible deviation from Rogers' (2003) model.

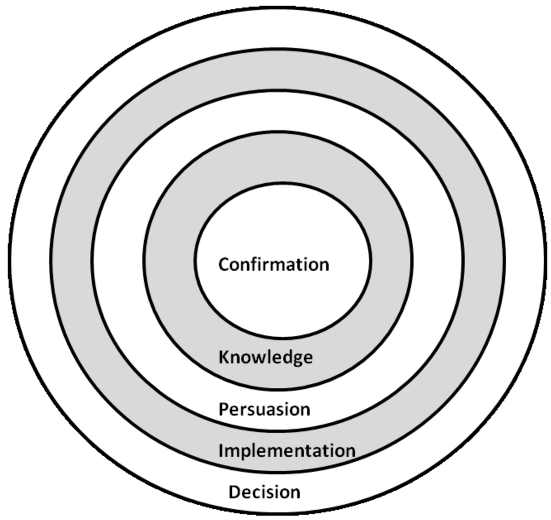


Figure 7.2. Relationship of GST adoption stage according to survey response.

Measuring General GST Awareness

Four survey items were developed to analyze the patterns of knowledge and to identify participants' places in Rogers' (2003) Innovation-Decision Process. The variables used to evaluate patterns of awareness addressed both desktop GIS software and other forms of GST using Likert scale and multiple choice items. Examples include:

- I am aware of desktop Geographic Information Systems (GIS) software.
- I am aware of online GST.
- What forms of desktop GIS software are you aware of? (Check all that apply.)
- What forms of GST are you aware of? (Check all that apply.)

As a reminder, GST form an array of tools. In their most basic form, they include simple visualization technologies with static images that, generally, cannot be changed or have data added to them (e.g., MapQuest, mapping games). More complex visualization tools that allow data layers (e.g., Google Earth) are next on the continuum. Geospatial technologies also include GIS-based applications that provide data layers for the user to analyze relationships among data (e.g., National Atlas). Finally, GST include online and desktop GIS, which are robust applications or software programs that allow the user to construct maps, add and delete data, and analyze by querying data to identify relationships or to understand processes. In Chapter VI, desktop GIS was addressed separately because this technology has been available to teachers longer than has online GIS. Additionally, Kerski (2000) examined only teachers' desktop GIS use. Therefore, it was reasonable to expect a more diverse awareness of these technologies among participants in this study who reflected new and experienced teachers with differing levels of technology exposure.

In general, participants were strongly aware of both desktop GIS and online GST as shown in Tables 7.2 and 7.3. Three stages of GST Knowledge, GST Persuasion, and GST Confirmation, exhibited 100 percent awareness of desktop GIS. All but one participant (97 percent) in the GST Implementation Stage agreed or strongly agreed that they were aware of GIS. While still demonstrating a high level of awareness, fewer participants (91 percent) in the GST Decision Stage recognized desktop GIS. Further, more than two-thirds of all participants in each stage were aware of online GST.

Following Rogers' (2003) model, it was anticipated that the GST Knowledge Stage would set the standard for knowledge. In other words, it was anticipated that all stages would be at or above the level of awareness found in the first stage. Viewing the survey items through the lens of the Innovation-Decision Process (Table 7.2), it seems that participants conformed to the behaviors of Rogers' (2003) Knowledge, Persuasion, and Confirmation Stages because they all were aware of GIS software. However, this was not the case for the Decision and Implementation Stages. Some participants were not aware of GIS software even though they scored high enough to be identified in these categories. It is possible that participants were more aware of other types of technology, which would account for high GST scores in any given stage.

Table 7.2. Response to: I Am Aware of [Desktop] Geographic Information Systems

Stage		Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	n	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
GST Knowledge	28	0	0	0	0	0	0	11	39	17	61
GST Persuasion	33	0	0	0	0	0	0	18	55	15	54
GST Decision	57	0	0	3	5	2	4	32	56	20	36
GST Implementation	41	0	0	1	2	0	0	21	51	21	51
GST Confirmation	27	0	0	0	0	0	0	14	52	13	48

Responses about online GST differed (Table 7.3). Participants in the GST Knowledge Stage were second only to those in the GST Confirmation Stage who were aware of these online technologies. The GST Decision Stage yielded the lowest average for participants' online awareness (79 percent). Although members of the GST Decision Stage were aware more than three-fourths of the time, this finding is surprising because one would assume that this stage would have as many or more knowledgeable participants than the two subsequent stages of decision-making. Moreover, members of the GST Decision Stage had diverse responses. This stage was the only one to yield a response of "strongly disagree" to knowing about online GST.

Table 7.3. Response to: I Am Aware of Online GST

Stage		Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	n	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
GST Knowledge	28	0	0	0	0	1	4	15	54	12	43
GST Persuasion	33	0	0	1	3	3	9	20	61	9	27
GST Decision	57	1	2	6	11	5	9	31	54	14	25
GST Implementation	41	0	0	2	5	0	0	26	63	13	25
GST Confirmation	27	0	0	0	0	0	0	19	70	8	30

The GST Persuasion and GST Implementation Stages each had at least one participant who did not know about online technologies, and the GST Persuasion Stage reflected more diverse responses. This dichotomy may suggest that geography teachers' initial steps toward adoption involve making decisions regarding geospatial innovations. Developing knowledge about and a favorable or unfavorable attitude toward the technology may occur later in this process.

Awareness: Identifying Forms of Desktop GIS

Participants were asked to identify specific types of GIS and other technologies of which they were aware. Those who selected "neutral" in the previous survey items were given another opportunity to address their GST awareness. Analyzing the data through the lens of Rogers' (2003) Innovation-Decision Process served to explain the kinds of technology that might resonate better with geography educators, and thus provided insight into possible paths of GST diffusion.

Participants were asked to identify technologies from a pre-selected list of 11 forms of desktop GIS or 10 forms of other GST. Participants could select multiple forms of technology for each survey item. Each choice was treated as individual variables. Considering each choice as a separate survey item may have influenced the average scores of general awareness (knowledge) of GST. Steps were taken to identify common forms of desktop GIS software and other technologies both within the education field and within GIS and geography courses. Including common GIS software was appropriate because participants were selected from states where geography was required for high school graduation and state teaching standards required the use of GIS (Milson and Roberts 2008). Additionally, secondary geography teachers and education leaders reviewed and edited the list during the pilot study.

Participants were less aware of the individual forms of desktop GIS than first indicated by their responses to the Likert scale survey items (Table 7.4). Overall, Esri ArcView GIS was the most popular form of desktop GIS. Over 80 percent of participants in each stage were aware of this technology with the exception of the Decision Stage in which 68 percent were aware. Additionally, 32 to 54 percent of participants were aware of ArcExplorer Java Edition for Educators (AEJEE) and My World GIS. At least half (range 49 to 56 percent) were aware of AEJEE. These responses were much lower than the 91 to 100 percent of participants who reported awareness of desktop GIS. It is possible that participants were more aware of the term *Geographic Information Systems* than the actual software. Overall, participants recognized desktop GIS software programs less than half of the time.

Members of the GST Decision Stage, once again, fell short in recognizing each type of software. My World GIS had a closer response rate across stages (range 32 to 48 percent); however, members in the GST Decision Stage remained the least aware. As expected, members in the GST Confirmation Stage were the most aware. In the GST Confirmation Stage, 33 percent or more identified six of the 11 forms of GIS and were within a few percentage points of the highest-ranking score for these software packages, which included ArcView GIS, MapInfo, ERDAS, AEJEE, My World GIS, and ArcVoyager. Of participants in the GST Persuasion Stage, more were aware of Esri ArcView GIS (88 percent) and Earth Resource Data Analysis System (ERDAS) Imagine (46 percent) than of the other programs. In the GST Implementation Stage, more participants knew about MapInfo (37 percent) and IDRISI (12 percent) than those in any other stage of adoption.

Table 7.4. Awareness of Desktop GIS Technologies by Stage

	GST Knowledge (n = 28)		GST Persuasion (n = 33)		GST Decision (n = 57)		GST Implementation (n = 41)		GST Confirmation (n = 27)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Esri ArcView GIS	24	86	29	88	39	68	33	81	22	82
MapInfo	8	29	10	30	15	26	15	37	9	33
IDRISI	3	11	3	9	5	9	5	12	3	11
MS MapPoint	3	11	5	15	6	11	6	15	5	19
Earth Resource Data Analysis System (ERDAS) Imagine	33	39	15	46	17	30	15	37	11	41
Geographic Resources Analysis Support System (GRASS)	6	21	6	18	7	12	7	17	6	22
SmallWorld	3	11	3	9	4	7	3	7	4	15
Manifold	1	4	1	3	1	2	1	2	1	4
ArcExplorer Java Edition for Educators (AEJEE)	15	54	16	49	20	35	20	49	15	56
InterGraph GeoMedia	1	4	1	3	2	4	2	5	1	4
My World GIS	13	46	14	42	18	32	16	39	13	48
ArcVoyager	15	54	17	52	21	37	21	51	15	56

Overall, a moderate number of participants recognized ArcVoyager software. More than half of all participants in each stage were aware of ArcVoyager, with the exception of members in the GST Decision Stage; less than 40 percent of participants in this stage knew about this free software application. Although not a desktop GIS, ArcVoyager provides a free desktop application similar to some online GIS applications available today.

Following the GST Decision Stage, the GST Implementation Stage yielded the lowest percentage of participants who were aware of the various forms of GIS. In other words, participants in the GST Knowledge, GST Persuasion, and GST Confirmation Stages were more aware of different kinds of desktop GIS software than were those in either the GST Implementation or GST Decision Stages. Identifying participants by adoption category and then analyzing their awareness served to illustrate the possible development and maturity of GST adopters. Additionally, the data revealed that some stages may be more open to more complex forms of technology compared to others stages.

Awareness: Identifying Forms of Other GST

Participants were also given an opportunity to identify technologies other than desktop GIS (Table 7.5). Details of participants' awareness using these technologies were important because they can show education leaders and trainers the types of technologies that best resonate with geography educators at different levels of adoption. Defining educators' levels of awareness at each stage of the GST Innovation-Decision Process supports the possibility of different diffusion patterns. For example, members in the initial phases of adoption may use less complex tools than those who were in the latter stages. As with GIS, steps were taken to list common and various forms of GST using comments from experts, technologies presented at conferences, and comments from participants during the pilot study for secondary educators.

In general, participants were more aware of other forms of GST than they were of desktop GIS software. Whereas the range of desktop GIS awareness fluctuated between two and 88 percent across the stages in the GST Innovation-Decision Process, general awareness of other forms of GST were much higher and more closely aligned. With the exception of Field Scope and Globalis, 42 to 100 percent of participants were aware of other forms of GST.

Table 7.5. Awareness of Other GST

	GST Knowledge (n = 28)		GST Persuasion (n = 33)		GST Decision (n = 57)		GST Implementation (n = 41)		GST Confirmation (n = 27)	
	n	%	n	%	n	%	n	%	n	%
Global Positioning System (GPS)	27	96	32	97	51	90	38	93	25	93
Mapping Games	21	75	23	70	30	53	28	68	19	70
MapQuest	26	93	32	97	51	90	38	93	25	93
Google Earth	28	100	33	100	57	100	41	100	27	100
National Atlas	19	68	19	58	29	51	25	61	17	63
Globalis	9	32	8	24	10	18	10	24	7	26
FieldScope	2	7	2	6	4	7	4	10	2	7
USGS Interactive Map	18	64	25	76	34	60	29	71	20	74
ArcGIS Explorer	18	64	21	64	27	47	25	61	17	63
ArcGIS Online	15	54	18	55	24	42	23	56	17	63
Remotely Sensed Images	20	71	24	73	34	60	30	73	20	74

It was anticipated that fewer participants would be aware of FieldScope because meaningful access to this technology was provided through grants in certain areas of the country, none of which were located in the five states selected for this study. Further, Globalis was an online application provided by the United Nations that was no longer available at the time of this study; therefore, it was expected that few participants would be aware of this technology. No more than four of the 78 participants were aware of

FieldScope and no more than 11 recognized Globalis. Exactly 100 percent of participants in each stage were aware of Google Earth. Rogers' (2003) Innovation-Decision Process model helped inform the understanding of the influence of technology knowledge on members at different levels of the adoption process. However, data revealed that the pattern of GST adoption might not be as linear as Rogers (2003) predicted.

Members in the GST Decision Stage were the least aware of the technologies presented. In fact, a gap of three to 15 percent existed between members in the Decision Stage and the next lowest group on awareness of the technologies listed. Participants' knowledge in the remaining stages was quite close regarding GST such as Global Positioning Systems (GPS), FieldScope, ArcGIS Explorer, and remotely sensed images. However, technologies such as Arc GIS Online, USGS Interactive Map, and National Atlas had a 10 to 13-percentage point difference in awareness among participants in stages other than the GST Decision Stage. This shift in GST awareness may suggest educators seek out technologies that provide instructional tools, such as static images, with which they are more comfortable and, perhaps, more familiar. Further studies should be conducted to determine the reasons for awareness of the various kinds of GST.

The findings regarding knowledge about desktop or online GIS and other applications may be skewed because participants selected multiple technologies of which they were aware. In other words, a participant who selected ArcView GIS may have also selected ERDAS, GRASS, and MapInfo. Furthermore, participants could be placed in multiple stages of adoption. Therefore, it is possible that the same group of participants were identified in each stage for a particular technology. For example, only six or seven participants recognized the GRASS GIS software (knowledge). Six or seven participants were also placed in each subsequent stage, which suggests that they accepted using GIS as an instructional technology in their classrooms. Therefore, it is possible that the same six or seven participants were identified in each case. Regardless of the potential duplication, the data revealed a pattern of participants with GIS or a broader GST knowledge, which is worth exploring.

Unlike responses to desktop GIS software, no stage had a clear majority of members who knew about most types of GST. In fact, members of the GST Knowledge and GST Persuasion Stages were more frequently aware of these technologies than were participants in the GST Implementation Stage. This phenomenon could reflect the fact that most of these technologies are relatively new to teachers, thus, teachers are still moving through the adoption process. Conversely, participants may have completed their adoption processes with comparatively well-known desktop GIS. Therefore, most participants who were aware of GIS were categorized in the GST Confirmation Stage.

Applying Rogers' (2003) research as a guide, it was anticipated that all participants in each stage would be knowledgeable of GIS and GST. Ideally, more participants would be represented in the GST Knowledge Stage because they were aware of these technologies, but had not progressed further in their decision-making. Thus, all members of each stage were expected to exhibit strong knowledge of GIS and other technologies. However, this was not the case. Rather, participants who yielded scores high enough to be placed in the middle stages sometimes indicated low knowledge about GST.

The patterns found in responses to the Likert scale items were mirrored in the multiple choice items. Participants in the GST Decision Stage were the least aware, and those in the GST Confirmation Stage were the most aware of both desktop GIS and other forms of technologies. Members of the GST Implementation Stage were sometimes less aware of these technologies than were those in other stages, with the exception of those in the GST Decision Stage. A substantial number of participants in both the GST Knowledge and GST Persuasion Stages were knowledgeable of most forms of these technologies, with those in the GST Persuasion Stage slightly more aware. Although the evidence supports a non-sequential adoption process, it also provides a clearer picture of knowledge relationships within the GST Innovation-Decision Process.

Exploring Patterns of GST Use

Rogers' (2003) model also recognized individuals' planned and executed actions as critical components of the adoption process. To form a general understanding of patterns, decisions, and actions, participants were asked to respond to Likert scale and multiple choice questions to identify whether they taught using these technologies. These relationships informed the analysis of the progression of GST adoption using Rogers' (2003) framework. The corresponding survey items included:

- I use GST to teach geography.
- Currently, I use geospatial technologies (GST) to teach geography: (Select the appropriate answer).
- How do you use GST in your classroom? (Check all that apply.)

A positive answer suggested that the participant had entered the GST Implementation Stage. The first question broadly addressed participants' decisions to employ these technologies as instructional tools. The other two questions sought to clarify the role of GST in the classroom by providing additional information about the frequency of use. This item also aimed to determine whether these tools were used personally or professionally. These items were developed intentionally to identify a steady use or integration of GST as a set of tools for instruction, thereby indicating whether a participant was in the GST Implementation or GST Confirmation Stages.

Geospatial technologies have grown in popularity since Kerski's study in the 1990s. Almost three-fourths of all participants used GST (range 71 to 81 percent) in each stage, with the exception of the GST Decision Stage in which 56 percent of the population used these tools as instructional enhancements (Table 7.6). The 15 percent difference between the GST Decision Stage and the other stages suggests that the adoption process may indeed begin at the Decision Stage rather than at the Knowledge Stage as Rogers (2003) implied. As reflected in Rogers' (2003) Innovation-Decision Process, participants in the GST Confirmation Stage represented those who more often agreed or strongly agreed to use GST when teaching geography.

Table 7.6. Participants' Current Use of GST as Instructional Tools

Stage		Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	n	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
GST Knowledge	28	0	0	4	14	3	11	17	61	4	14
GST Persuasion	33	1	3	3	9	4	12	19	58	6	18
GST Decision	57	2	4	12	21	11	19	25	44	7	12
GST Implementation	41	2	5	4	10	6	15	22	54	7	17
GST Confirmation	27	0	0	2	7	3	11	16	59	6	22

An indication of the adoption of an innovation was the frequency and diversity with which participants employed GST. Participants identified whether they used these technologies in three main categories: never, occasionally (once a semester or once a grading period), and regularly (once a month, once a week, two or more times a week).

Participants could select only one answer choice (Table 7.7). Responses indicated attitudes toward and willingness to implement GST when teaching.

Table 7.7. Frequency of Use: GST as Instructional Tools

	GST Knowledge (*n* = 28)		GST Persuasion (*n* = 33)		GST Decision (*n* = 57)		GST Implementation (*n* = 41)		GST Confirmation (*n* = 27)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Never	1	4	3	9	9	16	2	5	0	0
Once a Semester	5	18	3	9	10	18	8	20	1	4
Once a Grading Period	3	11	4	12	9	16	6	15	5	19
Once a Month	7	25	10	30	14	25	10	24	8	30
Once a Week	9	32	9	27	10	18	10	24	8	30
2 or More Times a Week	2	7	3	9	4	7	4	10	4	15
Missing	1	4	1	3	1	2	1	2	1	4

Each stage, except for the GST Confirmation Stage, included at least one participant who never included GST when teaching. All participants in the GST Confirmation Stage reported teaching with these technologies at some point during the year. This phenomenon supports Rogers' (2003) work, which expressed that individuals in the Confirmation Stage are involved in a series of ongoing uses of an innovation. Nine participants (16 percent) in the GST Decision Stage never used these technologies as tools for instruction. Additionally, more participants used these tools occasionally in the GST Decision (34 percent) and GST Implementation Stages (35 percent) than did those in the other stages. More than one-fourth of participants in the GST Knowledge Stage (29 percent) employed these technologies occasionally.

Applying Rogers' (2003) model, one could anticipate that most participants in the GST Knowledge and Persuasion Stages would occasionally employ these technologies. Thus, it was expected that comparisons with subsequent stages would yield an increasingly routine use of GST. The data revealed that a number of participants in the earlier stages of adoption regularly interacted with these tools. In addition, relatively few participants in the GST Decision Stage used these technologies routinely. Rather, 28 of 57 participants regularly employed them as a set of tools for instruction. Rogers (2003) also implied that those in the Implementation and Confirmation Stages are more likely to use an innovation regularly compared to those in previous stages. Although a large percentage of participants routinely used GST in these stages, a surprising number used them only occasionally.

Fewer than 25 percent of participants in the GST Persuasion and GST Confirmation Stages used these tools occasionally. In general, these participants used these technologies more regularly, as participants in both groups reported working with these tools monthly at least 30 percent of the time. Additionally, almost half (45 percent) of participants in the GST Confirmation Stage were more likely to teach with these technologies on a weekly basis, and three-fourths (75 percent) used them on a regular basis.

These findings correspond with Rogers' (2003) research, which suggests that members in this final stage are generally positive about their decisions to use an innovation and are in the process of refining these decisions. Thus, it is still possible for individuals to change their minds regarding new technologies, which may explain why some participants in this stage used these tools only occasionally. Over two-thirds of participants in the GST Knowledge and GST Persuasion Stages (64 and 66 percent, respectively) regularly taught with these tools on a monthly or weekly basis. Conversely, at least half of those in the GST Decision and GST Implementation Stages (50 and 58 percent, respectively), used them in the classroom regularly in the same fashion. These data are not consistent with Rogers' (2003) model.

This pattern of GST use reflects an order similar to that found in the pattern of technology awareness. Listed in order of least to greatest in terms of GST use and awareness, the stages are: GST Decision, GST Implementation, GST Knowledge, GST Persuasion, and GST Confirmation, as illustrated previously in Figure 7.3. Fewer participants were aware of or elected to use GST in the Decision Stage of the Innovation-Decision Process.

The stage with the second lowest level of technology use was the GST Implementation Stage, which does not reflect Rogers' (2003) original model. Rogers asserted that this stage should have one of the highest levels of innovation awareness and engagement. Therefore, one would expect regular integration of geospatial tools among individuals in this stage. In this study, the GST Knowledge and GST Persuasion Stages seemed to reflect a transitional period for participants as they seek to confirm or make final decisions on whether to adopt these technologies as pedagogical enhancements in their geography classes. Perhaps geography teachers initially decide to implement GST and then seek to build their knowledge and develop favorable or unfavorable attitudes toward these technologies. As with Rogers' (2003) Innovation-Decision Process model, the GST Confirmation Stage remained the highest uniformity of awareness and use among its members with most deciding to use GST regularly. These results suggest that, while some conformity with Rogers' (2003) stages and overall model exists, a deviation from his linear process also exists.

Examining Geography Teachers' GST Patterns of Use

Participants' adoption stories were further developed by examining how they employed GST in geography education (Table 7.8) using the following survey item: "How do you use GST in your classroom? (Check all that apply)." More than one-third in each stage worked with GST in some way, and more than half used these technologies to prepare for class. Over two-thirds of all participants employed technologies as pedagogical enhancements during instruction or student activities. However, all categories (levels) included at least one participant who did not use these technologies, with the exception of the GST Confirmation Stage. All participants in the GST Confirmation Stage used these technologies in some way, which supports Rogers' (2003) findings. Most participants who did not use GST were in the Decision Stage, which indicates non-conformity with Rogers' linear model.

Table 7.8. Ways Geography Teachers Use GST

	GST Knowledge (n = 28)		GST Persuasion (n = 33)		GST Decision (n = 57)		GST Implementation (n = 41)		GST Confirmation (n = 27)	
	n	%	n	%	n	%	n	%	n	%
Do not use GST	2	7	1	3	6	11	2	5	0	0
Personal use	10	36	15	46	20	35	19	46	14	52
Prepare for class	19	68	23	70	32	56	28	68	22	82
Teach geography	23	82	28	85	39	68	35	85	23	85
Student activities	23	82	29	88	37	65	33	81	24	89
Student assignments	15	54	19	58	23	40	22	54	15	56

Note: Each variable was available for response. Participants were instructed to "check all that apply."

Participants in the GST Knowledge, GST Persuasion, and GST Implementation Stages were very closely aligned, with only a few percentage points difference for each category of technology use. As before, those in the GST Decision Stage were less likely to use these technologies than were those in any other stage. Participants in the GST Confirmation Stage were most likely to use these tools.

Most participants in the GST Decision Stage worked with these technologies on some level. Of note, these data do not conflict with the 25 percent of participants who disagreed or strongly disagreed with the statement “I use GST to teach geography” because the answer choices included two ways in which participants could use but not teach with these technologies. As anticipated, more members in the GST Confirmation Stage used these technologies both personally and professionally than did those in the other stages. In this way, participants conformed to the behavior implied in Rogers’ (2003) model. It was encouraging to discover that the majority of participants in each stage employed GST in some way.

Phase II: Geography Teachers’ GST Decision Processes: What They Said

While the quantitative analysis provided a picture of the diffusion of GST among geography teachers, the telephone interviews provided a finer level of detail to evaluate participants’ decisions to adopt these technologies as instructional tools. Participants’ comments were analyzed through the lens of Rogers’ (2003) Innovation-Diffusion Process model.

Phase II results are divided into two parts. The initial discussion focuses solely on the description of participants and their decisions to use GST as pedagogical enhancements. The analysis then shifted to participants’ comments about other geography teachers to offer insight regarding the “majority” of geography teachers’ characteristics and decision patterns. Each part of this discussion aims to determine how participants conformed by identifying their appropriate stages of adoption. This discussion also addresses the linear progression of the GST Innovation-Decision Process and identifies evidence of technology adoption.

Participant Selection for Phase II: Qualitative Analysis

Participants were selected from a group of geography teachers who had volunteered to take part in a telephone interview. At the end of the online quantitative survey, participants were asked to provide their contact information if they were willing to participate in a telephone survey. Ultimately, 13 participants agreed to be interviewed in May 2012.

Participant Demographic Data

The 13 participants who agreed to telephone interviews were public school geography teachers with diverse ethnicities, ages, education, and teaching experiences. All were either on-level or pre-Advanced Placement (AP) World Geography teachers. Almost a third of participants (*n* = 4) were also AP Human Geography Teachers. Their comments served to enrich this analysis by further clarifying teachers' decisions to employ GST as pedagogical enhancements in a high school geography education setting.

Interviewees represented both genders and a variety of ethnicities and ages. Sixty-nine percent of participants were female (*n* = 9) and 31 percent (*n* = 4) were male. Participants in Phase II included Hispanic (*n* = 2), Asian (*n* = 1), and Caucasian (*n* = 10). Participants ranged in age from 20-30 (*n* = 1), 31-35 (*n* = 1), early 41-45 (*n* = 4), and 46-50 (*n* = 1). The remaining participants (*n* = 6) were over 50 years of age (Table 7.9).

Table 7.9. Demographics of Interview Participants (*n* = 13)

Demographic Data		Number of Participants
Subjects Currently Teaching	On-level/pre-AP World Geography	13
	AP Human Geography	4
	World History	1
Ethnicity	Caucasian	10
	Hispanic	2
	Asian	1
Gender	Male	4
	Female	9
Age	26-30	1
	31-35	1
	41-45	4
	46-50	1
	51+	6
Type of School	Urban	5
	Suburban	8
	Rural	0
	Low-socioeconomic	6
	Mid-socioeconomic	6
	High-socioeconomic	1
	Public	13
Teaching Certification	Social Studies Composite	12
	Geography	3
	U.S. History	2
	World History	2
Education	Bachelor's degree	8
	Master's degree	5
	At least one geography degree	5
Years of Teaching Experience	3-5 Years	2
	6-10 Years	2
	11+ Years	9
State	Minnesota	0
	Mississippi	0
	South Dakota	0
	Texas	12
	Utah	1

Participants mainly represented teachers from low- (46 percent) and mid- (46 percent) socioeconomic urban (38 percent) and suburban (62 percent) schools. The relatively equal representation of mid- and low- socioeconomic levels provided a realistic picture of high school geography education teachers. No teachers from rural schools participated in the telephone interviews.

Participant experience illustrated comprehensive knowledge of the social studies disciplines. All but one participant (n = 12) had a social studies composite certification, and 25 percent (n = 3) of those with composite certifications also held geography certifications. One of these 12 participants also held U.S. History and World History teaching certifications. The one participant without a social studies composite certification held Geography, U.S. History, and World History certifications. Teacher certification was just one indicator of educators' content and pedagogical knowledge and training.

Participants portrayed geography teachers with a range of formal training and teaching experience in the social studies disciplines. More than half of the participants (n = 8) had bachelor's degrees, and five participants had master's degrees. Over one-third (n = 5) had at least one degree in geography. In addition to formal training, these participants also exhibited varying levels of teaching experience. Almost two-thirds (n = 9) had taught for over 11 years. Two participants had six to 10 years of teaching experience and another two had three to five years of teaching experience.

Addressing Research Question 1: The Geospatial Technologies Innovation-Decision Process

The telephone interview protocol, which was influenced by Rogers' (2003) work, provided support for the quantitative analysis. Rogers (2003) asserted that different people have varying rates of adopting new technologies. Participants' interview comments described their reactions to GST and the challenges of accepting and using these technologies as instructional tools. Data from these conversations were used to identify types of adopters that participants most likely represented as well as their likely stages of adoption. Rogers' (2003) Innovation-Decision Process was refined to meet the needs of this study and to help better describe teachers' levels of decision-making regarding their use of these technologies as pedagogical enhancements when teaching geography. Recognizing characteristics of a GST Adopter among geography educators is a key component in the acceptance to use these technologies.

Understanding GST Adopters

When analyzing the adoption process, it was helpful to keep in mind the different parts of the population who may or may not embrace an innovation. The literature suggests that geography teachers who currently use GST fall into one of these two categories (Kerski 2000, 2003; White 2008). Generally, the Early Majority and Late Majority account for about 68 percent of a population (Rogers 2003). These individuals were referred to as the "majority" as sufficient literature does not exist about the dynamics of the high school geography population beyond GST Innovators and GST Early Adopters. The category of Laggards was not addressed. Rogers' (2003) Innovation

Diffusion research implies that capturing the interest of the majority of high school geography educators is critical to the diffusion of these technologies.

Interview Participants as Innovators and Early Adopters

Interview participants reflected the characteristics of individuals who were well into the adoption process. These participants were considered GST Innovators and Early Adopters. When applying the Innovation-Decision Process model, no interviewee was categorized at the lower levels of adoption (i.e., Knowledge and Persuasion Stages). Additionally, all participants showed evidence of positive decision-making regarding GST. They accepted the risks and uncertainty of innovations and forged ahead, excited by the potential of these innovations. Participants' enthusiasm also reflected characteristics of Innovators and Early Adopters (Rogers 2003). One participant embodied this excitement and creativity by stating,

> I think if you're a real geographer at heart, you're an explorer. To explore data is a little bit daunting, a little bit tedious, but there is hope elicited when you push that button and you've made a map out of all this mountain of information.

Another participant illustrated the difference between Innovators and Early Adopters and other teachers by stating,

> I don't mind if things come crashing down around my lessons, because it's a learning experience and the students get to see how adults manage a quote-unquote crisis. I don't mind it too much, but I can definitely see [why] other teachers may [get] a little frustrated.

This participant recognized that this attitude was largely because of his/her comfort with technology knowledge and content knowledge because he/she was "fortunate enough to take a GIS course" and was a "geography major as well." Therefore, this participant "realized the potential for this technology." Table 7.10 defines each stage of adoption as it pertains to the acceptance of GST as instructional tools. These descriptions were used to analyze the interview transcriptions and determine the appropriate stages for each participant.

Table: 7.10. Interviewees' Stages of the GST Innovation-Decision Process

Stage	Rogers (2003) Adoption Stage Description	GST Adoption Stage Description for Current Study	Number in Each Stage
Knowledge	"An individual is exposed to an innovation's existence and gains an understanding of how it functions" (Rogers 2003, 169).	An individual gained awareness of GST.	0
Persuasion	"An individual forms a favorable or unfavorable attitude towards the innovation" (Rogers 2003, 169).	Geography teachers developed perceptions of the array of GST and weighed their relative advantage and ease of implementation.	0
Decision	A individual engaged in activities to gather additional information to aid in choosing to accept or reject an innovation (Rogers 2003).	Geography teachers who were confident enough to make positive or negative decisions about GST. Initial decisions may be revisited as more knowledge is gained and teachers test GST during this phase.	1
Implementation	Implementing GST as pedagogical enhancements for geography instruction occurs. Prior to this stage, implementation is "a strictly mental exercise" (Rogers 2003, 179).	GST were meaningfully integrated into instruction in various forms such as teacher-centered instruction, a "hook" or introduction to a topic, or student-driven using a collaborative, constructivist approach.	1*
Confirmation	"An individual seeks reinforcement of an innovation-decision that has already been made but may reverse this decision if exposed to conflicting messages about the innovation" (Rogers 2003, 474). Individuals begin to recognize benefits of using the innovation, and they integrate it more routinely.	An iterative process of constantly seeking information, collaborating, implementing GST, evaluating and refining GST performance, and transferring GST knowledge and application to multiple places in the geography curriculum. Participants use trial-and-error to determine how to apply GST to instruction effectively.	11

* This participant was used as an example to discuss the Implementation Stage, but also represented the Confirmation Stage.

Determining the Decision Stage

Describing the Decision Stage

Rogers (2003) stated that individuals in the Decision Stage engage in activities to gather additional information to aid in choosing to accept or reject an innovation.

Individuals intentionally seek additional information about and try an innovation before determining whether they will implement the new technology (Rogers 2003). For geography teachers, activities at this level are mainly mental exercises with no actions taken to use GST as pedagogical enhancements.

Evidence from the combination of responses to the online questionnaire and telephone interviews suggested that participants had already developed an awareness (knowledge) about GST innovations and had formed favorable attitudes regarding these new technologies, which indicate that they had surpassed Rogers' (2003) Knowledge and Persuasion Stages. Responses inferred that they had gathered sufficient evidence to respond to GST positively and were probably planning to implement these technologies in the future. Additionally, participants' inclinations to try out new technologies on a trial basis to limit the uncertainty about these innovations also signaled their presence in the Decision Stage.

All interviewees indicated that they were willing to use GST in their instruction, which clearly illustrates their decision to accept these technologies. The Phase II qualitative data supported the finding that the interviewees were well established in the GST adoption process; therefore, evidence of conformity to the sequential process of Rogers' (2003) model was difficult to determine. Applying Rogers' (2003) framework proved useful when evaluating participants' perceptions and decision-making in the latter stages of accepting GST as tools for instruction.

Identifying Participants at the Decision Stage

The data revealed that only one participant represented the GST Decision Stage while the remaining 12 had moved on to either the GST Implementation or GST

Confirmation Stages. This one participant was over 50 years old and was knowledgeable in both geography content and pedagogy with over 11 years of teaching experience. Although this participant did not use GST for instruction, he/she worked continually to increase his/her knowledge about and comfort with these technologies and their applications in teaching geography.

Additionally, this participant had formed a favorable attitude toward GST and stated that using them “would provide a greater opportunity to incorporate the higher global thinking skills and critical thinking that these kids need to have.” This comment exhibited recognition of the benefits of using these tools to enhance instruction. When asked to rank his/her knowledge of GST between “1” (no knowledge or novice knowledge) and “10” (expert-level knowledge), this participant reported being at a “5” for both desktop GIS and online GST. Specifically, desktop ArcView GIS software was provided at this participant’s campus for teachers to use. Unfortunately, the school district had not provided any training on how to use the technology, thus, some teachers remained uncomfortable with it. The participant had to train him/herself, which impeded the decision to use and implement GST into instruction. Furthermore, his/her limited knowledge of simpler online GST and their applications to the geography curriculum hindered the implementation of these technologies.

The evidence suggested that this participant was not ready to make the decision to begin integrating GST into instruction because he/she was “not real confident” how to use these technologies. Additionally, this participant was “more uncertain than certain” in knowing appropriate teaching strategies to incorporate GST as instructional tools. The participant also stated that a lot of practice was required before he/she would consider using these technologies with students. Although this participant had decided to use GST during instruction, he/she had not yet used them in the classroom, but had continued to acquire information and resources toward this end.

Of note, the participant had attended a workshop that reviewed using an online GIS-based application tool, National Atlas, powered by the United States Geological Survey website. In this study, National Atlas was designated as a GIS-based application because users cannot create queries to compare relationship among data. This participant was shown how to use the technology and was given a few suggestions of how it may be applied in the social studies curricula. The participant reported that, following this workshop, he/she was more willing to use the technology the following school year. Once this participant moves beyond testing or trying these technologies in a few activities, he/she will progress into the GST Implementation Stage. By knowing the major challenges and supports for change at each stage of adoption, key stakeholders and professional development providers will be better able to help geography teachers in a "just in time" fashion, thus aiding the acceptance of these technologies as tools for instruction.

Determining GST Implementation and GST Confirmation Stages

Describing the GST Implementation Stage

An analysis of participants' comments revealed that most either implemented GST only when teaching or confirmed their decisions to use these technologies to enhance instruction. When an innovation is used, the individual enters the Implementation Stage; prior to this stage, implementing technologies "has been a strictly mental exercise" (Rogers 2003, 179). The GST Implementation Stage may occur over a long period of time depending on the technology and the user. A direct approach was taken when identifying participants in the GST Implementation Stage. The GST Decision Stage was recognized by acquiring information to make a decision, and the GST Implementation Stage was recognized as committing to an action that uses these technologies as a way to enhance instruction. In general, the GST Implementation Stage is relatively short and leads to a longer GST Confirmation Stage. This stage was identified when participants moved from "considering" to "acting," or purposefully employing GST when teaching.

Identifying Participants in the GST Implementation Stage

Applying Rogers' (2003) description of the final two stages and the implications for GST adoption previously mentioned, 12 of the 13 participants had reached the GST Implementation Stage and had begun or fully entered the GST Confirmation Stage. Participants were asked to respond to the survey item, "I use GST to teach geography" using a Likert scale with responses from "Strongly Agree" to "Strongly Disagree." Eight participants selected "Agree," while three selected "Strongly Agree." Each participant had used these technologies as a set of tools for instruction either in a teacher-driven setting or with hands-on, student-centered activities.

A participant moved from the GST Decision to the GST Implementation Stage when he/she acted on favorable attitudes and actually used these technologies as instructional tools in geography education using either teacher- or student-driven strategies. While 12 participants were identified in the GST Implementation Stage, 11 participants exhibited evidence of progressing to the GST Confirmation Stage.

The remaining participant in the GST Implementation Stage might have been in the beginning of the confirming process. In his/her early 40s with over 11 years of teaching experience, this participant was initially self-identified as not using technology in instruction. Strong geography content and pedagogical knowledge was evidenced by the participant's teaching experience, level of education, time spent in geography professional development, and leadership in the school district.

Initially, this participant replied "Disagree" when asked to respond to the statement, "I use GST to teach geography." During the interview, his/her answer changed to "Agree" because his/her Social Studies Supervisor had bought and required teachers to use the software program, StrataLogica, an application built on Google Earth. Although not a GIS software, this online virtual globe is considered a type of GST. The application interface is akin to desktop GIS software in that users can visualize data layers and discuss relationships among data or maps displayed.

Upon further questioning, it became clear that this participant had actually entered the GST Implementation Phase of the GST Innovation-Decision Process between the time of the survey and the interview. The participant stated that he/she did not use these technologies because he/she had not allowed students to manipulate the GIS software; rather, the technology was employed using teacher-driven instruction to discuss geographic concepts using images that he/she created.

The participant's goal for imbedding GST into instruction was to provide a hands-on experiential learning environment where students could explore relationships among physical and human data to analyze regions and events around the world. The participant did not seem to recognize teacher-centered instruction that incorporated GST or technologies other than GIS as a true “use of GST.” Rogers’ (2003) detailed framework aided in identifying clear boundaries and decision-making patterns, which allowed a better assessment of this participant’s level of adoption.

The analysis of the interview data revealed that this participant’s portrayal of his/her knowledge and use of GST was faulty. Technologies such as online GIS-based maps, GPS, virtual globes, and remotely sensed images are instructional tools that aid in the development of students’ content knowledge, reasoning, and analytical skills through teacher-centered instruction. For instance, the participant stated, “I do use GPS and MapQuest. I do use premade lessons using GIS. I do use ArcView automated for the classroom, but the students don’t use ArcView.” The term *automated* referred to creating maps using ArcView GIS and inserting them into PowerPoint presentations.

The participant also expressed a desire for students to use GIS software actively, but felt, “insecure with allowing my students to have that technology, because I feel like I don’t understand it well enough myself. It was a little over my head.” This participant also stated, “I need to know it before I can teach my students and that’s why my students aren’t using it.” The qualitative data illustrated that, while participants may have exhibited evidence of adoption, internally these individuals may not have been confident of their pedagogical knowledge to apply these technologies in a geography education setting.

Further explanation by the participant revealed that he/she understood the data portrayed by the technology and its relationship to the geography content in a real-world context. However, he/she lacked an understanding of how to manipulate complex GIS technologies. The participant talked about how GIS “could be” used as “a good project tool" but did not indicate that he/she had confirmed this fact through use of these technologies.

Clearly, this participant had entered the GST Implementation Stage, but may not have been confident enough in his/her own abilities to routinely enter into the iterative trial-and-error process indicative of the GST Confirmation Stage. Although, the participant may have begun the process of reinforcing his/her decision to use GST in teacher-centered instruction, he/she struggled with the confirmation of the teacher-driven GST model because of the belief that these technologies should provide a hands-on, exploratory experience for students. This belief was the personal impetus to push the participant to seek more information to refine the incorporation of these technologies into daily instruction.

For this study, participants were categorized in the GST Confirmation Stage when they had developed routine use of these technologies into instruction with ongoing evaluation of the effects of students' geographic learning and development of reasoning skills that, in turn, led to modification of the teachers' instruction methods. This participant was initially identified in the GST Implementation Stage because of his/her refusal to allow students to use these technologies to construct their own geographic knowledge. The "use of GST" for instruction was recognized using both teacher- and student-centered methods. Therefore, the participant could be viewed as beginning to move into the GST Confirmation Stage because of the continual review and refinement of teacher-centered instruction with these technologies as instructional tools.

Describing the Confirmation Stage

In the GST Confirmation Stage, an individual still seeks information about the innovation to reinforce his/her decision. Because of ongoing application, teachers in this stage may be better able to articulate the benefits of these technologies with examples of appropriately employing them when teaching. More than merely maintaining one’s decision to use an innovation, this stage involves seeking new ways to adapt these tools for learning and to seek out new technologies for instruction. However, Rogers (2003) implied that the duration of the Implementation Stage depended on the comfort level of the individual using the innovation and its intended purpose. This stage involves the initial steps of figuring out how to use the GST innovation through trial-and-error attempts in applying these technologies when teaching geography concepts, skills, and thinking strategies.

The Confirmation Stage begins when GST are used in such a way that teachers begin to evaluate their effectiveness and seek ways to refine their influence on student learning and engagement. It was assumed that the GST Confirmation Stage was an iterative process of constantly seeking additional information; collaborating with others; and implementing, refining, and transferring knowledge of technology across the geography curriculum (Figure 7.3). Trial-and-error attempts are vital components to this final phase. As the use of GST becomes routine, teachers can evaluate technologies as useful pedagogical enhancements both formally and informally on a regular basis, thus aiding the adoption process.

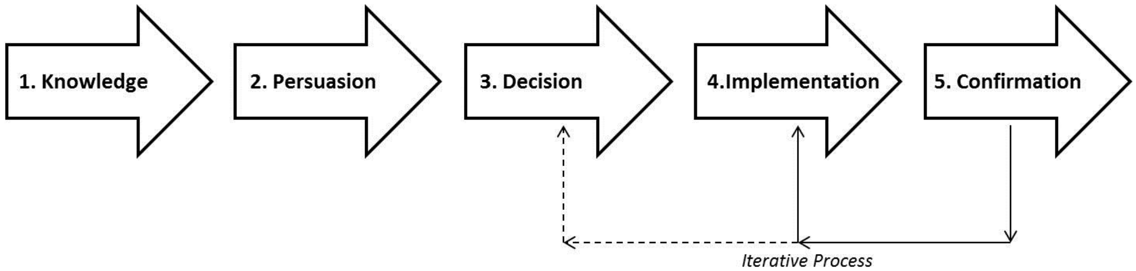


Figure 7.3. Rogers' (2003) Innovation-Decision Process as an iterative model. Adapted from Rogers (2003).

Identifying Participants at the GST Confirmation Stage

The remaining 11 participants represented geography teachers at the GST Confirmation Stage. Rogers (2003) described the action in this phase as one of maintenance or reinforcement for a decision already made. However, this stage may be more involved than Rogers (2003) implied.

For many participants, the GST Confirmation Stage was where they "figured it out." Initially, they may have discovered how to employ these technologies into instruction during the GST Implementation Stage. However, they reinforced their decisions to determine the best ways to integrate them for instructional purposes through the iterative process of trial-and-error during the GST Confirmation Stage. In this instance, teachers applied their knowledge of high school geography content, the functions of the technology, and the applications of some pedagogical knowledge.

Almost two-thirds of the participants (*n* = 9) in this stage referred to their actions as "figuring it out" and said that they mainly did it on their own through a series of trial-and-error attempts. One participant said that he/she continuously gathered information and applied it to teaching by attending workshops and "then by myself, just planning and reading." He/she continued by saying, nobody taught "[me] to teach [with GST] in my class. I learned that from practicing."

Another participant explained the trial-and-error process as, “What I do is basically look at questions, look at the [Texas State Geography Education Standards], and try and see if there is any way I can get GST involved with that.” Part of this process also involved working around barriers, which one participant said was “trial-and-error” and “It’s just try something and see if it works.” Another indicated that technology use was routine: “I have remote sensing Thursday.” Routine integration was a key characteristic of this stage.

Other indicators of the Confirmation Stage included recognizing the benefits of the innovation for learning experiences (Rogers 2003). One participant noted that incorporating GST when teaching “helps kids see patterns a lot more clearly than just reading about them; it makes it much more real for them and easier to understand what’s going on if you can have a picture of it.” Another said that “it gives students a real-world perspective” and “it provides a window outside the classroom, outside the textbook, that gives the students the global view that geography is supposed to provide.” Another participant, who learned to use GST late in his/her career, recognized the ongoing benefit to his/her ability to teach:

> I learned it when I was in the later part of my career, but the more I use it, the more I want to be using it. The more I found out how fascinating and intriguing and a very robust way it is to teach. I felt I used a more rigorous standard, if you will, using it.

New technologies, such as online geospatial digital technologies, may cause teachers to re-enter the GST Decision Stage briefly, as they consider whether the new technologies could and should be used for instruction. Once teachers decide to use these new technologies, they will re-enter the Implementation and Confirmation iterative stages. For example, one participant stated, “Whatever you use, there’s just so much out there, and it moves so fast. It's almost like you're forced to retool and relearn every year or every other year." Another participant shared this concern: "In the future, GST [are] going to do nothing but grow [as it has grown by] leaps and bounds" within the last 10 years.

With online digital technologies, an individual may be faced with deciding whether to adopt and continue to refine his/her skills and knowledge base continually. This attitude of continued development differs from prior instructional technologies that were relatively static and did not require the persistent development of technological knowledge and skills at this scale. Adaption is especially difficult if an individual chooses not to keep up with evolving technologies. One participant stated,

> It changes so fast. If you're going to utilize [GST] you need to be up on it. You need to keep checking it out, keep seeing what's new, [and] learning whatever you can if you want to be proficient in it so that you can have your kids become proficient in it as well.

Geospatial technologies are abundant, with many online options for educators. Therefore, it is important that users recognize that the use of GST is part of an on-going process that will never become static because of the nature of online digital technologies. Therefore, in this study, it was possible that an individual was at the GST Confirmation Stage with one type of technology and the GST Decision Stage with another type. For example, one participant who used GPS devices in the geography classroom was clearly in the GST Confirmation Stage. An investigation into the uses of GPS units online allowed the participant to diversify instruction with this technology. Working with English instructors, he/she used GPS units to find "information strips that [students] would use to write a short story" and then presented this activity at a state conference. Using GPS devices in a routine manner and beyond the scope of the geography classroom, this participant engaged in activities that reinforced the decision to use this technology in instruction.

However, when the same participant was asked about his/her use of other GST, his/her response was, "No, not that I'm aware of." On the other hand, when asked about the value of GST he/she stated, "Students need to understand geography more than just the facts that are presented to them in a textbook. They need the hands-on application of technological information in order to be global citizens." Furthermore, this participant rated his/her knowledge of both online and desktop GST as a "7" on a scale of "1" (novice) to "10" (expert). This dichotomy suggests that, although the participant may have been at the GST Confirmation Stage regarding integrating GPS devices into instruction, he/she might have been at a lower level with other technologies.

Phase II: The Majority: A Commentary on Other High School Geography Teachers

Discussing the adoption of GST would not be complete without recognizing that the majority of geography educators must still undergo the adoption process. The combination of Rogers' (2003) Innovation-Decision Process and participants' remarks provided insight into this largely understudied population. In the current study, qualitative interviews were used to develop an understanding regarding "other" geography teachers' decisions to use or not use GST as tools for instruction based on Rogers' (2003) framework.

As witnessed through the participants' eyes, "other" geography teachers typically represented those who were not trained, formally or informally, in geography; lacked an appreciation of the true nature of the discipline; or chose not to attend training in geography content, skills, and pedagogy. Therefore, these “others” might represent the majority of the high school geography education population who look to individuals, such as the Early Adopters, for guidance regarding GST. Interviewees’ comments allowed for an indirect qualitative analysis of this subpopulation. It was anticipated that the results would serve as a primer for a conversation about the diffusion of these technologies among this population by recognizing characteristics that suggest other teachers’ current levels of knowledge and uses of GST as tools for instruction.

According to the literature, educators who use GST actively at the high school level are Innovators and Early Adopters, and the education community may view them as opinion leaders or key decision makers (Kerski 2000, 2003; White 2008). Rogers (2003) contended that these groups tend to be part of their professional communities. As such, participants in the current study were involved with the geography education community through their state Geographic Alliances and were observant of other colleagues in their discipline. Therefore, participants naturally revealed possible aspects of decisions and actions of the majority regarding GST.

Participants were asked to discuss their observations of other geography teachers’ reasons for not using GST, circumstances that would compel their use, and the value placed on these technologies as instructional tools. The intent of these interview items was to identify characteristics of and attitudes toward GST. Concerning these topics, interview participants were asked the following questions:

1. Even though you indicated in your response to the survey that you were willing to use GST, some of your colleagues may not wish to use GST in their

instruction. Do you know what reasons your colleagues have for not using GST?

2. If no, is this "no" absolute? What would be a compelling reason to change their minds?
3. Do high school Social Studies teachers in your district value using GST? Geography teachers?

In the following section, participants' responses to the three interview questions are examined, then conformity to the stages of the GST Innovation-Decision Process by other geography teachers are discussed as suggested through this qualitative analysis.

Describing Other High School Geography Teachers

Participants' comments revealed motivations and characteristics about other geography teachers. Much research has focused on the lack of diffusion of GST and the population who uses it, namely Innovators and Early Adopters. However, no study has clearly identified characteristics of the majority population of geography educators. The purpose of study was not to explore the types of GST adopters or the different stages of Rogers' (2003) Innovation-Decision Process. Rather, the purpose was to assess high school geography teachers' conformity to Rogers' (2003) model and to identify where they were in the process of adopting these technologies as pedagogical enhancements and to offer recommendations for the future. Comments from the interviews may provide insight regarding the perspectives on GST among this population.

To begin this discussion, it should be noted that participants recognized that other geography teachers typically fall into two major categories: 1) those who know and respect the discipline of geography and 2) those who do not know geography content well or who lack respect for the discipline. Participants' comments suggested that the former group was smaller. For example, one participant noted, "I am one of the few [trained] geographers that I met that actually studied geography as an undergrad." Some participants went out of their way to emphasize other geography teachers in their departments who had well developed content knowledge. One participant stated, "I'll be honest. Our geography department is very strong. I mean, they're great teachers." Anecdotally, this behavior, emphasizing whether a colleague is really knowledgeable, is seemingly common because the geography education community tends to believe that high school geography teachers' knowledge is weak. These two camps of geography teachers may reflect the content knowledge of this dynamic population, which may assist in explaining the slow diffusion of GST into American high school geography classrooms. However, this phenomenon was beyond the scope of this study and warrants further research.

Addressing Interview Question 1: Suggested Reasons for Non-Use of Geospatial Technologies by Other Geography Teachers

Participants were asked to share reasons why they thought other teachers were not willing to use GST as instructional tools in their geography classrooms; all 13 participants responded (Table 7.11). Because the literature supporting the notion that most users of new technologies are Innovators or Early Adopters and that GST are slow to diffuse into K-12 education, this interview question assumed that most other geography teachers represented those who did not use technologies when teaching (Kerski 2000, 2003; White 2008). Participants' comments also identified appropriate interventions that would move geography teachers into or thorough the GST adoption process.

Table 7.11. Suggested Reasons for Non-Use of GST by Other Geography Teachers

Reasons Why other Teachers May not use GST	Agreed (n = 13)
Dedicated time (learning technology, planning, curriculum)	7
Do not know how to use GST	6
Lack of training	6
Lack of GST awareness	5
Uncomfortable with technology	5
Lack of geography content knowledge	3
Do not recognize value of GST	3
Not a risk taker	3
Unwilling to change teaching practices	3
Do not know how to apply to curriculum	2
Do not understand what they are seeing (e.g., remote sensing)	1
Lack of computers	1
Not interested in geography concepts (only facts)	1
Technology perceived as difficult	1

The majority of participants cited a lack of dedicated time (n = 7), lack of knowledge of GST (n = 6), and lack of training (n = 6) as the three most important reasons for non-use. These reasons were followed closely by a lack of awareness of GST (n = 5) and lack of comfort with technology (n = 5), meaning both technology in general and specific technologies related to geography concepts. The next areas of concern included a lack of content knowledge (n = 3) and other geography educators' teaching styles.

The limited dedicated time for teachers and limited knowledge about using GST could negatively influence integration as a pedagogical enhancement. Time is a well-documented obstacle for these teachers (e.g., Bednarz and Audet 1999; Kerski 2003; Baker 2005; Milson and Earle 2007). One participant shared that other geography teachers "say it takes up too much time, which, on the front end, it does because you're learning." Over 50 percent (*n* = 7) pointed to challenges such as the lack of dedicated time to learn the technology, use GST, and implement it into district-mandated curriculum.

Knowledge is critical to the implementation of an innovation. Over one-third of participants (*n* = 5) said that their colleagues lacked awareness of available technologies. Nearly 50 percent (*n* = 6) supported this finding and stated that not knowing how to use GST was a problem. Awareness is a basic construct in Rogers' (2003) model. Collectively, and accounting for multiple responses, 75 percent of participants (*n* = 9) stated that the majority of geography teachers either lacked awareness, knowledge of how to use GST, or the ability to apply these technologies to class content. These results suggested that other geography teachers were either in a Pre-Knowledge Stage or in the lower level of adoption (i.e., Knowledge Stage).

The limited ability to apply GST to the required curricula may stem from a lack of understanding of the discipline of geography. Three participants cited limited geography content knowledge as a challenge. At least three others echoed this reason, which became a theme during their interviews. One participant explained that his/her experiences as a geography major enabled him/her to recognize the potential of GST, whereas "not all of [his/her] colleagues came from that same environment."

Two of the biggest challenges to GST implementation were summed up as follows: "Lack of training. Lack of geographic knowledge." One participant responded by saying, "Maybe they are afraid [because] they don't have enough training." Another stated, "I see that teachers who haven't had any courses, or very much familiarity, don't use it." These remarks highlight possible weaknesses in this population that must be addressed before geography teachers, as a whole, can embark on a meaningful adoption process. Additionally, the larger geography community must recognize and address these weaknesses to ensure the diffusion of GST as well as the health of the discipline.

Participants shared mixed feelings regarding the willingness of other geography teachers to change, and some recalled negative experiences with these other teachers. For example, one participant stated, "I do have colleagues that don't know how to use [GST]; they are not strong enough on the computer and they're not willing to spend any time cultivating that." For example, assigning chapter questions is easier than adapting questions to teach using technology. These remarks suggest that some geography teachers may represent Laggards (Rogers 2003), and may be resistant to change. However, not all who are resistant to change are Laggards. Rather, individuals in this population may be slow to change until they recognize the worth, or relative advantage, of the GST innovation and develop confidence and positive attitudes toward these technologies.

Some participants shared the positive views of their colleagues' willingness to use GST. For example, one participant recognized that other geography teachers "think it's great because sometimes I share some images with them, but they don't have the training so they don't understand. It's not because they don't want to. They never had a formal training or workshop." This participant went on to say, "When a teacher is not ready or did not master [skills with GST], there are not going to teach it to the students."

Evidence from the interviews suggest that other geography teachers may lack comfort with GST and may be motivated differently from the participants in this study; however, they may also be willing to change how they teach. Comfort with technology is influential and affects teachers' decisions to use a technology (Ertmer and Ottenbreit-Leftwich 2010). Almost 50 percent of participants (*n* = 6) were concerned that other geography teachers may not be comfortable with technology, in general, and GST, specifically.

One participant shared that other geography teachers were "uncomfortable" with these technologies because they were not familiar with them or they did not know how to "manipulate the software." He/she continued, "You have to have some training in [how to use GST], and they haven't." Another participant stated that part of the problem is "ignorance" of GST and the other "part of the reason is just not being very comfortable with the technology." One participant said that teachers might be "willing to use [GST] if they felt comfortable with it." These observations support Ertmer and Ottenbreit-Leftwich (2010) who asserted that teachers' attitudes toward a technology are critical to their decisions to use these innovations.

Participants felt that the majority of geography teachers were different than those who were Innovators and Early Adopters of GST, thus motivation and willingness to experiment with new technologies or new ways of teaching may appear very different. Almost 25 percent of participants (*n* = 3) noted that other teachers did not like to "figure it out" and were not risk takers. For example, one participant stated that most teachers want to use GST,

> [But] if it's going to take a whole lot of effort and time and whatever on [their] part, and there's not a guarantee that [they] will be able to use the lesson in class because [the] technology won't work [or be] available, then they're more likely not to dedicate time to it.

In other words, some teachers are not comfortable with an instructional technology that might be unreliable. These individuals might be governed more by the cultural norms of teaching than are Innovators and Early Adopters (Cuban 1986; Rogers 2003; Lee and Wizenreid 2009). Other geography teachers "like to teach by the book. They don't like to do anything different without permission." Some participants recognized that other teachers may be "stuck in a rut" or prefer to direct-teach using only the textbook. Three participants shared that some geography teachers preferred this kind of direct-teaching approach. One participant stated,

> It's easier to give a kid a book, tell them to read Chapter 12, answer the questions at the end of the chapter. Anytime you want to change that, incorporate technology, do something different, it makes it harder. Some teachers just don't want to do that.

Just as it is important to know why individuals may choose not to use an innovation, it is equally as important to understand factors that might encourage teachers to use an innovation. Based on the interview responses, it was apparent that a number of participants believed that other geography teachers were not aware of GST. It was also clear that other geography teachers were likely in the Pre-Knowledge or Knowledge Stages with limited awareness of these technologies and knowledge of how they operate.

Addressing Interview Question 2: Compelling Reasons for Using Geospatial Technologies as a Pedagogical Enhancement

Interview participants were asked to share their observations and offer insight into other teachers' reasoning for their non-use of GST in the classroom. The second question required participants to discuss whether their colleagues' decisions to not use GST were absolute or whether there were compelling reasons that would change their minds. Data from this item were expected to yield information indicating whether other teachers were Laggards or whether they were willing to change given the right set of conditions. One participant chose not respond to this question because he/she was from a technical school where all colleagues used GST in some way. The remaining participants (*n* = 12) replied "No" to this question. In other words, this decision was not absolute, indicating that other teachers would use these technologies given adequate support.

The major factors influencing other teachers' decisions included leadership, training, and knowledge. According to participants, the most compelling contributors to the adoption process included the value, support, and expectation of GST among education leadership (*n* = 5); training (*n* = 5); technology awareness development (*n* = 4); comfort level development (*n* = 4); knowledge of how to use these technologies (*n* = 4); and ability to apply technologies to instruction (*n* = 4) (Table 7.12). Content knowledge was also cited as a concern (*n* = 3). Rogers (2003) noted that the awareness and application of an innovation as well as comfort with the technology reflected the development of three types of knowledge that are necessary to the successful adoption of technologies: awareness knowledge, how-to knowledge, and principles knowledge. Powerful incentives to accept GST as pedagogical enhancements may stem from teachers' knowledge bases, leaders' expectations and visions, or the knowledge and appreciation for the differences between early and late adopters (i.e., Innovators and Early Adopters versus the majority).

Table 7.12. Compelling Reasons for Other Geography Teachers to Use GST

Compelling Reasons to use GST for Other Teachers	Agreed (*n* = 13*)
Education leadership's value, support, and expectation of GST	5
GST training	5
Build GST awareness	4
Increase teachers' GST comfort levels	4
Knowing how to use GST	4
Simple applications; easy to fit into instruction	4
Develop teachers' knowledge & interest in geography content	3
Proof that GST improves learning (content, skills, and thinking)	2
Resources (lessons, software, books, etc.)	2
Success stories to model GST implementation	1
Teach educators how to be flexible when teaching	1
Recognize not all GST requires learning software programs	1
Recognize teacher low morale	1

*One participant chose not to respond to this question.

Teachers need a compelling reason to change. "First of all," as one participant emphasized, geography teachers "have to see the need for it." Rogers (2003) called this phenomenon a relative advantage, which may be "one of the strongest predictors of an innovation's rate of adoption" (233). The necessity for a compelling reason to change was especially true for the majority and Laggard populations within geography education. In response to the second interview question, participants recognized that many of their colleagues were not Laggards as defined by Rogers (2003); rather, they represented educators who were willing to change given the right set of conditions. These conditions develop from pedagogical and content knowledge demands, support and available resources, and relationships with education leaders and decision makers.

These findings revealed that geography teachers in the majority population may require more and different pedagogical and content support than GST Innovators or Early Adopters. Otherwise, these teachers might feel less energized and more overworked with little interest or time left to experiment with new technologies. For example, one participant stated,

> It needs to be real easy. It needs to be real easy to implement and develop and all of that because teachers are so worn out just in general from all of the other stuff here that's come done the pike, so to speak. That's the last thing on a lot of teachers' minds is development something awesome and new because we're just so worn out from everything else.

Implementing GST easily into the curricula involves not only resources but also an appreciation for the application of these technologies to a variety of teacher- and learner-centered teaching approaches.

Other geography teachers may be motivated differently and require more on-going support that is unlike their GST Innovator and Early Adopter counterparts. For example, one participant stated that it was necessary to "[reinforce] the idea that it really is okay not to know everything. And if it breaks, don't worry. It really is just trying to build the confidence." Furthermore, teachers need compelling reasons to change their teaching practices beyond the notion that it is the "latest and greatest thing" for teaching. These teachers are not risk-takers and need a smooth entry and facilitation pattern to follow.

On-going support can come from a number of sources. For example, one participant suggested "provid[ing] them with the resources" such as software, books, easy-to-use and ready-made lesson plans, and step-by-step instructions for using GST. Innovators and Early Adopters can also provide support. One participant noted, "Success stories are a good buy-in for my colleagues" so they can see that a technology was successfully implemented. Concrete examples that clearly and easily apply GST to the taught curricula may be necessary.

Finally, Rogers (2003) implied that the social norms of the K-12 geography community, education leaders' perceptions of GST, and classroom demands heavily influence those teachers in the majority population. Education leaders' support at the campus, district, and state levels is critical to the diffusion of GST in secondary education. Almost 40 percent of participants (n = 5) agreed that, for these technologies to be a successful pedagogical enhancement in geography education, they must be valued, supported, and expected to be used by education leadership.

Teachers, administrators, and other key leaders alike embrace the twenty-first century and Digital Information Age by requiring data-driven decisions. Therefore, educators need to know how to respond to their supervisors who ask for reasons why GST should be supported in the classroom. According to two participants, teachers need to be armed with proof that these technologies positively influence learning geography content, skills, and cognition in some way. Leadership is very influential and affects teachers' willingness to develop content knowledge and interest in any discipline.

Key stakeholders (e.g., policymakers, superintendents, principals, etc.) and educators must recognize and understand that GST are beneficial to students' education and should be encouraged in geography education. Such support is vital to the success of an innovation (Cuban 1986; Rogers 2003; Lee and Wizenreid 2009; NRC 1996, 2013). Therefore, the geography education community must consider creative ways to engage leaders at different levels of governance. Without their support, change will be difficult, if not impossible.

Addressing Interview Question 3: Educators' Value of Geospatial Technologies in Instruction

For the final question about other geography teachers, interview participants were asked to comment on whether they thought their district social studies teachers, in general, and geography teachers, specifically, valued GST. The value educators place on the role that technology plays in geography education suggests that they understand and appreciate the connections among GST, geography content, and pedagogical strategies. Thus, Interview Question 3 was not simple to answer because it involved the influence of contributing factors such as teacher knowledge, environmental and social constraints, and education leadership's expectations and limitations. Three participants answered this question as intended with the delineation between social studies teachers, in general, and geography teachers, specifically. The other participants (n = 10) included all social studies teachers and did not discuss geography teachers separately. Responses were combined regarding the general social studies teachers (Table 7.13).

Table 7.13. The Value of GST Among Social Studies Educators

Value of GST by Social Studies Educators	Agreed (n = 13)
Social studies teachers, including geography–Yes	5
Social studies teachers, including geography–No	8

Although five participants indicated that social studies teachers valued using GST, the overwhelming majority (n = 8) said they did not value using these technologies in instruction. One participant explained this lack of enthusiasm by saying, "I don't think they value it only because they don't know what it is." Another participant shared that some teachers only liked to teach basic facts and were "not interested in exposing the kids to more conceptual learning. They just don't do it because, I guess, they don't want to take the time." These remarks imply that other teachers might be in the Pre-Knowledge or Knowledge Stages because they are in the process of developing an awareness of and an appreciation for the role of GST in geography education.

Trends Influencing GST Adoption by Other Geography Teachers

When viewing the responses to the three interview questions together, common themes emerged that suggest underlying reasons why the majority of geography educators do not use GST. The data also offered insight into the possible stages of adoption and knowledge evident among these teachers. The qualitative themes revealed through participants' commentaries concentrated on the following themes: 1) other geography teachers' lack of awareness of GST (n = 11); 2) lack of "how-to" knowledge (n = 9); 3) lack of content knowledge (n = 6); 4) lack of interest in and appreciation for the discipline of geography (n = 5); 4) education leaders' lack of value and support for GST (n = 4); 5) lack of teachers' value of GST (n = 4); and 6) lack of understanding of how to apply GST to the curriculum (n = 6) (Table 7.14). Collectively these themes shed light on the adoption process of these technologies as pedagogical enhancements within the high school geography education community.

Overwhelmingly, participants' remarks revealed other geography teachers' insufficient knowledge constructs for GST, geography content, and application of these technologies into the curriculum. Without an awareness and an understanding of a technology or the discipline in which it will be used, one can expect that implementation of that technology will be slow at best. Therefore, it was quite understandable why other geography teachers would find applying GST to the geography curricula problematic.

Table 7.14. Trends Influencing GST Adoption by Other Geography Teachers

	Responses in Agreement			
	Question 1	Question 2	Question 3	Total*
Lack of GST awareness	5	4	7	11
Lack of knowledge how to use GST	6	4	-	9
Lack of geography content knowledge	3	3	2	6
Lack of interest and appreciation for geography discipline	0	5	0	5
Education leaders' lack of GST value, support, and expectation	3	0	2	4
Lack of value for GST	3	0	2	4
Do not know how to apply GST to curriculum	2	4**	0	6

* Repeated answers were accounted for in the total.
** The number of participants who said other geography teachers needed to be provided with simple applications to the geography curriculum.

Summary

Rogers' (2003) Innovation-Decision model provides a good structure for understanding individuals' decisions to adopt and use new technologies. The interviews from 13 participants offered insight into geography teachers' GST-decision processes. As established previously, the interviewees represented GST Innovators and Early Adopters who acted as role models and leaders in the education community. Therefore, they were uniquely positioned to identify and comment on characteristics of other geography teachers. The data gathered were interesting and provided a starting point for future research to study the characteristics, differences, needs, and motivations of other geography educators.

The purpose of this study was to identify whether geography teachers conformed to Rogers' (2003) Innovation-Decision Process. Therefore, it was beyond the scope of this study to examine the characteristics of other geography teachers within each stage of adoption. Specifically, it is too soon to know whether other geography teachers conformed to the sequential aspects of the model because of their incomplete adoption processes.

Rogers' (2003) definitions of the adoption stages and the types of adopters furthered the understanding of this largely unstudied population. Clearly, the interview responses suggested that these teachers were in the GST Pre-Knowledge and GST Knowledge Stages, with a few possibly in the GST Persuasion Stage. Participants' remarks began a conversation within the geography education community about the general population of geography teachers and the diffusion of these technologies.

Educators have recognized the potential for GST since the 1990s. However, diffusion into high school geography learning environments has been exceedingly slow (Bednarz and Ludwig 1997; Audet and Ludwig 2000; Kerski 2003; Bednarz 2004; Baker 2005; Milson and Earle 2007; Milson and Kerski 2012). By the late 1990s, education was not "affected much by the GIS explosion;" however, these technologies became "valuable asset[s]" to K-12 education (Bednarz and Ludwig 1997, 124). In fact, few newly certified teachers were even prepared for how to teach geography as required by state and national standards, let alone how to teach with GIS (Bednarz & Audet 1999). This problem persists today.

Rogers' (2003) Diffusion of Innovation also offers a framework for understanding the progression of adoption of an innovation, also called the Innovation-Decision Process. This study first aimed to discover whether geography teachers conform to the five stages of adoption when deciding to accept GST as pedagogical enhancements. In this sense, conformity refers to the stages of adoption within the Innovation-Decision Process, its sequential pattern, and evidence of technology adoption.

Data from the two phases of this study yielded results that addressed the initial research question using specifically coded variables for the stages of adoption: Knowledge, Persuasion, Decision, Implementation, and Confirmation. Quantitative data were collected using an online questionnaire in Phase I, and conducted telephone interviews in Phase II. The survey results identified teachers in each stage of GST adoption. However, the data indicated that the adoption process for geography teachers may be non-sequential. Eighteen participants were identified at the Pre-Knowledge level, which indicates low levels of GST knowledge, decision-making, and action (use) patterns. On the other hand, 27 were placed in the GST Confirmation Stage, suggesting a purposeful engagement in an iterative process of evaluating, refining, and implementing these technologies into geography instruction.

With the exception of those in the Pre-Knowledge Stage ($n = 18$), all participants could have been identified in multiple stages. Therefore, determining the actual number of participants in the first four stages was not possible. The results support the assumption that, while the participants in this study showed a predisposition to enhance their geography content knowledge and skill sets, they represented geography teachers at various stages of GST adoption. The findings also suggest that the initial step in adoption may begin with a positive or negative decision toward using technology. However, the qualitative data could neither confirm nor deny these results because of the small sample size used in Phase II ($n = 13$).

Rogers' (2003) definitions of adopter populations and stages of adoption proved useful to the overall understanding of GST acceptance in high school geography education. Recently, use of GST has grown tremendously in industry. During this time, there has been a progression, albeit slow, of GST users' development in high school geography education. If these technologies are to be widely accepted, then the majority of geography teachers must be involved.

Responses, particularly in Phase II, illustrated some differences between participants (Innovators and Early Adopters) and other geography teachers who represented the majority. The main differences were that the former group enjoyed experimenting with GST creatively when teaching and accepted the risks of these technologies not working or being available when desired. The latter group needed concrete, easy-to-use examples of how to apply these technologies when teaching specific elements of their curricula as well as evidence that supports the notion that GST enrich learning geography concepts, which could be shared with their supervisors.

Rogers' (2003) explanation of the knowledge, decision-making, and action patterns expected at each level of adoption allowed a better analysis of participants' behaviors to assess conformity to his model. Except for the possible deviance from the linear pattern, participants largely conformed to the Innovation-Decision Process model and furthered the understanding of the diffusion of GST into high school geography education.

CHAPTER VIII

INVESTIGATING THE INFLUENCE OF G-TPCK ON DECISION-MAKING

Addressing Research Question 2: The Influence of TPCK on Teachers' Decisions

In the mid-2000s, Koehler and Mishra (2005) developed a framework of teacher knowledge that encompassed the evolving technological knowledge of the Digital Information Age (Lindeman and Vastag 2011). Building upon Shulman's (1986) work, Mishra and Koehler developed a way to understand the interplay of information technology knowledge with that of teachers' content and pedagogical knowledge. They contend that not only are all three types of knowledge important for effective teaching, but they also support the importance of understanding the dynamic interrelationship among all three knowledge sets. Mishra and Koehler (2006) also asserted that it is critical to grasp the interplay of all three knowledge sets to sustain the application of instructional technologies in the classroom. They refer to this interplay as, Technological Pedagogical Content Knowledge (TPCK) (Figure 8.1).

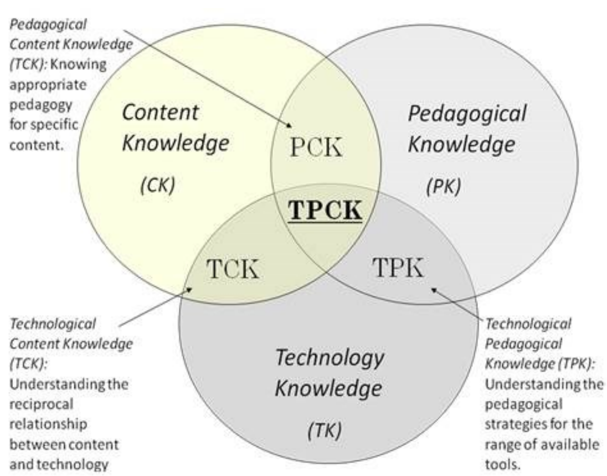


Figure 8.1. Technological Pedagogical Content Knowledge . Source: Koehler and Mishra (2005)

Mishra and Koehler concluded that, for sustained, quality integration of technology in instruction, teachers must know how a technology relates to specific content as well as how to go about developing pedagogical strategies best suited for the instructional technology as it relates to a specific discipline. Following Mishra and Koehler, the collection of these three types of knowledge (technological, pedagogical, and content), which work together to inform a teacher's practice were supported.

Geospatial Technological Pedagogical Content Knowledge and Geography Education

Doering and Veletsianos (2007) noted, "The integration of geospatial technologies will not be successful until the design and development of pre-service and in-service teacher education programs also includes geographical technological pedagogical knowledge (G-TPCK)" (223). Therefore, the overriding aims of this study were to: 1) determine the extent to which geography teachers conform to Rogers' (2003) Innovation-Decision Process model (addressed in Chapter VII) and 2) examine how possessing different levels of the three types of knowledge might influence teachers' decisions to use geospatial technologies (GST) more frequently in their instruction. The latter purpose of this study is reflected in the second research question of this study and is discussed in this chapter. Educators' knowledge varies and, most likely, develops at separate times and through a variety of mediums, such as a collection of professional development and other learning experiences, online experiences, books, and collaborations with colleagues. The following section explores the nature and level of TPCK as revealed in the quantitative and qualitative data from Phases I and II of this study.

Nature of Participants' Content and Pedagogical Knowledge

It was assumed that the acquisition of any knowledge or skill related to geography teaching is not isolated. It was also assumed that the existence of content knowledge would be based on participants' connections with their state Geographic Alliances, teacher certification process, and placement as geography teachers. As a result, this study focused on Geospatial Technological Content Knowledge (G-TCK) and Geospatial TPCK (G-TPCK). This assumption was validated. It ensured that no participant used GST to teach only basic, rote geographic facts, and that each teacher recognized the potential of these technologies as tools to elicit higher-ordered, authentic geographic reasoning experiences for learners. The implementation of GST in teaching occurs when teachers are comfortable with the interplay of geography content, pedagogy, and technology.

Because the network of Alliances represented geography educators nationwide, teacher participants possessed an array of attitudes about and experiences with various types of technologies. The state Geographic Alliances have developed a culture that expects its members to participate in professional development to enhance their geographic knowledge and skills; therefore, participants represented educators who were most likely open to learning about and engaging GST in the classroom.

Bednarz and Ludwig (1997) asserted that most geography teachers "attain GIS skills and software through geography Alliance-sponsored training" (125). Therefore, it was expected that, while teacher participants might have heard about these technologies, their actual knowledge and use of them would range from those who did not value and did not use GST, to those who were strong advocates of and had significant experience using these technologies. Most likely, this latter group reflected the greater portion of high school geography teacher participants in this study.

Addressing Research Question 2: Determining Participants' Levels in the Three Knowledge Sets

The diffusion of GST into high school geography education has been slow (Kerski 2000, 2003; Bednarz 2004; Baker 2005; Milson and Kerski 2012). An underlying aspect of the current research was to understand the process of adopting an innovation—in this case, the adoption of GST by teacher participants. Earlier in this study, Rogers' (2003) Innovation-Decision Process helped explain the phases of knowledge and decision-making when adopting an innovation. Mishra and Koehler's (2006) framework was incorporated to serve as a theoretical guide to reflect the relationships among internal influential factors that might explain whether a geography educator would adopt technologies as pedagogical enhancements for instruction.

Research Question 2 was: Using Koehler and Mishra's Technological Pedagogical Content Knowledge (TPCK) framework, do high school teachers who exhibit more TPCK use GST more frequently than other teachers? To investigate this question, this mixed methods approach called for the development of two phases. Quantitative Phase I administered an online survey that was designed to target participants' G-TCK and G-TPCK. Next, qualitative Phase II followed with telephone interviews to support and add to the quantitative data by asking questions targeting participants' knowledge.

Phase I: Identifying Levels of Participants' G-TPCK

Survey items were developed based on Rogers' (2003) stages in the Innovation-Decision Process model to elicit responses that might indicate participants' levels of TPCK or G-TPCK; that is, technology or geospatial technological and pedagogical knowledge levels. After initially recoding string responses to numeric representations of nominal and interval data, survey items were coded to reflect elements of TPCK. Questions that addressed both geospatial technological and pedagogical knowledge were coded TPCK. Items that pertained to only GST knowledge were coded TCK. At times, dual coded items for both knowledge sets were used when analyzing the different categories in the Statistical Package for the Social Studies (SPSS) software. See Appendix I for the list of variables and codes for survey items.

Participants' responses were coded using a binary system to reflect their GST knowledge; "1" represented a positive response and "0" represented a non-positive response to a survey item. An example of a positive response included either "agree" or "strongly agree" to questions using a Likert scale. An example might also have included certain multiple choice answer selections that demonstrated the strength of a participant's G-TPCK. A non-positive response was reflected in a "neutral," "disagree," or "strongly disagree" response to questions using a Likert scale format or the selection or non-selection of certain multiple choice responses. The initial research design required participants to have 50 percent or more positive TPCK responses to be assigned to the G-TPCK category. Those with 50 percent or more positive TCK responses were assigned to the G-TCK category. The other participants were assigned to the Limited G-TPCK category.

Because of the dual coding structure of the survey items, only the TPCK coded data were used to group participants. After comparing the TCK and the TPCK averages, it was determined that the results were too similar. In other words, it seemed that participants with high technology knowledge also had high technological pedagogical knowledge; therefore, using the average scores of the two groups overlapped. For consistent categorical breaks, the average TPCK scores were used to assign participants into G-TPCK, G-TCK, or Limited G-TPCK groups.

The average of the responses indicated the level of TPCK for each participant. If a participant had an average of 50 percent or more positive answers, then he/she was assigned to the G-TPCK category. A participant's G-TPCK average that fell between 30 and 49 percent indicated a lower level of technological and pedagogical knowledge, and the participants was assigned the G-TCK category. Participants with less than 30 percent positive responses were determined to have limited knowledge and were assigned to the Limited G-TPCK category. Table 8.1 summarizes the number of participants for each knowledge group.

Table 8.1. Chi-Square Results for Participants' Levels of GST Knowledge

	Observed *n*	Expected *n*	Residual	Level of G-TPCK	df	*p*
G-TPCK	30	26	4.0			
G-TCK	26	26	.0			
Limited G-TPCK	22	26	-4.0			
Chi-Square				1.231	2.0	.540

To clarify, no participant was thought to "have" or "not have" G-TPCK; they were simply identified as exhibiting all elements of this type of knowledge for at least half of the responses. Participants were assessed regarding their awareness and use of these technologies to teach world geography. The sample of teacher participants was almost evenly divided, which reflected an array of technological pedagogical and content knowledge levels.

It was assumed that participants represented the typical general geography teacher who may or may not be aware of GST or pedagogical strategies with which to teach geography using these technologies. In other words, despite their propensity to participate in professional development to enhance their geographic content and pedagogy knowledge, participants were equally likely to be identified in one of three geospatial technological knowledge categories: G-TPCK, G-TCK, and Limited G-TPCK.

A Chi-square goodness of fit test was conducted to assess the association among these groups. The null hypothesis assumed that no significant difference existed among these knowledge categories (levels); therefore, the frequency for each category would be the same (uniform distribution). Results for the three factors are reported in Table 8.1. The results indicated that the three GST knowledge categories (levels) were not statistically significant (p = .540). Because no statistically significant difference existed among the three knowledge categories, the null hypothesis was not rejected.

Assessing General Awareness of Desktop GIS and GST among Participant Groups

The following section reports the examination of participants' awareness of GST, desktop Geographic Information Systems (GIS), and other forms of these technologies with respect to participants' levels of the three knowledge groups. Four survey items were developed to explain participants' GST awareness levels:

- I am aware of desktop Geographic Information Systems (GIS) software.
- I am aware of online GST.

- What forms of desktop GIS software are you aware of? (Check all that apply.)
- What forms of GST are you aware of? (Check all that apply.)

The first two questions used a Likert scale for responses, which provided a broad understanding of the nature of GST awareness. The latter two questions required more specific answers to illuminate details regarding participants' levels of knowledge.

Most participants reported some level of awareness of both desktop GIS and online GST (Tables 8.2 and 8.3). All (100 percent) participants in the G-TPCK group "agreed" or "strongly agreed" that they were aware of these technologies; 89 percent were aware of desktop GIS and 74 percent indicated they were aware of online GST. Participants might have been more aware of desktop GIS because these technologies have been available for a longer period of time than others. Additionally, a majority of related professional development targets desktop GIS. Participants in the Limited G-TPCK category were more aware of desktop GIS (41 percent) than online GST (14 percent). These participants might have attended fewer professional development events outside of the school district; therefore, were less aware of other related technologies. Additionally, these participants might have been uncomfortable with the term *online GST* despite attempts to provide definitions.

Chi-Square Results: Understanding Awareness of GST and GIS Variables

The survey yielded both nominal and ordinal level data; therefore, more robust parametric statistical tests were not permissible. Because the GST knowledge level categories were separated into groups of participants, Chi-square tests of independence were appropriate. When conditions permitted, Chi-square tests were used with descriptive statistics to analyze data and interpret results.

Table 8.2. Participants' Awareness Levels of Desktop GIS

	G-TPCK (Positive TPCK score ≥ 50% of the time) n = 30		G-TCK (Positive TPCK Score 30-49% of the time) n = 26		Limited G-TPCK (Positive TPCK Score < 30% of the time) n = 22	
	n	%	n	%	n	%
Strongly Disagree	0	0	1	4	3	14
Disagree	0	0	1	4	7	32
Neutral	0	0	1	4	3	14
Agree	12	40	20	77	9	41
Strongly Agree	18	60	3	12	0	0

Table 8.3. Participants' Awareness Levels of GST

	G-TPCK (Positive TPCK score ≥ 50% of the time) n = 30		G-TCK (Positive TPCK Score 30-49% of the time) n = 26		Limited G-TPCK (Positive TPCK Score < 30% of the time) n = 22	
	n	%	n	%	n	%
Strongly Disagree	0	0	0	0	4	18
Disagree	0	0	3	12	10	46
Neutral	0	0	4	15	5	23
Agree	18	60	16	62	3	14
Strongly Agree	12	40	3	12	0	0

Assessing the strength of association among levels of G-TPCK and participants' awareness of desktop GIS and online technologies was critical to determining whether TPCK played a meaningful role in technology diffusion and aided in accounting for participants' decisions to use these technologies as instructional tools. A Chi-square test of independence was conducted to assess the strength of association between the G-

TPCK, G-TCK, and Limited G-TPCK groups and 1) desktop GIS and 2) online GST. The null hypothesis stated that no significant association existed between the levels of G-TPCK and participants' awareness of either desktop GIS or online GST. For this test to be valid, no cell could have a value less than the expected value of five. Data for both tests included nine cells below the expected value. Although the results were not valid, they indicated significant patterns and associations between variables that should be investigated further. Therefore, the null hypothesis was rejected. The Chi-square results are detailed in Table 8.4.

Table 8.4. Chi-Square Results: GST Awareness & Level of G-TPCK

Association	Chi-square	df	*p*
Desktop GIS awareness & level of G-TPCK	48.350	8	<.001
Online GST awareness & level of G-TPCK	5.860	8	<.001

Figures 8.2 and 8.3 illustrate a strong association among these variables. More participants in the G-TPCK group indicated that they were aware of both desktop GIS and online GST compared to those in G-TCK or Limited G-TPCK groups. Although participants in the G-TCK group were very aware of these technologies, a few participants were either unsure or unaware of both types of technology. Additionally, a direct association existed between those participants with Limited G-TPCK and those who were unaware of these technologies. The presence of pedagogical knowledge, as it relates to G-TCK, appeared to be an important factor in geography teachers' levels of awareness.

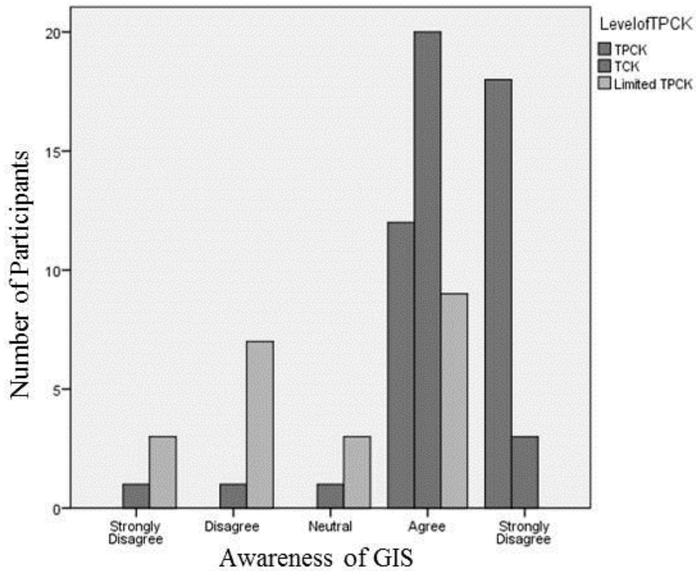


Figure 8.2. Participants' desktop GIS awareness & level of G-TPCK.

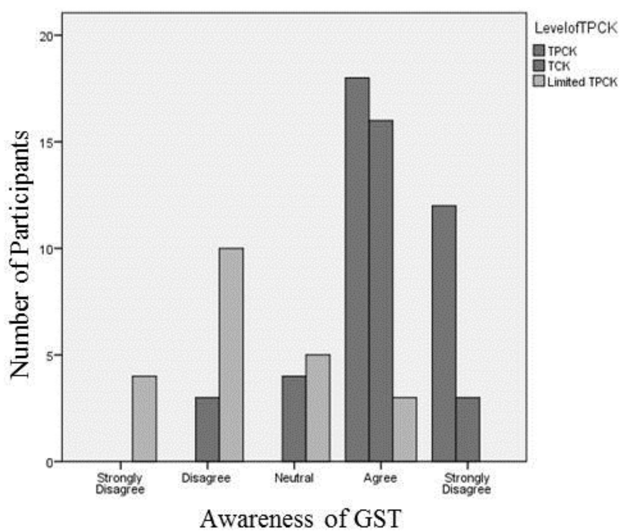


Figure 8.3. Online GST awareness and level of G-TPCK test of independence.

Recognizing Specific Forms Geospatial Technologies

Specific attention was paid to the forms of technology that participants' were aware of to better explain their levels of GST awareness at each stage of adoption. Participants were asked to identify 11 forms of desktop GIS and 10 forms of other types of technologies (Tables 8.5 and 8.6). The ArcView GIS software, developed by the

Environmental Sciences Research Institute (Esri), was chosen most frequently by each category of participant; nearly all G-TPCK participants (*n* = 27; 90 percent) were aware of this technology. Each form of desktop GIS was recognized by at least one G-TPCK participant. Over half identified ArcExplorer Java Edition for Educators (AEJEE) (63 percent), ArcVoyager (63 percent), and My World GIS (50 percent).

While most instructional technologies are designed for industry with little regard for educators (Cuban 1986), some are designed specifically with educators in mind. Manufactures also provide educators with resources and training (e.g., My World GIS, AEJEE). Therefore, it was understandable that they were known to participants' who portrayed elements of TPCK. Although Esri's ArcView GIS was developed as a robust tool for industry, Esri, an international GIS corporation, has made great strides to provide educators with resources and make this technology as teacher-friendly as possible.

Over half of the G-TCK participants (54 percent) were also aware of Esri's ArcView GIS. MapInfo and ERDAS Imagine were the next two most identified desktop GIS packages. Less than 15 percent of the G-TCK group identified the remaining GIS technologies, with the exception of Geographic Resources Analysis Support System (GRASS), Manifold, and InterGraph GeoMedia, which no participant recognized.

Table 8.5. Participants' Levels of Awareness of Desktop GIS Technology

	G-TPCK (Positive TPCK score ≥ 50% of the time) *n* = 30		G-TCK (Positive TPCK Score 30-49% of the time) *n* = 26		Limited G-TPCK (Positive TPCK Score < 30% of the time) *n* = 22	
	n	%	*n*	%	*n*	%
Esri ArcView GIS	27	90	14	54	3	14
MapInfo	12	40	5	19	0	0
IDRISI	4	13	2	8	0	0
MS MapPoint	5	17	1	4	0	0
Earth Resource Data Analysis System (ERDAS) Imagine	13	43	4	15	1	5
Geographic Resources Analysis Support System (GRASS)	7	23	0	0	0	0
SmallWorld	3	10	1	4	0	0
Manifold	1	3	0	0	0	0
ArcExplorer Java Edition for Educators (AEJEE)	19	63	1	4	0	0
InterGraph GeoMedia	2	7	0	0	0	0
My World GIS	15	50	2	8	1	5
ArcVoyager	19	63	3	12	0	0

Table 8.6. Participants' Awareness Levels of Types of GST

	G-TPCK (Positive TPCK score ≥ 50% of the time) *n* = 30		G-TCK (Positive TPCK Score 30-49% of the time) *n* = 26		Limited G-TPCK (Positive TPCK Score < 30% of the time) *n* = 22	
	n	%	*n*	%	*n*	%
Global Positioning System	29	97	21	81	15	68
Mapping Games	24	80	8	31	5	23
MapQuest	28	93	22	85	18	82
Google Earth	30	100	26	100	20	91
National Atlas	21	70	7	27	3	14
Globalis	9	30	1	4	1	5
FieldScope	3	10	1	4	0	0
USGS Interactive Map	24	80	11	42	3	14
ArcGIS Explorer	22	73	7	27	0	0
ArcGIS Online	20	67	4	15	0	0
Remotely Sensed Images	24	80	11	42	3	14

Participants in the Limited G-TPCK group expressed little awareness of Desktop GIS. Three of the 22 participants in this group recognized Esri's ArcView GIS; only two participants recognized ERDAS Imagine (n = 1) and My World (n = 1). No participant recognized the other desktop GIS. Overall, those with technological pedagogical knowledge were more aware of desktop GIS than were either those with technology knowledge or those with Limited G-TPCK. This pattern held true regarding the forms of other technologies. Far more participants were aware of online GST than of desktop GIS. Those with TPCK were usually two to three times more aware than were those with only technology knowledge.

More than two-thirds of the G-TPCK population was aware of all forms of GST except for Globalis and FieldScope. It was anticipated that participants' knowledge of Globalis and FieldScope would be relatively low as Globalis was no longer available online at the time of this study, and FieldScope is an online GIS application that provides data and maps for certain areas of the United States, none of which were in the states surveyed.

At least one participant in the G-TCK category recognized each form of technology listed. Participants in the G-TCK group were most aware of the following forms: Google Earth (100 percent), MapQuest (85 percent), Global Positioning System (GPS) (81 percent), USGS Interactive Map (42 percent), and Remotely Sensed Images (42 percent). These technologies fall within the visualization tools category. These technologies produce static images similar to those that social studies teachers comfortably use in instruction.

A few technologies (e.g., Google Earth and USGS Interactive Maps) may be more complex and may serve as a transition to more GIS-based tools. GIS-based tools are interactive, dynamic maps that allow users to visualize and analyze layers of data. No queries or statistical analysis of data can be made using these GIS tools because they are based on predetermined data. A full GIS system (online or desktop) allows for the statistical analysis of data and the illustration of data by layers. Online technologies such as National Atlas, ArcGIS Explorer, and ArcGIS Online were the least known to the G-TCK group.

With the exception of Google Earth (91 percent), MapQuest (82 percent), and Global Positioning Systems (GPS) (68 percent), participants with Limited G-TPCK did not indicate strong knowledge of any form of technology listed. Almost a quarter of participants (23 percent) knew about the Mapping Games software applications. Three out of five participants were aware of Remotely Sensed Images, USGS Interactive Maps, and National Atlas. No participant in the Limited G-TPCK group was aware of FieldScope, ArcGIS Explorer, or ArcGIS Online.

The level of awareness for each group of participants may show the progression of diffusion of GST within geography education. Additionally, the Limited G-TPCK responses may illustrate the forms of technology that are popular and that resonate most among educators. Given time, more involved, intermediate level GST, such as Remotely Sensed Images, USGS Interactive Maps, and National Atlas, could be diffused more widely as teachers increase their technology knowledge overall. Finally, educators may use more GIS-based technologies as they gain more technology knowledge and, importantly, pedagogical knowledge.

Those in the G-TPCK group were two to three times more likely to be aware of a form of GST than were participants in either the G-TCK or Limited G-TPCK groups. This finding might be the result of attending more professional development opportunities and other training in which their technology knowledge was continually reinforced and expanded as they obtained and learned more pedagogy. Awareness of these technologies might also affect whether participants teach with GST as well as the frequency in which they engage these technologies.

Exploring the Influence of G-TPCK on Participants' Decisions to Teach with GST

Integrating new instructional technologies into an education community can be a long, slow process (Cuban 1986; Lee and Wizenreid 2009). However, this process may be fast-tracked with buy-in from members of the education community. According to Mishra and Koehler (2006), such buy-in may be possible only on a large scale when educators have elements of technological knowledge, pedagogical knowledge, and content knowledge, and when they understand the relationship among and between the three types of knowledge (i.e., G-TPCK). As defined previously, this study sought to understand the extent to which teacher participants demonstrated G-TPCK knowledge and to determine the extent to which this knowledge influenced their use of these technologies as a set of tools for classroom instruction.

The geography community of higher education scholars desires the diffusion of GST into high school education as they recognize that these technologies are slow in making inroads among secondary educators (Bednarz and Audet 1999; Kerski 2000, 2003; Bednarz 2004; Baker 2005; Milson and Kerski 2012). As explored in this study, decisions to use GST may rest on the development of high school geography teachers' G-

TPCK. The following three survey items were developed to record participants' decisions to teach or not teach with GST:

- I use GST to teach geography.
- Currently, I use geospatial technologies (GST) to teach geography: (Select the appropriate answer)
- How do you use GST in your classroom? (Check all that apply.)

The initial question provided an overview of participants' employment of GST as instructional tools while the other two questions indicated the frequency and particular types of technology use.

Overall, when technology knowledge was present, participants incorporated GST in some way (Table 8.7). Nearly all (24 out of 26) G-TPCK participants "agreed" or "strongly agreed" that they used these technologies to teach geography. Only three out of 30 stated that they did not use GST, while two participants remained undecided. On the other hand, nearly half (11 out of 26) of those with technology knowledge were limited in their pedagogical knowledge and indicated that they did not use these technologies in the classroom; seven remain undecided. However, on another survey item, eight participants indicated that they agreed to incorporate GST when they taught. More telling, no participant in the Limited G-TPCK group chose to use these technologies as instructional tools. However, four remain undecided; perhaps these participants had more technology knowledge than the others in this category. Exploring the frequency and ways that teachers use GST aided in defining participants' true usage patterns.

Table 8.7. Participants' Responses of Current GST Usage as Instructional Tools

	G-TPCK (Positive TPCK score ≥ 50% of the time) *n* = 30		G-TCK (Positive TPCK Score 30-49% of the time) *n* = 26		Limited G-TPCK (Positive TPCK Score < 30% of the time) *n* = 22	
	n	%	*n*	%	*n*	%
Strongly Disagree	0	0	4	15	5	23
Disagree	3	10	7	27	13	59
Neutral	2	7	7	27	4	18
Agree	18	60	8	31	0	0
Strongly Agree	7	23	0	0	0	0

Chi-Square Results: Association of G-TPCK and Teaching with GST

A Chi-square test for independence was conducted to determine whether a statistically significant association existed among the three levels of G-TPCK and participants' decisions to use GST when teaching geography. The null hypothesis assumed there would be no statistically significant difference among the knowledge categories, thus the frequency of participants would be uniform. Results of the Chi-square test are detailed in Table 8.8 and indicate a statistically significant association between these variables ($p < .001$); therefore, the null hypothesis was rejected. Because of the nature of Likert scale questions, some cells fell below the expected value of five. Although the results were not valid, they indicate potentially strong associations among variables that should be investigated further. Figure 8.4 depicts these data visually.

Table 8.8. Usage of GST when Teaching and Levels of G-TPCK

Association	Chi-square	df	*p*
Level of G-TPCK and Usage of GST when Teaching	45.098	8	< .001

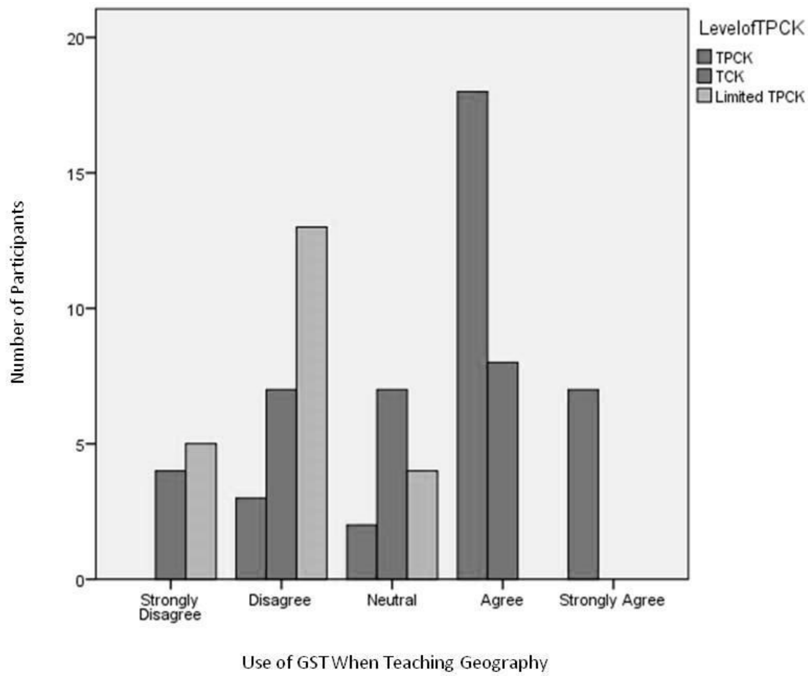


Figure 8.4. GST usage and levels of G-TPCK

Pedagogical knowledge appears to play an integral role in determining whether a teacher engages GST in the geography classroom setting. Overwhelmingly, participants in the G-TPCK group incorporated technologies when teaching. In fact, they were the only participants who emphasized their decisions by selecting “strongly agree.” Participants who seemed to be lacking pedagogical knowledge regarding GST were less likely to use these technologies. Almost as many participants were unsure of their use of GST compared to those who agreed to teaching with these technologies. Clearly, participants with Limited G-TPCK did not feel comfortable engaging GST, and no participants agreed to use GST when teaching.

Frequency and Integrating Geospatial Technologies into Geography Education

Educators' decisions to regularly or occasionally employ an instructional technology indicates a level of commitment. Participants were asked to respond to the multiple choice question "Currently, I use geospatial technologies (GST) to teach geography" by selecting the answer that best reflected their frequency of GST use. Weekly or monthly use of GST exhibited a "regular" decision to employ these technologies, while "once a grading period or semester" indicated more "occasional" use. When asked to describe their frequency of use, 100 percent of participants in the G-TPCK group specified that they engaged GST at some point during the year. The five participants who disagreed or were unsure whether they used these technologies, as evidenced by their defining "use" as regularly employing technology into their instruction on a previous survey item.

Five of those participants had disagreed or were unsure whether they were comfortable using GST when they answered the question "I use GST to teach geography." It is possible that they defined "use" as regularly incorporating these technologies into instruction rather an occasional during the school year. This survey item allowed participants more flexibility to think about how and when they might have employed GST. Three-fourths (21 out of 30) of the participants engaged regularly, either monthly or weekly, in technology use. In fact, 33 percent of participants with TPCK used these technologies weekly and 10 percent employed them more than twice a week. On the other hand, participants with only technology knowledge and limited pedagogical knowledge seldom engaged GST on a regular basis. Most (43 percent) of these participants occasionally employed these technologies as tools for instruction. Nine participants in the G-TCK group did not use GST for instruction. Finally, participants with Limited G-TPCK seldom used these technologies. Four participants indicated that they engaged in technology use once a grading period or once a month; no other participants incorporated GST in the classroom (Table 8.9).

Table 8.9. Frequency of Participants' GST Use in Geography Classroom Instruction

	G-TPCK (Positive TPCK score ≥ 50% of the time) n = 30		G-TCK (Positive TPCK Score 30-49% of the time) n = 26		Limited G-TPCK (Positive TPCK Score < 30% of the time) n = 22	
	n	%	*n*	%	*n*	%
Never	0	0	9	35	16	73
Once a Semester	3	10	8	31	0	0
Once a Grading Period	5	17	3	12	2	9
Once a Month	8	27	4	15	2	9
Once a Week	10	33	0	0	0	0
2 or More Times a Week	3	10	1	4	0	0
Missing	1	1	1	1	2	9

Chi-square Test Results: Associations between G-TPCK and Frequency of GST Use

A Chi-square test of independence was conducted to determine whether a statistically significant association existed among levels of participants' G-TPCK and frequency of usage in the classroom. Because of some participants' limited use, some cells had frequency levels less than the expected values; however, the Chi-square results displayed in Table 8.10 indicate a statistically significant association ($p < .001$) among levels of G-TPCK and frequency of usage (Figure 8.5 displays this association visually). The null hypothesis assumed there were no differences among the three categories G-TPCK, G-TCK, and Limited G-TPCK. The null was rejected. Because of the nature of Likert scale questions, some cells fell below the expected value of five. Although the results were not valid, they indicate potentially strong associations among variables is worthy of further research.

The findings revealed a clear association between the levels of G-TPCK and the frequency by which teachers engaged these technologies. Participants who indicated higher G-TPCK incorporated GST into their instruction more frequently (e.g., meaning monthly or weekly). In fact, only participants in the G-TPCK group engaged these technologies at least once a week. Participants in the G-TCK group who have relatively limited pedagogical knowledge only used these technologies occasionally (once a grading period or once a semester). Finally, those in the Limited G-TPCK group rarely used these technologies when teaching. Thus, future study might explore the association between participants' levels of G-TPCK and the frequency with which GST are used.

Table 8.10. Chi-Square Results: Levels of G-TPCK and Frequency of GST Usage

Association	Chi-square	df	*p*
Levels of G-TPCK and frequency of GST use when teaching geography	51.415	10	< .001

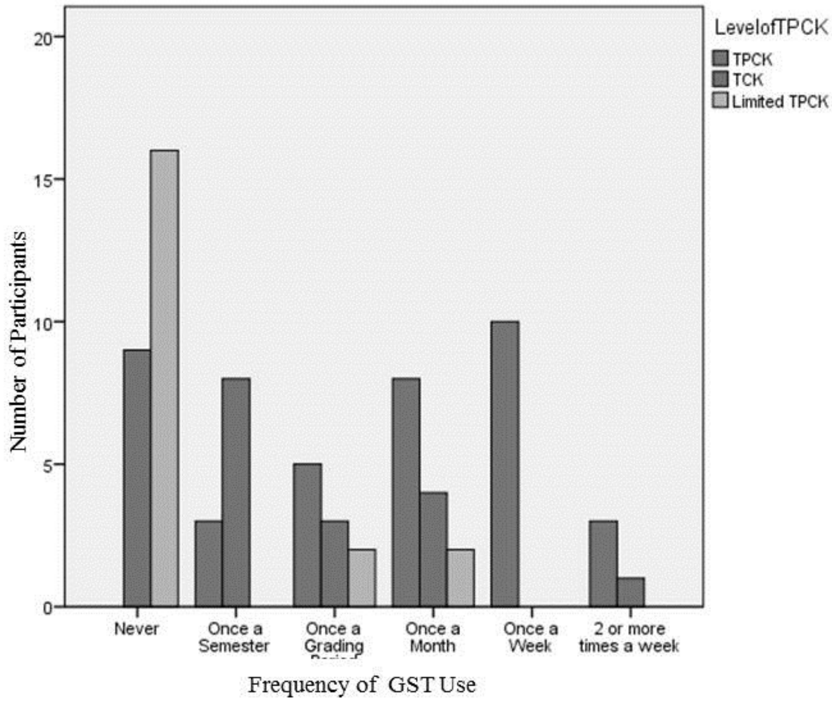


Figure 8.5. Levels of G-TPCK and the frequency of GST usage.

Defining Participants' Use of Geospatial Technologies

While some participants indicated that they had not incorporated GST as pedagogical enhancements, they might have engaged these technologies in other ways. Participants were asked to respond to the multiple choice question "How do you use GST in the classroom?" to explain whether they used GST personally and professionally. They selected choices from a list of possible actions that best reflected their usages and approaches to these technologies. Multiple responses were permitted (Table 8.11). Over 50 percent of G-TPCK participants engaged GST personally. Almost all G-TPCK participants (90-93 percent) employed these technologies when teaching or during student activities. Nearly three-fourths (73 percent) of these participants used them when preparing lessons. Nearly two-thirds (63 percent) of G-TPCK participants encouraged student participation by incorporating technologies into student assignments. Finally, at least one-third of the sample engaged these tools actively both personally and professionally.

Table 8.11. Geography Teachers' Overall Use of GST

	G-TPCK (Positive TPCK score ≥ 50% of the time) n = 30		G-TCK (Positive TPCK Score 30-49% of the time) n = 26		Limited G-TPCK (Positive TPCK Score < 30% of the time) n = 22	
	n	%	*n*	%	*n*	%
Do not use GST	0	0	9	35	9	41
Personal Use	15	50	4	15	2	9
Prepare for Class	22	73	8	31	3	14
Teach Geography	27	90	12	46	2	9
Student Activities	28	93	8	31	1	5
Student Assignments	19	63	4	15	0	0

Note: Each variable was available for response. Participants were instructed to "check all that apply."

Participants in the G-TPCK and G-TCK groups taught with GST and used them with student activities more often compared to participants in the Limited G-TPCK group. One-third of G-TCK participants (35 percent) did not engage these technologies on any level. Almost one-third of G-TCK participants used them when preparing lessons (31 percent) or during student activities (31 percent). Almost half (46 percent) of the G-TCK participants incorporated GST when teaching. Only four out of 26 (15 percent) included them as part of student assignments. A few participants (4 percent) used these technologies personally. Compared to the G-TPCK participants, G-TCK participants were two to three times less likely to engage GST personally and professionally, which indicates that G-TPCK might be a strong influencing factor in educators' decisions. Furthermore, strong personal use also might be an indicator of strong professional use. Both of these phenomena warrant further study within the geography education community.

The Limited G-TPCK group indicated low usage of GST on both the personal and professional levels. As anticipated, no participants in this group incorporated these technologies into student activities; only one out of 22 used them in student activities. Additionally, a few participants included GST when teaching, preparing for class, or for personal use. Overall, the results presented in this phase indicate a strong positive relationship between levels of G-TPCK and frequency of use among participants.

Phase II Qualitative Results: G-TPCK

Qualitative data were collected during Phase II from 13 telephone interviews, which provided in-depth information and additional insight into participants' levels of TPCK (TPCK and G-TPCK) and how these levels might explain geography teachers' decisions to adopt and use technology in the classroom. Participants' comments also provided data that illuminated other geography teachers' knowledge characteristics, which shed perspective on the likelihood of these individuals using GST.

Participants were asked specific questions regarding elements of their G-TPCK. Additional information was coded from other comments made throughout the interview process. Participants revealed that they possessed elements of each type of knowledge (i.e., technological, pedagogical, and content). The following discussion presents the qualitative results as they pertain first to participants and then to other geography teachers. After each section, characteristics of each group's levels of G-TPCK are summarized.

Participants' Geospatial Technological Content Knowledge (G-TCK)

Participants were asked a series of questions to elicit information and ascertain their levels of knowledge of GST. A copy of the telephone interview protocol is provided in Appendix J. Participants were asked to rank their GST knowledge level with “1” being the lowest or novice level and “10” being the highest or expert level. On average, participants ranked their knowledge between “5” and “8,” indicating that most felt knowledgeable about and experienced with using these technologies. Here, the term *use* means strictly knowing how the technology functioned. All participants indicated having an average or above average knowledge of GST (G-TCK).

When describing the value and ways that GST could be employed when teaching, participants often voiced knowledge of multiple technologies. For example, one participant stated “I do use GPS and MapQuest. I do use…GIS,” indicating a wide knowledge of these technologies. Another explained that students could investigate data and compare and contrast information if teachers, “have access to computers and said program [meaning GIS] or…even the online [websites].” One stated, “Students need to be able to interact with GIS, GPS,” and continued to comment that he/she also included Google Earth applications when teaching.

Some participants recognized that their G-TCK was ever-evolving and expressed concern regarding the perpetual development of online digital technologies. For example, one complained, “It changes so fast, it’s hard to keep up.” On the other hand, some participants knew more about desktop technologies (e.g., ArcView GIS or ArcGIS), but were unfamiliar with online ArcGIS applications.

Even with average and above average GST knowledge, a few participants ($n = 2$) were not comfortable using these technologies with their students. Almost two-thirds ($n = 9$) stated that they applied GST to geography content through “trial-and-error” and model lessons; however, they would like to know more concrete ways to apply them to their curriculum because they were not taught specific pedagogical strategies and applications for their state-mandated curricula.

Technology Integration and Practice: TPCK at Work

Participants were also asked questions regarding their knowledge of teaching strategies that employed GST as a set of tools for instruction to determine whether they had geospatial pedagogical knowledge to complement their general technology knowledge. Responses were mixed. Over two-thirds of the participants (*n* = 10) agreed that most training either taught basic skills or simply illustrated how to integrate these technologies, but did not teach pedagogical strategies directly (Table 8.12).

Table 8.12. Participants' G-TCK: Summary of Interviews

	Yes	No	Uncertain
Participant Response: Do You Know Teaching Strategies to Teach with GST?	7	3	3
Participant Response: Were You Taught GST Pedagogy by Trainers or Other Experts?	3	9	1
Sources Cited to Learn Pedagogy	• Introduced at a Workshop • Modeled Lessons	• Workshop with Modeled Lessons • Books (i.e., *Mapping Our World: Lessons for Geographic Educators*) • Piecing together knowledge • Online lessons • Applied Skills Learned (Trial/Error)	• Model Lessons • Workshop • Applied Skills Learned (Trial/Error)

Three participants said that they did not know of any pedagogy, or teaching strategy, for using GST to teach geography; however, they pieced together their technology knowledge with their expertise as teachers to determine how to best include these tool in the learning environments. For example, one participant said that he/she attended the Texas Alliance for Geographic Education (TAGE) summer training for remote sensing and received "a lot of online resources. I read a lot. I started researching and creating my bank of images. Basically that's how I learned how to do it." This participant continued by saying that he/she learned to teach with technology "by myself, just planning and reading. I didn't have a formal course or somebody…that would show me."

Two of the three participants cited workshops and model lessons as resources for "ideas" and a "starting point" to develop lessons. One participant said he/she was uncertain and uncomfortable teaching with GST. The remaining nine participants responded more positively. Two said they "think so" and seven said, "yes" to knowing pedagogical strategies for incorporating these technologies when teaching.

All teacher participants cited their state Alliance as the main source for their training with other sources including Humanities Texas, Advance Placement Institutes, and formal geography courses. Two of the seven participants recognized workshops as sources of their technological pedagogical knowledge. Over 50 percent of the participants (n = 7) answered positively and either stated or implied that they could also transfer their GST knowledge to other learning experiences for their students. However, five of these participants did not think they had been taught specific pedagogy for using these technologies as instructional tools. Most of these participants (n = 4) agreed that they learned "ideas" from model lessons given in workshops and other resources, such as the book *Mapping Our World Geography Lessons for Educators*, which provides lessons, step-by-step instructions for teachers and students, hand-outs, and a disk with the data necessary for each lesson. The remaining participant said he/she learned GST pedagogy from attending workshops that taught related skills, and then he/she applied these technical skills based on prior geographical content knowledge.

The overwhelming majority (n = 9) implied that, although they used GST, they had not been taught specific pedagogy for employing them as instructional tools. Although these participants were strong advocates for these technologies and represented Innovators and Early Adopters, they identified themselves as having limited G-TPCK, which explains their concerns with incorporating and/or applying technology into their curricular goals. This finding indicates the importance and suggests the significance of pedagogical knowledge. Participants' comments suggested that the majority of geography educators do not engage GST in educational settings because they have difficulty relating these technologies as pedagogical tools to their geography curricula.

In the interviews, teacher participants also indicated that they mainly learned how to operate technologies, but were not adequately taught how to apply them when teaching or how to relate them to the required curricula. Geography teachers need to be shown how to teach with technology just as much as their students. Participants were grounded in their content knowledge and understanding of the geography discipline. By continuously relating their learned technology and pedagogy to their content knowledge, they built their own G-TPCK for geography education informally and formally. For example, one participant stated that he/she, "Just Googled for sites that could fit that need, and built a lesson around what existed on websites." Another participant said that he/she looked at the state standards to "try and see if there's any way I can get GST involved with that." However, participants may not have been taught pedagogy specifically for GST in geography education, which hindered their G-TPCK development.

Figuring It Out: Developing TPCK (G-TPCK)

As presented in the introduction to this chapter, Koehler and Mishra (2005) contended, "True technology integration…is understanding and negotiating the relationships between…three components of knowledge:" technology, pedagogy, and content (Bruce and Levin 1997, 134; see also Dewey and Bentley 1949; Rosenblatt 1978). Most participants (*n* = 12) indicated their abilities to apply these components when teaching geography, which suggests they have developed G-TPCK to some extent. For example, one participant shared that, when he/she teaches students to read a topographic map, he/she now uses Google Earth. This participant noted that Google Earth,

> Allows me to manipulate it such that the kids can actually get a handle on the topographic mapping…they'll have a flat contour map and then [using Google Earth]…we can go up the mountain side so that they can see the elevation changes. So, that's a pretty cool thing to do.

Another participant stated, "No, it's not really about incorporating the technology as it is about the information that's being taught…it's more about the information being shown in GIS, not necessarily as much about how to use the GIS." One other participant illustrated the combination of these types of knowledge this way: "I know the standards that we have to teach, which included technology." This participant noted that he/she was "one of the few geography [trained] teachers that I've met." He/she continued, "I'm a pretty creative person…I developed the lessons specifically for" standards using strong content and technology knowledge as well as pedagogical training as a teacher.

Koehler and Mishra (2005) asserted, “For teachers to become fluent with educational technology means going beyond mere competence with the latest tools, to developing an understanding of the complex…relationships between users, technologies, practices, and tools” (132). Geography educators who possess elements of G-TPCK go beyond a simple understanding of GST to understanding its potential and true power as instructional tools. Many participants viewed these technologies as ways to “engage students” and as “big motivators” that inspire curiosity and a more experiential learning experience.

Geospatial technologies are tools that allow individuals to view data and situations that can be “interpreted in different ways.” According to one participant, GST allow people to “visualize the world” so they can, “ask better questions and reveal new relationships that have not been available…before.” One other participant explained the potential of these technologies this way: “[GST] would provide a greater opportunity to incorporate the higher global thinking skills and the critical thinking that these kids need to have.”

Overall, these participants felt that the benefits of teaching with GST are not to provide basic content learning, rather to engage students in geographic thinking. One participant expressed the following:

> I feel like having the maps up on the screen, showing the overlays of information, I can get to those higher levels of understanding. I feel like I can get to the higher levels of Bloom’s, of analyzing the maps, and evaluating and drawing opinions from [students].

Each interviewee revealed the potential of GST to engage students in higher-order thinking with geography content.

Seeking More Knowledge: Applying Geospatial Technologies to Teaching Standards

Participants sought reinforcement and support for their current employment of GST and collaboration with others to gain ideas of how best to continue their use of these technologies in geography education. However, over half of the participants (n = 6) felt unsure or wanted to know more about how to apply GST appropriately to the required district and state curricula. Three others indicated that it would be nice to have more training, to collaborate with others, and to discover ideas for technology use by observing other teachers' usages.

One of the biggest challenges identified by one participant was, "Using it appropriately. Having a lesson being able to apply it towards the [state geographic learning standards]." This person was concerned how one knows whether students "take anything out of this [lesson] that's going to help them on their final state assessment at the end of the year." Others in the study echoed this sentiment.

Mostly self-taught, these educators were keenly aware that there was more to know about teaching effectively with these innovative technologies. Along the same lines, a few participants said that they would like to know how GST were tied to specific standardized state tests. Another stated that the "biggest challenge is [that] there's so much out there. What technology do you use that would be better?—I think this is a key barrier."

Model Lessons as a Pedagogical Resource

Many interview participants recognized that they were not completely adept or comfortable with negotiating the relationships among GST knowledge, pedagogical knowledge, or content knowledge. They sought to enhance and develop their geospatial technological pedagogical knowledge through trainings, online resources, and printed materials. These resources often provide model lessons and are based on research supporting pedagogy, such as problem-based learning and constructivist approaches. Often, participants provided examples to demonstrate how to relate the technology to geography content that could be transferred to other examples in the curriculum. For example, one participant stated, "Sometimes…something has been modeled and I've taken that and done other things with it." Although participants had mixed feelings about learning specific pedagogy through modeled lessons, most agreed that this approach at least presented ideas or "starting points" from which to create their own lessons.

When participants were asked to explain how they knew how to relate the technologies to teaching, some said they used model lessons as guides and "trial-and-error," meaning that they would experiment with different ways to integrate these technologies into their instruction. One participant called this process "self-experimentation." Another said, "A lot of time I spend is experimenting with different lessons." He/she continued to say that it was "just trial-and-error." One participant supported this sentiment: "I learned from practicing…good and bad experiences."

The majority of participants were not taught specific pedagogy for GST. Therefore, the process of "figuring it out," although creative, and perhaps inspiring to Innovators and Early Adopters, might frustrate other teachers and slow the diffusion of these technologies into secondary classrooms. This finding also underscores the fact that participants recognized their limited pedagogical knowledge and actively sought ways to enhance it.

Participants were successful in their use of and approach toward GST because of their strong content knowledge, solid technology knowledge, and limited, but growing, TPK. The presence of all three types of knowledge provides an environment conducive to adapting, or being willing to adapt, teaching methods to incorporate these innovations. The more limited their TPK and abilities to connect GST into specific curricula criteria, the less likely participants were to implement these technologies into the geography classroom. Instead, they continued to consider them and "play" with them on a personal level. This difference is noteworthy as some have stressed the importance of teaching with and not about GST (Baker 2005; Bednarz 2004; Sui 1995). The crux of the matter is understanding how and when to teach using these technologies. Until such a time when geography teachers are comfortable with their TPK, they may continue to teach only about GST.

Participants' Perceptions of Colleagues' Usage of Geospatial Technologies

As Innovators and Early Adopters, interview participants may be viewed as leaders who vetted new technologies, which is in keeping with Rogers (2003) and Kerski (2000). Peers in the geography community especially recognized Early Adopters as role models (Rogers 2003). Participants were observant of other teachers in their discipline, and formed opinions of 1) why other geography teachers did not use GST, 2) circumstances that would compel their use, and 3) the value placed on these tools for instruction. On this topic, participants were asked the following interview questions:

- Even though you indicated in your response to the survey that you were willing to use GST, some of your colleagues may not wish to use GST in their instruction. Do you know what reasons your colleagues have for not using GST?

- Is this "no" absolute? What would be a compelling reason to change their minds?
- Do high school social studies teachers in your district value using GST? Geography teachers?

It should be reemphasized that participants believed "other teachers" of geography fell into two distinct categories: those who know and respect the discipline of geography, and those who do not. Anecdotally, it was expected that, among the geography education community, high school geography teachers would be criticized automatically for having weak levels of knowledge in geography. When circumstances reinforced this belief, participants typically went out of their way to make it understood that other teachers know geography content. The following section examines participants' responses to the three interview questions listed above. Participant comment were used to suggest possible levels of G-TPCK for other geography teachers. This chapter also examines participants' comments from their interviews as they related to the research questions to illuminate aspects of G-TPCK development among the majority of geography teachers.

Addressing Interview Question 1: Participants' Beliefs of Why Colleagues Do Not Employ Geospatial Technologies

As discussed in Chapter VII, interview participants were asked to share reasons why they thought other geography teachers were not willing to use GST as instructional tools in their geography classrooms. The majority of participants cited 1) the lack of dedicated time, 2) knowledge of these technologies, and 3) lack of training as the three most important reasons for non-use (Table 7.11). These reasons were followed closely by lack of awareness of GST and comfort with technology (technology, in general, and GST, specifically). Accounting for multiple responses, almost 75 percent of participants (n = 9) stated that the majority of geography teachers either lacked awareness, knowledge of how to use GST, or an understanding of how to apply these technologies to content.

The next areas of concern, based on interview responses, included a lack of content knowledge and other geography educators' teaching styles. Three participants cited the lack of geography content knowledge as a challenge, and three others echoed this theme. One participant identified two of the biggest challenges to GST implementation was a "lack of training; lack of geographic knowledge." Another participant stated that part of the problem was "ignorance" of GST. Another indicated, "Part of the reason was just not being very comfortable with the technology." These comments highlighted the perception that other geography teachers seriously lacked technological knowledge, including how to use and apply GST to teaching. Additionally, interview participants believed that other educators had weak geography content knowledge.

Addressing Interview Question 2: Participants' Perceptions of Why Colleagues Do Employ Geospatial Technologies

Participants were asked to suggest compelling reasons why they thought other geography teachers used GST as tools for instruction (Table 7.12). The qualitative data revealed that nearly 40 percent of participants (n = 5) identified specific training and education leaders' directions and support for these technologies as the top two compelling reasons for use. Four of the 13 stated the need for awareness and knowledge as critical factors. Just as telling, participants also stressed the need to develop teachers' knowledge and interest in geography content. Responses to Interview Question 2 reinforced the lack of knowledge and/or awareness of GST among geography teachers. According to Mishra and Koehler (2006), without all three types of knowledge (technological, pedagogical, and content), educators are less inclined to include technology in their classrooms. Participants' comments and other research that has recognized the slow diffusion of GST into secondary geography education support this notion.

Addressing Interview Question 3: Participants' Perceptions of Social Studies Educators' Value of Geospatial Technologies in Instruction

Interview participants were asked to comment on whether they thought their districts' social studies teachers, in general, and geography teachers, specifically, valued GST (Table 7.13). Although five participants indicated that social studies teachers did value using these technologies, the overwhelming majority (n = 8) said that social studies teachers generally did not value using them in instruction. One participant explained this lack of enthusiasm by saying, "I don't think they value it only because they don't know what it is."

Overall, participants offered a mixed review regarding GST as a valued instructional technology, and most believed that the social studies community, in general, and high school geography educators, specifically undervalued the use of these technologies. Collectively, the three qualitative questions concerning the perceptions of other teachers demonstrated that the overwhelming majority of participants (n = 10) recognized the lack of GST awareness as a major concern. Adding the belief that a lack of commitment to the discipline by some teachers and education leaders, it was easy to comprehend why teachers thought these technologies were undervalued as pedagogical enhancements.

Perceptions of Other Geography Teachers' G-TPCK

A teacher must possess three types of knowledge for sustainable instructional technology integration to occur. These types of knowledge include technological, pedagogical, and content. Combined this knowledge is called TPCK (Mishra and Koehler 2006), and it allows teachers to be fluent enough to apply technologies continuously to suitable content areas with appropriate pedagogical strategies. Comments from the three interview questions reflected participants' perceptions of other geography teachers and provided possible insight into the levels of G-TPCK of their teacher colleagues. Based on the qualitative telephone interview comments ($n = 13$), Figure 8.6 illustrates the degree to which participants believed other geography teachers possessed each knowledge set, with longer dashed lines and a lightly shaded circle representing geospatial content knowledge.

Unsolicited comments to Interview Question 2 resulted in over 50 percent ($n = 7$) of participants citing that other geography teachers' lack of content knowledge was a critical contributing factor to the lack of support for GST usage in the classroom. As one participant stated, "These are not teachers of geography. Well, they *are* teachers of geography, but they *aren't* geographers" (emphasis by participant). Another stated that geography teachers "know what they are looking at" and can discuss it with their students, which indicates the presence of content knowledge.

Participants opined that their colleagues lacked the awareness or understanding of GST. Their comments suggested two camps that described the “majority” of geography teachers—those who lacked foundational geographic knowledge—and those with geography content knowledge. It is likely that geography related technologies continue to slowly diffuse into the secondary geography community because of the apparent dearth of GST awareness and knowledge and a lack of appreciation for and understanding of geography as a discipline.

Without an awareness for and an understanding of the discipline in which technology will be used, it is to be expected that implementing technology will be slow or non-existent. As discussed in Chapter VII (Table 7.14), almost 100 percent of interview participants (n = 11) agreed that, overwhelming, geography teachers lacked awareness of GST, which might account for the 69 percent (n = 9) who said that these teachers did not know how to use these technologies. Coupled with the nearly 50 percent who stated that other teachers lacked geographic content knowledge of (n = 6), an interest in, or appreciation for geography as a discipline (n = 5), it is quite understandable why educators might find applying these technologies to geography problematic.

Pedagogical Content Knowledge within G-TPCK means knowing how to apply the appropriate teaching strategy given a specific content area and geospatial instructional technology. In general, it was assumed that participants possessed PCK because they had to learn it when becoming certified to teach. This assumption is represented by a darker circle for PCK in Figure 8.6, which indicates more knowledge in this area. Pedagogical approaches may be reflective of the “two camps” of geography teachers—those with strong content knowledge and those with limited content knowledge. Some participants emphasized that their geography teachers were "really good," indicating that they knew how to teach geography, but just did not know how to use specific technologies. On the other hand, one participant said that other geography teachers "like to teach by the book." Another shared that some teachers only like to teach basic facts and are "not interested in exposing the kids to more conceptual learning." Comments such as these suggested that other geography teachers had varying degrees of strength in pedagogical knowledge with it becoming more limited or non-existent when technology was involved. This finding is illustrated by dashed lines in Figure 8.6.

Geospatial Technological Knowledge (G-TCK) among the majority of geography teachers seemed to be non-existent. Over 20 percent of participants (n = 3) believed that other geography teachers did not value GST. The evidence was clear to these teachers; geospatial technological knowledge was seriously lacking, thus barred the majority of geography teachers from sustainable use of these technologies as pedagogical enhancements in high school geography education. Figure 8.6 represents these data with a lightly colored dotted line and no shaded area, suggesting limited or non-existent G-TCK.

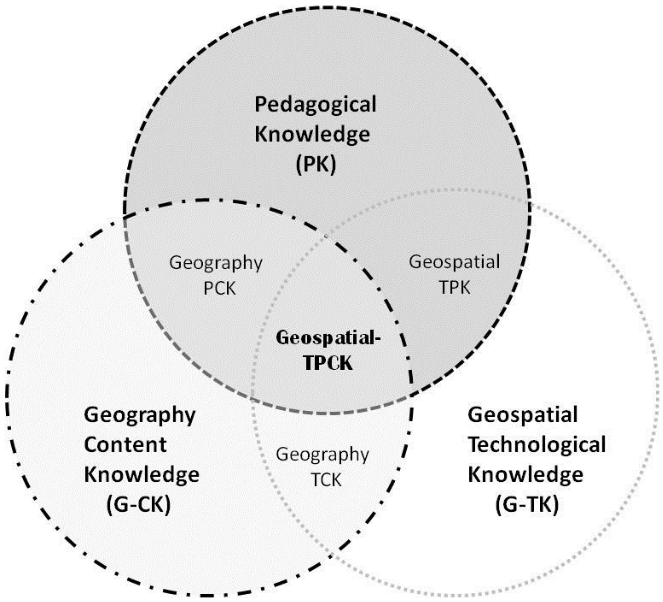


Figure 8.6. Other geography teachers' suggested G-TPCK.

Summary

Quantitative Phase I provided details regarding participants knowledge and patterns of GST usage. The results indicated a statistically significant association between the levels of TPCK and technology awareness and the use and frequency of use of these tools for instruction. This possible relationship warrants additional research. Qualitative Phase II served to extend these data and offer commentary regarding other geography teachers who may represent the majority (Rogers 2003).

The supporting qualitative interviews were designed to extend the understanding of the decision to use or not use GST as pedagogical enhancements. Specific attention was paid to participants' decision-making and development of their G-TPCK. Recognizing that many participants represented Innovators or Early Adopters, it was assumed that they possessed some level of G-TPCK. Therefore, participants were asked to comment on how they developed this type of knowledge. Ideally, responses would identify types of training or resources that could be replicated to aid in the diffusion of these technologies into high school geography education. However, most indicated that they had to "figure out" how to "use" a technology when teaching. In other words, their pedagogical knowledge of technology might not have been developed purposefully through training or professional development. Rather, participants had largely developed this knowledge on their own.

Mishra and Koehler's (2006) framework set forth key components necessary to ensure the adoption of GST as pedagogical enhancements. Geospatial-TPCK offers possible associations between levels of knowledge and geography educators' awareness, use, and frequency of use of technology. Participants were assigned to one of three levels of G-TPCK based on their combined knowledge scores. It was assumed that all participants had basic geography content and pedagogy knowledge; therefore, only GST and pedagogical knowledge were examined.

These designations of G-TPCK, G-TCK, and Limited G-TPCK were useful to group participants with common characteristics. It should be recognized that an individual does not "have" or "not have" TPCK; rather, it is an on-going, ever evolving continuum of knowledge and skills regarding each type of knowledge (pedagogy, technology, and content) separately and together. For the purposes of this research, a marker was necessary to allow for comparison among educators who exhibited characteristics common to those with different levels of knowledge.

To be a highly qualified and effective educator, Schulman (1983) asserted that teachers must know both content and pedagogy as it applies to their disciplines. Evidence from participants' interviews suggest that it is questionable whether most geography teachers possess even these most basic components. Mishra and Koehler's (2006) research added their TPCK model to explain teachers' knowledge sets in the new millennium. Although the Innovators and Early Adopters represented in this study recognized and used varying forms GST to some degree, these technologies remain largely unused as pedagogical enhancements by the majority of American high school educators. A discouraging commentary when, according to some academic leaders in the field of geographic education, it is critical for highly qualified teachers to embrace technological tools in their disciplines to operate effectively as twenty-first-century teachers preparing learners in the Digital Information Age.

CHAPTER IX

UNDERSTANDING GEOSPATIAL TECHNOLOGIES ADOPTION: A COMPARISON OF FRAMEWORKS

The purpose of this investigation was to understand the adoption of geospatial technologies (GST) by high school geography teachers with the aim of informing education leaders, pre-service teachers, professional development providers, and the geography education community about both the diffusion of GST into secondary geography education and the influencing factors regarding awareness and technological and pedagogical knowledge of these technologies. Rogers' (2003) Innovation-Decision Process framework suggests that most individuals in a community have a basic knowledge of technologies. However, fewer individuals are in the subsequent phases of adoption because they have gained more knowledge and experience and are progressing through the adoption cycle. Mishra and Koehler (2006) examined the adoption of instructional technologies using the Technological Pedagogical Content Knowledge (TPCK) framework. This study augments Rogers' (2003) work on the Innovation-Diffusion Process by identifying the types of knowledge necessary for teachers to be successful and move to the next level of adoption. This chapter provides a comparison of these two frameworks to explore how geospatial-TPCK (G-TPCK) informs the stages of the GST Innovation-Decision Process to better understand the diffusion of these technologies in high school geography education.

Measuring G-TPCK within Rogers' (2003) Model

The Knowledge Stage of Rogers' (2003) model served as the entry point for adoption, which was followed by the Persuasion, Decision, Implementation, and

Confirmation Stages. As indicated in Chapter VII, geography educators may begin their adoption process at any phase from which the other phases flow. By placing participants in both stages of the geospatial Innovation-Decision Process and G-TPCK categories, insight was gained into the process of technology adoption (Table 9.1). The category of GST Pre-Knowledge Stage for participants who did not identify with any stage of adoption because of a combination of low knowledge, decision, and usage patterns of these technologies. Additionally, Limited G-TPCK indicated participants with low levels of technological, pedagogical, and content knowledge.

Table 9.1. Understanding the GST Innovation-Decision Process: Adoption Stages and G-TPCK

	G-TPCK (Positive TPCK score ≥ 50% of the time) *n* = 30		G-TCK (Positive TPCK Score 30-49% of the time) *n* = 26		Limited G-TPCK (Positive TPCK Score < 30% of the time) *n* = 22	
Stage	*n*	%	*n*	%	*n*	%
GST Pre-Knowledge	0	0	6	23	12	55
GST Knowledge	22	76	5	22	1	1
GST Persuasion	27	93	6	23	0	0
GST Decision	30	100	18	82	9	41
GST Implementation	30	100	11	42	0	0
GST Confirmation	25	86	2	1	0	0

While the G-TPCK, G-TCK, and Limited G-TPCK categories were assigned based on participants' specific knowledge sets to a single, exclusive category, the coding for the stages of the GST Innovation-Decision Process allowed for multiple placements. In other words, within the various G-TPCK categories, participants could be identified in multiple stages of adoption. The interplay among data represented by these frameworks is illustrated in Figure 9.1. The following discussion explores the stages of the Innovation-Decision Process as they related to GST in this study.

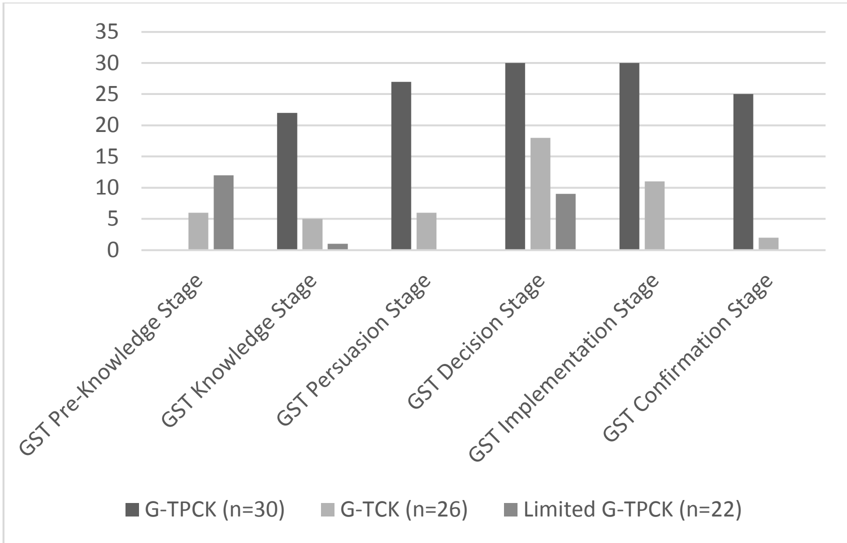


Figure 9.1. Participants' GST knowledge identified by stages of adoption.

Exploring the Possibility of a New Progression of Adoption

Categorizing participants based on evidence of strong G-TPCK confirmed key traits that might be influential in diffusing these technologies among high school geography educators. The largest assignment to the G-TPCK category was in the GST Decision Stage (G-TPCK: 100 percent; G-TCK: 82 percent; and Limited G-TPCK: 41 percent). These findings suggest that the Decision Stage may be the entry point for adoption of these technologies as tools for instruction, as evidenced by the number of Limited G-TPCK participants who were in either the GST Decision (41 percent) or GST Pre-Knowledge Stages (55 percent). Among this group, those in the GST Knowledge Stage were outliers. Those in the Pre-Knowledge Stage indicated that they did not positively answer items coded for each stage of the GST Innovation-Decision Process 50 percent or more of the time. Coupled with placement in the Limited G-TPCK category, these participants showed low levels of technology and pedagogical knowledge.

Following the GST Decision Stage, participants seemed to quickly demonstrate the implementation of these technologies before engaging in the GST Knowledge or

Persuasion Stages. Eighteen of 26 G-TCK participants (82 percent) were in the GST Decision Stage of adoption. Forty-two percent of participants reported implementing technologies in their classrooms, and half as many were in the GST Knowledge (n = 22) and GST Persuasion (n = 23) Stages. Only a few (n = 2) were in the GST Confirmation Stage. It is possible that they had higher levels of pedagogical knowledge than did other participants, thus, were more confident to begin the iterative process of reinforcing their decisions.

Additionally, six out of 26 G-TCK participants were identified as being in the GST Pre-Knowledge Stage, meaning that they did not answer items positively for each stage 50 percent or more of the time. However, their answers may have yielded a relatively high score for this category, which would indicate they may be newly arrived from the Limited G-TPCK level. Those in the Limited G-TPCK category either had sufficient awareness to make a positive decision regarding GST or had limited exposure to these technologies.

Understanding where most geography educators gain knowledge outside of independent professional development and formal education would aid in identifying how to best expose teachers to GST. For example, textbooks may be very influential in this process. Therefore, a concerted effort should be made to delineate the different levels of these technologies and their applications to the required high school geography curricula.

Participants with high levels of G-TPCK were clearly well into the adoption process. Rogers' (2003) model predicted a decrease in the number of individuals in the initial GST Knowledge to Confirmation Stages. Early analysis indicated that geography teachers might first make a favorable or unfavorable decision regarding these technologies, and then implement them while working to be fully persuaded and knowledgeable about them as tools for instruction.

One hundred percent of G-TPCK participants identified with both the GST Decision and GST Implementation Stages; 93 percent of participants identified with the GST Persuasion Stage. However, the GST Knowledge Stage included only 76 percent of the participants, which may be due to the way the knowledge questions were coded, thereby undervaluing participants' actions of awareness and knowledge levels. Overwhelmingly, 86 percent of those in the G-TPCK group were in the GST Confirmation Stage of adoption. These results support Mishra and Koehler (2006) who asserted that individuals with strong TPCK are more likely to use innovative instructional technologies, such as GST.

Summary

Understanding how to teach with GST seems to be a strong indication of the adoption and diffusion of these tools among high school geography educators. With the exception of the GST Decision Stage, G-TPCK participants were two to three times more likely to engage these technologies as pedagogical enhancements. Those in the Limited G-TPCK category were less likely to interact with these technologies in a meaningful way; however, some might decide to experiment with them as they teach.

Based on these findings, it appears that teaching becomes a way to first test the viability of a technology before dedicating time to learn more about and committing to it. This phenomenon suggests that geography educators might first decide to use and implement a technology before they develop a deeper knowledge of it through additional trainings, which would influence whether they are persuaded that GST should be considered as tools for instruction. Ultimately, confirming their decisions is the last step in the process. Few studies have focused on specific clusters of teachers, which may prove beneficial to understanding whether the process of adopting GST truly varies from Rogers' (2003) suggested model.

The current findings indicate a strong relationship between possessing all three types of knowledge (technological, pedagogical, and content) and the decision to use GST as pedagogical enhancements in high school geography education. These results were expected because the implications of both frameworks suggest that individuals with more knowledge and experience with an innovation are better positioned to make a decision to adopt an innovation.

Rogers (2003) asserted that the ability to make a well-informed decision is attained in the latter stages of his model while Koehler and Mishra (2005) contended that the decision occurs when educators have the trifecta of the three key types of knowledge. These frameworks not only support one another but also strengthen one's understanding of the GST adoption process in geography education. However, future study should explore this relationship further to best inform pre- and in-service instruction and training so more educators become comfortable, confident, and willing to employ GST as tools for geography instruction.

CHAPTER X

CONCLUSION AND IMPLICATIONS

An and Reigeluth (2010) noted, "There is little argument that the traditional factory model of education is incompatible with the evolving demands of the information age" (52). Although most citizens expect vital industries, such as the medical field, law enforcement, government, and the like, to implement the latest technologies for their fields, "Teachers of the twenty-first century use roughly the same tools as those who came before them" (Ertmer and Ottenbreit-Leftwich 2010, 256). It is past time for high school geography teachers to prepare students for the future; it is the twenty-first century, and preparation includes developing students into citizens who are expected to demonstrate deeper cognitive analysis, make far-reaching connections, solve complex problems, and extend their thinking beyond basic facts and simple processes or procedures (Webb 1997; Kay 2010).

The application of geospatial technologies (GST) in high school geography classrooms has the potential to engage learners, facilitate higher-order thinking experiences, and encourage greater technical knowledge and skills. Exposure to these tools is vital to preparing students for the twenty-first century workforce where the geospatial industry has experienced a 30 percent annual growth over the last 10 years (Palmer and Baker 2013). Thus, this industry is fast becoming a mature market primed for students equipped with appropriate technical and analytical skills (Palmer and Baker 2013).

Inspired by Kerski's (2000) seminal study, the present research explored the progression of GST adoption in high school geography education. The broad scope of this study included online and desktop tools ranging from visualization technologies to low-level and full GIS applications. The inclusion of online GST was a key deviation from Kerski's study and provided a unique look at geography teachers in the Digital Information Age. Significant results emerged from the Phase I questionnaire on topics dealing with technology awareness (knowledge), use, and frequency of use when teaching.

This study aimed to determine how well high school geography educators conformed to Rogers' (2003) Innovation-Decision Process and whether the presence of Geospatial Technological Pedagogical Content Knowledge (G-TPCK) was an influential factor on teachers' decisions regarding technology adoption. Questions for future research also arose during the study. This chapter discusses the overarching conclusions of the current research, explores implications, and discusses future research regarding GST and pre-collegiate geography education.

Rogers' (2003) Innovation-Decision Process model aided in identifying the stages for GST learning and the progression of decision-making that ultimately leads to the adoption or rejection of these technologies. Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPCK) framework was particularly useful in isolating how technological, pedagogical, and geographic content knowledge work together to create positive attitudes toward and desires to use these technologies regularly as pedagogical enhancements.

Participants were grouped by adoption stage and depth of knowledge as determined by answers to coded questions for the Phase I survey. The telephone interview results supported and extended the survey analysis. Identifying adopter characteristics was instrumental in comprehending the knowledge and usage patterns of GST engagement by participants and the “other” geography teachers they described. Influences on participants’ decisions clarified reasons why some educators may choose to accept or not accept technologies as pedagogical enhancements. These frameworks also served to inform future research recommendations, as discussed later in this chapter. Both frameworks complimented and enriched each other to provide a lens for a clearer understanding of educators who chose to use or not to use GST as tools for instructions. The current results can inform pre- and in-service training experiences as well as key stakeholders and policymakers’ decisions regarding geography education.

Overarching Conclusions

Rogers’ (2003) Innovation-Diffusion Process and Mishra and Koehler’s (2006) TPCK constructs framed the two research questions for this investigation:

1. Using Everett Rogers’ (2003) Diffusion of Innovations theoretical framework, how do teachers conform to Rogers’ five stages of the Innovation-Decision Process with respect to the acceptance of geospatial technologies (GST) as pedagogic techniques for teaching high school geography?
2. Using Mishra and Koehler’s (2006) Technological Pedagogical Content Knowledge (TPCK) framework, do high school teachers who exhibit more Technological Pedagogical Content Knowledge use geospatial technologies more frequently than other teachers?

Examining Results: Addressing the Research Questions

Conforming to Rogers' (2003) Stages of Adoption

Recognizing that the diffusion of GST has been notoriously limited in K-12 education, Rogers' (2003) framework served as a model from which to design survey items and identify key teacher characteristics, knowledge, and patterns of GST use at various stages of adoption as tools for instruction. As a reminder, Rogers (2003) asserted, "The Innovation-Decision Process is an information-seeking and information-processing activity in which an individual obtains information in order to gradually decrease uncertainty about the innovation" (21). The less uncertain an individual is, the more likely he/she is to view an innovation positively. Rogers' model includes a five-step (or stage) "time-ordered sequence" (21) that leads to the adoption or rejection of an innovation. Throughout each stage, knowledge is built continually and leads to more complex judgments as progress is made toward a decision.

Answering the original research questions required determining whether teachers conformed to Rogers' (2003) Innovation-Decision Process. Conforming, in this case, referred to identifying participants by stage, assessing their sequential processes, and evaluating their GST adoption in high school geography classrooms. Items were coded to detect knowledge, decisions, and actions at each stage. Thus, by clustering participants, patterns were examined at each level of the process. Rogers' (2003) model helped explain what occurs at each step of adoption and provided insight regarding what may be required to continue toward the acceptance of an innovation; in this case, use of GST.

Overall, participants conformed to Rogers' model, which clarified geography educators' patterns of GST behaviors and decision-making. As participants were identified and analyzed by the stages of adoption, light was shed on their progress and decisions to use these technologies regularly. The results informed the GST Innovation-Decision Process.

It seemed that Rogers' (2003) sequential model did not accurately reflect the decision-making patterns of the sample population. Most participants were clustered in the Decision Stage, which suggested that the Knowledge Stage may not be first in the progression of adopting GST as pedagogical enhancements. This finding will be discussed in detail later in this chapter. This study would be well served by further investigation as to how GST adoption travels through Rogers' (2003) model.

The Trifecta: Geospatial Technological Pedagogical Content Knowledge

Identifying knowledge necessary for effective teaching is critical for the development of twenty-first century educators who prepare students to be successful in the Digital Information Age. Mishra and Koehler (2006) built upon Shulman's (1986) work by adding technological knowledge to the pedagogical content knowledge required for teachers to provide valuable instruction to their learners. The current study was designed to place individuals on a continuum of GST receptiveness and success using Rogers' (2003) framework. The study design also allowed an examination of participants' exhibited levels of G-TPCK using Mishra and Koehler's (2006) framework. Their research provided a lens to distinguish whether teachers with higher levels of G-TPCK engaged technologies frequently in the classroom compared to those with lower levels of G-TPCK. The results from the present study support Mishra and Koehler's model. The data analysis also suggests a strong relationship between those with G-TPCK and those who use these technologies frequently.

It should be noted that an individual does not have or not have G-TPCK. Rather, the characteristics revealed through the survey and interview items suggested elements of technological and/or technological pedagogical knowledge. It was assumed that all teachers had basic geographic content and pedagogical knowledge, and educators were identified by those who exhibited signs of strong knowledge in some or all of these criteria.

The quantitative Phase I survey analysis revealed that the presence of strong elements of G-TPCK significantly influenced high school geography teachers' frequency of use patterns. Specifically, participants were asked whether and how frequently they used GST during instruction. Responses of 'regularly' or 'frequently' were considered as monthly, weekly, or multiple times a week. Eighty-three percent of participants exhibited high TPCK scores (G-TPCK category) and were most likely to use these technologies. Over one-third (35 percent) responded that they regularly used these technologies. All participants in this category employed these technologies at some point during the year.

Those with lower levels of TPCK, either in the Geospatial Technology Content Knowledge (G-TCK) or Limited G-TPCK categories, were less likely to engage these technologies as pedagogical enhancements. Thirty-one percent in the G-TCK category initially stated that they used GST, thereby illustrating that those with more TPCK were twice as likely to engage them when teaching. No one in the Limited G-TPCK group agreed or strongly agreed to this action. Furthermore, only five out of 26 G-TCK and two Limited G-TPCK participants regularly used these tools when teaching. Both the decision to employ GST as tools for instruction and the frequency of use were statistically significant ($p < 0.001$), which indicates a strong association between the level of TPCK and the decision to engage these technologies in a geography classroom setting.

Questions for qualitative Phase II were designed as extensions of the quantitative Phase I results by addressing some ways in which GST pedagogy was formed and reinforced. The results suggested that educators must connect their technological, pedagogical, and content knowledge themselves through “play” based trial-and-error or experimentation. Although participants acknowledged that resources (i.e., lessons) have recently been developed, generally few, if any, training opportunities illustrate how to implement GST into the approved curricula.

Throughout the interviews, participants expressed an intrinsic motivation to learn GST to explore geography concepts and ways of thinking based on their own personal affinities for the subject. Additionally, available trainings and resources modeled strategies to implement these technologies, rather than explicitly teach “best practices” (i.e., pedagogy) for employing GST as tools for high school instruction. However, these resources are not plentiful or easy to find for a novice or someone outside of the GST network of teachers.

Teachers’ recognition of the potential of GST and their determination to learn enabled them to develop elements of G-TPCK. Furthermore, comments regarding other geography teachers indicated that the majority, referring to the combination of Rogers’ (2003) Early Majority and Late Majority, might not have sufficient content knowledge to understand the output displayed by these technologies and incorporate them as pedagogical enhancements effectively and confidently. A more concerted effort must be initiated to develop both in-service and pre-service teachers’ technological pedagogical knowledge (TPK) and relate it to the taught and required curricula, which is not always reflected in state standards.

Understanding Phases of GST Adoption as it Relates to G-TPCK Development

Together, Rogers' (2003) and Mishra and Koehler's (2006) work form a robust partnership to explain the diffusion of GST, or lack thereof, in high school geography education. Both frameworks complement each other by adding depth to understanding the adoption process. For example, Rogers (2003) asserted that the perceived relative advantage of an innovation significantly influences an individual's decision to adopt a technology. Mishra and Koehler (2006) explained this phenomenon through the presence or absence of TPCK within an innovation. In reality, it is likely that the relative advantage of GST is realized through the combination of these knowledge sets.

Researchers caution educators to teach with, rather than about, GST (Sui 1995; Kerski 2003; Baker 2005). However, the current data suggest that following the directive to teach with GST is problematic because geography educators may not have adequate pedagogical knowledge of these technologies. For example, of the 78 participants surveyed, 38 percent (n = 30) were identified as having strong G-TPCK; alternatively, 100 percent were in the GST Implementation Stage, and 86 percent (n = 25) were in the GST Confirmation Stage. Therefore, all three knowledge sets strengthen educators' positions to engage these technologies.

On the other hand, those identified as exhibiting G-TCK (n = 26), meaning they had strong technology knowledge but weaker pedagogical knowledge, were recognized 42 percent (n = 11) of the time in the GST Implementation Stage and one percent (n = 2) of the time in the GST Confirmation Stage. These percentages reflect a substantial decline of technology use between the two groups, possibly because of differences in their pedagogical knowledge. Most of these individuals (82 percent) were in the GST Decision Stage. Over half of those with Limited G-TPCK (55 percent) were not engaged in the adoption process at the time during this study. Those with stronger G-TPCK knowledge were mainly recognized in the Decision Stage (41 percent). These data imply that teachers first decided to use, or test, GST in the classroom setting.

Those who decided to use, implement, and confirm their decisions were also those who had strong indications of GST technological and pedagogical knowledge. For example, participants in the final stages of adoption (Implementation and Confirmation) showed evidence of high levels of TPCK. Future research should explore the interplay between the Innovation-Decision Process and TPCK to better inform decision-makers and professional development providers so they can mold their decisions to address the needs and expectations of geography educators and ensure greater acceptance of GST as tools for instruction.

Examining data by grouping participants into stage and level of TPCK produced results that made a stronger argument for their conformity to Rogers' (2003) Innovation-Decision Process model and the influence of TPCK on geography teachers' decisions to use these tools for instruction. The evidence also illustrated the importance of these stages (informed by TPCK) in conceptualizing the progress of knowledge, decision-making, and actions, which support the finding that participants largely conformed to the model. The data also revealed a high cluster of participants in the GST Decision Stage across all three levels of knowledge, which indicates nonconformity to Rogers' (2003) adoption process. Further, the level of educators' TPCK significantly and directly affected their decisions to use these technologies.

Individuals who decide to accept an innovation have experienced the five stages of decision-making: Knowledge, Persuasion, Decision, Implementation, and Confirmation. Rogers (2003) acknowledged and explained that what inspires an Innovator and Early Adopter does not necessarily encourage the majority of the population to adopt an innovation. The qualitative data support this assertion. Participants' comments about other geography teachers revealed that those teachers might need different training experiences and levels of resources. Thus, the path and impetus to initiate the adoption process may be different between Innovators, Early Adopters, and Majority adopters. Of particular note, we could be at a tipping point regarding the GST adoption process. In other words, the majority of geography educators may begin to use these technologies as they become ubiquitous and accepted in society; however, patterns of use may be reflective of geography teachers' current teaching styles.

Addressing Conformity to the Rogers' (2003) Sequential Model

In the course of this study, new decision-making patterns emerged that altered the conceptual framework originally used as presented by Rogers (2003). To review, Rogers' Innovation-Decision Process presents a time-ordered sequential progression of stages in which an individual maneuvers when deciding to accept or reject an innovation in the following order: Knowledge, Persuasion, Decision, Implementation, and Confirmation. Ideally, as knowledge increases and an individual makes decisions regarding the innovation, subsequent stages have fewer members.

Data from the current research suggest that geography educators may engage these phases of decision-making using a different approach. According to both the quantitative and qualitative results, most geography teachers appeared to first make a decision about these technologies and then implement them into their instruction. Thus, these teachers weigh the pros and cons to GST as pedagogical tools during implementation as they enter into a trial-and-error period. The geography educators interviewed referred to this phenomenon as "figuring it out" or "trial-and-error." At the time of this study, participants were continually constructing new knowledge about the these technologies, how they work, and how they are used to deliver content. Thus, the adoption process appears more complex than Rogers' (2003) model initially suggested (Figure 10.1).

An alternate flow model, the Geospatial Technologies Adoption Process (GAP), is proposed in contrast to Rogers' (2003) sequential model to capture the process of geography teachers' GST adoption process. The GAP model is based on a combination of data from geography educators' quantitative results and qualitative comments. According to the GAP structure, initially educators are "hooked" by a primary persuasive event (indicated by a lowercase "p" on the diagram) when they are introduced to these technologies. This introduction can include anything from teachers exploring the Internet to listening to a presentation at a conference or training event.

The introduction is the first step in awareness at which point teachers form very little or no complex GST knowledge. Following the introduction, comes the first acceptance or rejection decision, marked by a lowercase "d." Acceptance signals that the educator is willing to try out or test the technology, which begins the complex, interrelated, and iterative process of implementation, persuasion, and confirmation of the decision to use these tools for instruction.

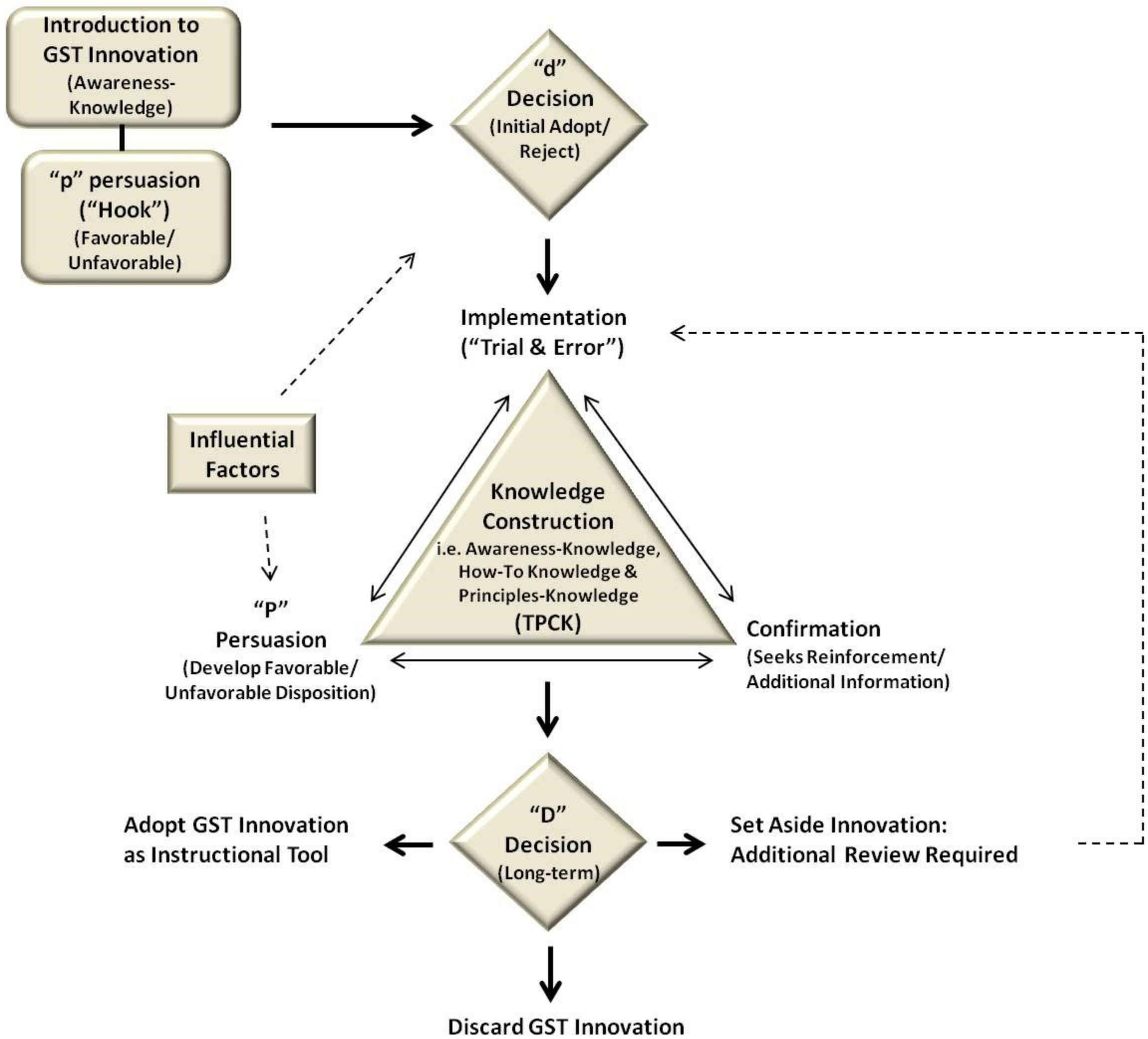


Figure 10.1 The Proposed GST Adoption Process (GAP). Source: Adapted from Rogers (2003)

In this phase, educators are "figuring out" how GST connect to the curriculum, aid the delivery of instruction, and motivate student learning. During this time, educators may seek various trainings, resources, and other support systems to assist in learning more about GST and to weigh the pros and cons of engaging these technologies.

Therefore, three types of knowledge, as identified by Rogers (2003), are constructed constantly: awareness, functional (or "how-to"), and principle. This knowledge development is akin to Mishra and Koehler's (2006) TPCK. After teachers spend sufficient time testing the technology, they make their final decisions (marked by a capital "D") regarding GST as pedagogical enhancements: accept, reject, or continue gathering more information and experience.

Participants' nonconformity to Rogers' (2003) model may stem from the fact that business and agricultural studies have influenced the diffusion research more heavily than have geography and education studies. Therefore, it is understandable that an individual first gathers data to build sufficient knowledge before weighing the pros and cons and forming a favorable opinion for the innovation and deciding to invest capital.

It is likely that most people, especially in business, will not spend money on a chance that something might work before they know for certain that the innovation will meet their needs. Therefore, for them, the process may be more sequential in nature. However, educators act and react in a different fashion as they are more willing to test an innovation while teaching to determine whether it is worth pursuing. It is also possible that this flow model refers to the behaviors of Innovators and Early Adopters, and the majority of educators could behave in a more sequential manner.

Rogers (2003) suggested that each stage gains in complexity as knowledge continues to develop, which may account for some of the complex knowledge construction presented in the GAP flow model. However, where Rogers (2003) asserted that his process is a "time-ordered sequence," this researcher posits that the construction of knowledge is a constant that is developed continually during an iterative, non-sequential implementation, confirmation, and persuasion process.

Geospatial Technologies Diffusion: Is There Any Progress?

Kerski (2000, 2003) revealed that relatively few secondary educators use Geographic Information Systems (GIS) software. In fact, he reported that fewer than half of those surveyed used GIS at least once, and about 20 percent of those participants used this technology more than once in their classrooms (Kerski 2000). Although these findings include an entire sample in which science teachers outnumbered geography teachers two to one, the results were reflective of the proportion of geography teachers who use GIS. Kerski's findings offer a helpful comparison for the current study.

Almost 15 years after Kerski's (2000) study, at least two-thirds (77 percent) of participants in the present study indicated that they used GST in the classroom at least once a semester (twice a year). Sixty-three percent reported using these technologies multiple times a semester. Additionally, a little over half reported using GST in their instruction, and over 40 percent used them in their lesson preparation or student activities. Clearly, more geography educators are engaging these technologies than before.

Implications and Recommendations

This timely study adds to the literature by expanding the understanding of the process of GST adoption and shedding light on the deficits of not only technology knowledge and awareness but also on geography educators' pedagogical and geography content knowledge as it relates to these technologies. The following section discusses key findings in the study, policy implications, and recommendations.

Factors Influencing Geospatial Technologies Implementation

The qualitative and quantitative data analysis revealed that four factors hinder GST implementation that can be addressed to influence and inform professional development providers, pre-service educators, education policy leaders, and key stakeholders. These factors include 1) limited geographic knowledge, 2) identifying a pattern of diffusion via different forms of technology, 3) knowing the adopter audience, and 4) addressing limited pedagogical knowledge related to technologies. Participants' comments suggest that the majority of educators, also referred to as other geography teachers, represent two camps: Those who know geography content and understand the discipline of geography versus those who lack geography content knowledge and awareness of the discipline of geography.

This categorization of geography teachers supports the largely anecdotal accounts of those who rely on the book and rote facts because they do not understand, nor were they trained to understand, geography concepts and geographic thinking strategies. In 2004, Bednarz echoed this sentiment by stating that geography teachers may be the "weakest link" in the diffusion of GIS because of their lack of geographic knowledge, which negatively affects their abilities to read and comprehend what is displayed by these technologies. Teachers with limited knowledge of the field could perpetuate misconceptions that the geography discipline is based on simple place-location and trivial facts. Results from the current study illustrate the strong relationship between pedagogical knowledge and the diffusion of GST. Coupled with the lack of content knowledge, the situation is dire. These findings have serious implications for the field of geography and the preparation for learners who need to be ready to face the twenty-first century globalized economy and society.

Participants recognized online GST more often than desktop GIS. In fact, 42 percent to 100 percent of participants recognized most forms of these online technologies. A higher percentage recognized technologies that show static images and allow users to zoom in and out for more detail, while fewer recognized more robust forms of GST. This difference in awareness may suggest that educators seek out technologies that provide instructional tools with which they are most comfortable and that suit their preferred styles of teaching. This finding leads to questions such as "How is GST meaningfully implemented into instruction?" and "What does implementation look like for different teaching and learning styles?" More importantly, the varied awareness of these technologies may showcase a path of diffusion into K-12 education, from simple to complex tools. Thus, determining a pattern of diffusion could inform trainings that facilitate educators to engage in more robust and rigorous applications of GST in instruction.

Knowing the future pre- and in-service audience is critical to ensuring the adoption of GST in the geography classroom. For the past 15 years, the geography education community has worked with Innovators and Early Adopters who enthusiastically and creatively employ technologies through mostly trial-and-error. Moving forward, the majority of geography educators may be joining the ranks. Recognizing that two very different groups of teachers exist and have different characteristics, motivations, and tolerance for using unpolished materials will require software and professional development providers to increase training program development efforts.

The difference in the two groups of teachers is akin to that of an “advanced” or “honors” level geography class to that of an “on-level” or “regular” level geography class. In the former, students tend to be excited by learning and are independently creative in their approaches to their education. The latter classroom reflects an array of students who are eager and knowledgeable to those who are struggling and resistant. This second group may also reflect the majority of geography educators who require a more direct approach that walks them through the analysis and synthesis of geography concepts, content, and skills. Therefore, geography content knowledge needs to be reinforced at the same time that GST are introduced.

On a cautionary note, Innovators and Early Adopters must not be ignored because they will still need continual training, collaboration, and attention as they strive to implement technology into high school geography instruction. Additionally, Early Adopters should be cultivated from new and pre-service teachers to keep the momentum going. These teachers should be groomed to accept their place as role models and be shown how to connect with other geography teachers.

Knowing the audience that is adopting GST also involves comprehending what motivates and challenges teachers’ uses of these technologies as pedagogical enhancements. The literature abounds with a litany of barriers to implementation (e.g., Cooper 1999, Bednarz and Audet 1999, Kerski 2003, Baker 2005, Milson and Earle 2006, Edelson, Smith, and Brown 2008). Although discussion occurs on the benefits of GST to learning, there appears to be a gap regarding high school educators’ motives to implement them despite the challenges they face. While many of these situations are daunting, a number of geography teachers persevere. Understanding the power of motivating factors can add to the growing body of literature and possibly aid the diffusion of GST.

In the current study, G-TPCK seemed to be the determining factor for geography educators' decisions to engage these technologies in the educational setting. Of those originally surveyed (*n* = 78), 38 percent with high TPCK scores also implemented GST in their instruction. However, most of those interviewed on the telephone (68 percent) implied that although they taught with these technologies, they were not specifically taught any pedagogical strategies to incorporate them into instruction. Instead, they had to piece together ways to teach with GST on their own.

Many in the geography community are concerned that their teachers tend to teach about rather than with GST (e.g., Sui 1995, Kerski 2003, and Baker 2005). Importantly, high school teachers may not be as equipped with sufficient Geospatial Technological Pedagogical Knowledge (G-TPK) to teach with these technologies as researchers suggest. Knowing how to teach geography and knowing how to use a technology does not connote that an educator is able to apply GST to his/her instruction.

Finding data to support key concepts that must be taught, and then finding the right GST for instruction, is an involved process. The reality is the majority of teachers are not able or willing to "figure it out." If the Innovators and Early Adopters represented in this study have difficulty applying these technologies to their curricula, then the majority of educators will continue to be hesitant to engage seemingly complicated tools for instruction. Therefore, a concerted effort to develop practical lessons that tie directly into the taught curricula would aid tremendously in the diffusion of GST into high school geography classrooms.

Policy Implications

The geography education community has had to react to and evolve with the ever-changing and rapidly expanding development of GST. Researchers have long recognized that students of all ages should be aware of and interact with these tools. A number of professionals within the community have worked diligently to conduct research, develop resources, and provide training in the hopes of enhancing teachers' knowledge about GST. While a significant regard for these technologies and their challenges, benefits, and potential has continued to increase over the past two decades, more work needs to be done. Specifically, the geography community must devise ways to engage the majority of geography educators in working to secure the training of highly qualified educators, building and expanding relationships with education leaders and policy makers, and developing a task force to plan strategic ways to diffuse GST into geography education.

The qualitative component of this study offers a glimpse into the possible challenges and motivational factors for the majority of the geography education population. These results may begin a dialogue within the geography community to devise strategies to target and infiltrate the large contingency of educators who have limited geography content and geographic pedagogical content knowledge. Further, the lack of basic geographic knowledge, understanding of the discipline, and respect for the discipline must be addressed to ensure the effective implementation of GST and high school geography instruction.

Highly qualified geography educators cannot be nurtured in the current geography teaching environment, which consists of two types of geography teachers—those who know geography content and those who do not. For too long, the geography community has accepted that its educators are rarely prepared to teach geography. Many are social studies teachers prepared by non-geography oriented pre-service educators who have no understanding of the discipline and how it differs from a social studies course. Furthermore, not all educator preparation programs require social studies teachers to take a geography course. Thus, the geography community must demand that policy makers are committed to requiring the training of highly qualified high school geography teachers to prepare the nation's youth. Professional, applied, and academic geographers need to work together with K-16 geography educators to testify, participate on state and local education committees, and meet with key stakeholders and decision-makers to ensure that educators are receiving the proper training to meet the needs of today's students.

Education leadership is at the crux of instituting change and bringing about the diffusion of GST in the high school setting. According to Holden and Rada (2011), the perception of the usability of a technology significantly influences the acceptance of that technology. Rogers (2003) called this notion the relative advantage. Cuban (1986) and Lee and Wizenreid (2009) supported Rogers and emphasized the role that organizational leadership plays on the adoption of an innovation. Education leadership must have positive perceptions of GST and recognize the relative advantages in including these technologies into geographic education.

In the current study, multiple interviewees stated that they needed to know how to justify using GST as tools for instruction to their supervisors and principals. Specifically, they required data to support their statements and an understanding of the relative advantages beyond gut feelings and personal observations. Thus, the geography community must arm K-12 educators with data from research and equip them with the knowledge to address their superiors' concerns. It is imperative that the geography community engage leadership at the school district and state levels to demonstrate how these technologies are effective pedagogical enhancements. Strategies should include attending and presenting at meetings and conferences with principals, superintendents, and social studies supervisors.

Finally, it is time that a comprehensive task force be formed to develop a strategic plan to address the lack of diffusion of GST in American schools. The members of such a committee should represent the following: Education leaders, K-16 geography educators, experienced GST professional development providers, geography and GST professionals, and pre-service educators. The task force should undertake the following activities: 1) develop a research agenda to provide data that support GST as integral tools for instruction and pedagogical strategies to integrate these technologies into geography education, 2) inform and attract education leaders and others to advocate for GST in geography education, 3) develop strategies for in-service professional development and pre-service teaching on how to teach with these technologies, and 4) create resources and a repository for GST education information for secondary educators.

Care should be taken to be pragmatic and practical while keeping in mind the intended audiences. This task force should also conduct a study to better understand the secondary social studies education culture so the larger geography community can become better informed regarding appropriate and meaningful ways to develop a culture that is more accepting of GST in high school geography. It is only with a comprehensive appreciation of the nuances that shape this issue that education leaders, professional development providers, pre-service educators, researchers, and others can work to bring geography education into the twenty-first century.

Unanswered Questions: Addressing Future Research

Linking together GST and research-based pedagogical practices is imperative to creating "buy-in" among geography educators in their realization that these tools are important instructional technologies. Making this a reality entails four major components: empirical data supporting GST as instructional tools, identification of forces motivating use, identification of best practices for teaching with these technologies, and empirical data determining characteristics and knowledge bases of high school geography educators.

First, as Downs (1994) requested, a bit of data would be nice. According to Bednarz (2004), little is known about the benefits of GST as pedagogical enhancements. Participants in the current study echoed this sentiment when they asked for data to take to their principals. High school educators and education leaders want to know how GST enhances the learning experience by conveying state-required geography concepts, motivating learning, and preparing learners for the future. If these technologies are to be more than a passing fad, a concerted effort must be made to investigate how these tools make geography education better.

Future research should include the identification for a path of diffusion, if one exists, as moving from simple to complex applications may elicit buy-in more readily. Unless GST can be shown to further learning in a high school World Geography setting, these technologies could potentially be regulated to career and technology courses that do not provide foundational geographic knowledge for students (and teachers) to understand the patterns and relationships displayed on the computer. Future studies must include in-depth examinations of how these technologies aid the geography instruction and learning process.

Second, understanding what drives educators to overcome barriers is paramount to knowing how GST can diffuse among high school geography educators. Many researchers have identified barriers to using these tools. However, it is asserted here that the question should not be, “What impedes a teacher from using GST?” Rather, the question should be, “What motivates a teacher to overcome barriers and integrate GST into instruction in a sustainable way?” Pinpointing factors that drive educators to persevere, despite overwhelming institutional and technological barriers, is critical.

Third, evidenced-based best practices for teaching with GST is vital to infusing geography courses with twenty-first century technology. Whether an Early Adopter or a part of the majority, all teachers need to be shown how to apply new technologies to instruction. Holden and Rada (2011) emphasized the need to provide teachers with examples of integrating technologies within the curricula, and GST are no different. Although many in geography education have made significant efforts to provide lessons online and in text, few researchers have identified common topics and concepts of the taught (district required) curricula and tied them to effective instructional practices using GST.

Instructional technologies that seamlessly enter an educational setting have a better chance at longevity (Cuban 1986). Ways to create a seamless interaction among novice GST users may be another avenue to aiding diffusion. Thus, future research should explore a variety of learning and teaching styles that use these technologies. Although these technologies may best fit one approach (i.e., constructivist), it is not pragmatic to support only a limited number of instructional methods. Identifying common teaching and learning styles and researching best practices to incorporate GST in those settings may make introducing and garnering support for these technologies easier and more palatable for the non-Innovator or Early Adopter.

Fourth, on multiple occasions, interview participants shared that other geography teachers sometimes do not respect or like geography enough to learn it; therefore, they only teach rote facts and basic place locations. In other words, geographic cognitive skills, point-of-view recognition, analyses, processes, relationships, and the like may not be a part of these classes. Combating these attitudes is a major hurdle to overcome for a complete diffusion of GST. Understandably, Innovators and Early Adopters have accepted these tools for use in instruction; however, the majority of educators have not.

Future studies should address topics such as attitudes toward geography within social studies, motivating educators with little content knowledge, and assessing the extent to which teachers are highly qualified and knowledgeable on the subject of geography. On a cautionary note, teachers in the majority are those with varying degrees of technological, pedagogical, and geography content knowledge. They are simply different in nature than those previously trained. Therefore, care should be given when interacting with the majority population to ensure that a negative or condescending impression is not conveyed as it could translate into an "us" versus "them" environment. Finally, future research should explore the differences between the majority of geography educators and Innovators and Early Adopters with recommendations that delineate strategies to best approach these educators.

Final Statement

While much more work is required in the area of GST and high school education, this research adds to the foundational understanding of what motivates teachers to accept them as instructional technologies. Educators have been tossed by one pendulum swing to another with each new innovative educational fad. The key to the longevity of GST in education is demonstrating its worth as a means of developing and expanding students' knowledge of geography content and skills and providing learners with critical twenty-first century skills.

Educators tend to teach how they have been taught. Breaking into pre-service education via methods and social studies content classes is imperative to instilling a respect for GST as tools for geographic instruction. Educators must be able to answer the questions, "Why are you using these technologies?" and "How do these technologies aid your students' learning of World Geography content and skills?" If the geography community does not equip educators with meaningful, research-based answers, these teachers will be powerless to defend the use of these technologies and may be unable to access them on their campuses.

The adoption of GST as tools for instruction includes much more than basic teacher decisions; it involves infiltrating different levels of the education community and leadership to demonstrate the power and potential of teaching with these technologies. We have been dealing with the potential of GST long enough. It is time to make this potential of teaching with GST in high school geography education a reality.

APPENDIX SECTION

Appendix A:

Survey Item: Geospatial Technology in High School Geography Education

Geospatial Technology in High School Geography Education

Welcome!

Welcome!

You have received a link to join a project looking at the use of geospatial technology by high school Geography educators. Your participation in the study is entirely voluntary and much appreciated.

The purpose of the research is to explore the training for and the awareness and the use of geospatial technology in high school (Grades 9 – 12) geography classrooms from both users and non-users of technology.

As a geography educator, this research can only be completed with your help! It is important for researchers to hear your story so that the learning and teaching environments in America's high schools can be better understood.

Geospatial technology (GST) is a general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

As a survey participant, you will be anonymous to the researchers unless you choose to provide your name and contact information at the conclusion of the survey. Even if you identify yourself on the survey form, you will remain anonymous in any future presentations and/or publications of the research results. Your identification will be kept strictly confidential. Results will be used in a summary form only to protect the confidentiality of the participants.

If you have any questions or concerns regarding your participation in this research, please contact Mary D. Curtis (mc1321@txstate.edu). This survey will only take approximately 15 minutes to complete.

Thank you for agreeing to participate in the Geospatial Technology in High School Geography Education survey and making your voice heard!

Sincerely,
Mary D. Curtis
Doctoral Candidate
Texas State University-San Marcos

Note: This study has been reviewed by the Institutional Review Board (IRB) at Texas State University-San Marcos. The IRB has determined that this study fulfills the human research subject protections obligations required by state and federal law and University policies.

Awareness and Experience with Technology In Geography Education

Definitions to keep in mind:
Geospatial technology (GST): a general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

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Geospatial Technology in High School Geography Education

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Aware: Having heard about or are familiar with a topic or application. You are not an expert.

Confident: Having a strong belief or full assurance, sure regarding your knowledge and/or ability.

Use: To purposefully engage or put into service some object or tool.

Directions: Carefully read each statement below. Determine whether you agree or disagree to each statement and mark the answer that best fits your experience with technology and best describes your teaching practices. Please base your answers on what you currently know and how you currently teach.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The use of technology (i.e. MS Word, PowerPoint, PhotoStory3, etc.) when teaching is important.	○	○	○	○	○
I am confident in my ability to use technology.	○	○	○	○	○
I am confident in my ability to use technology to plan lessons.	○	○	○	○	○
I am confident in my ability to use technology when teaching.	○	○	○	○	○
The use of technology specific to a course of study is important.	○	○	○	○	○
I use technology when teaching.	○	○	○	○	○
I am aware of teaching strategies to incorporate technology (i.e. PowerPoint, PhotoStory3, etc.) into my lessons.	○	○	○	○	○

Awareness and Experience with Geospatial Technology In Geography Education

Definitions to keep in mind:
Geospatial technology (GST): a general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

Aware: Having heard about or are familiar with a topic or application. You are not an expert.

Willing: Being inclined or opened to an idea, action, or experience.

Comfortable: Mentally or emotionally satisfied with the way things are; feel at ease with an idea, action, or experience.

Use: To purposefully engage or put into service some object or tool.

Geospatial Technology in High School Geography Education

Directions: Carefully read each statement below. Determine whether you agree or disagree to each statement and mark the answer that best fits your experience with technology and best describes your teaching practices. Please base your answers on what you currently know and how you currently teach.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am aware of desktop Geographic Information Systems (GIS) software.	◯	◯	◯	◯	◯
I am aware of online geospatial technology (GST).	◯	◯	◯	◯	◯
I am aware of teaching strategies to incorporate GST into my geography lessons.	◯	◯	◯	◯	◯
I know how to use Geographic Information System (GIS).	◯	◯	◯	◯	◯
Using geospatial technology is important when teaching geography.	◯	◯	◯	◯	◯
I am comfortable with my knowledge of geospatial technology (GST).	◯	◯	◯	◯	◯
I am willing to learn more about GST.	◯	◯	◯	◯	◯
I use GST to teach geography.	◯	◯	◯	◯	◯
I feel confident that I can teach students how to use GST.	◯	◯	◯	◯	◯
I am confident in my ability to use geospatial technology to plan geography lessons.	◯	◯	◯	◯	◯

Awareness and Experience with ONLINE Geospatial Technology in Geographic E...

Definitions to keep in mind:
Geospatial technology (GST): A general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Confident: Having a strong belief or full assurance, sure regarding your knowledge and/or ability.

Geospatial Technology in High School Geography Education

Directions: Carefully read each statement below. Determine whether you agree or disagree to each statement and mark the answer that best fits your experience with technology and best describes your teaching practices. Please base your answers on what you currently know and how you currently teach.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am confident in my ability to use online geospatial technology (GST) when teaching geography.	○	○	○	○	○
I am confident in my ability to teach students how to use online GST.	○	○	○	○	○
I am confident with my ability to use different teaching strategies to incorporate online GST.	○	○	○	○	○
There are professional development opportunities available to me that teach me how to use online GST.	○	○	○	○	○
There are professional development opportunities available to me that teach pedagogical strategies for the use of online GST in geography education.	○	○	○	○	○
I attend professional development workshops to learn more about online geospatial technology.	○	○	○	○	○
I am interested in using online GST to teach geography.	○	○	○	○	○

Training and Use of Geospatial Technology In Geography Education

Definitions to keep in mind:

Geospatial technology (GST): A general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Plan: Intentionally deciding to take an action.

Use: To purposefully engage or put into service some object or tool.

Geospatial Technology in High School Geography Education

Directions: Carefully read each statement below. Determine whether you agree or disagree to each statement and mark the answer that best fits your experience with technology and best describes your teaching practices. Please base your answers on what you currently know and how you currently teach.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I look for GST Websites to use when teaching geography.	○	○	○	○	○
My students use GST to complete homework and projects.	○	○	○	○	○
I look for lessons online for ideas of how to use GST.	○	○	○	○	○
I seek out opportunities to learn about GST.	○	○	○	○	○
I share my knowledge of general GST and teaching strategies with colleagues.	○	○	○	○	○
It is important to participate in training to learn about geospatial technology.	○	○	○	○	○
There are in-service opportunities to train high school teachers about geospatial technology.	○	○	○	○	○
There are in-service opportunities that inform high school teachers about teaching strategies for geospatial technology in general.	○	○	○	○	○
I am interested in teaching using geospatial technology (GST).	○	○	○	○	○
I am interested in teaching using geographic information systems (GIS) software.	○	○	○	○	○
Using GST has improved student understanding of geography concepts.	○	○	○	○	○
Using GST has improved my ability as a geography educator.	○	○	○	○	○

Available Geospatial Technology, Use, and Support

Definitions to keep in mind:
Geospatial technology (GST): A general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

Geospatial Technology in High School Geography Education

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Aware: Having heard about or are familiar with a topic or application. You are not an expert.

Directions: Answer the following questions by selecting the answer. Note: Some questions will indicate that multiple answers are acceptable. Please base your answers on what you currently know and how you currently teach.

What resource(s) have been instrumental in your awareness of desktop or online geospatial technology (GST)? (Check all that apply.)

- ☐ State Geographic Alliance Trainings
- ☐ School Professional Development
- ☐ Online Tutorials (i.e. ESRI free online tutorials)
- ☐ Mapping Our World: GIS Lessons for Educators

Other (please specify)

When did you become aware of ONLINE geospatial technology (GST)?

- ◯ I am not aware of online GST
- ◯ Within the last 12 months
- ◯ 1-3 years
- ◯ 3 – 6 years
- ◯ 7 – 9 years
- ◯ 10 years or greater

When did you become aware of geographic information systems (GIS)?

- ◯ I am not aware of GIS
- ◯ Within the last 12 months
- ◯ 1-3 years
- ◯ 3 – 6 years
- ◯ 7 – 9 years
- ◯ 10 years or greater

Available Geospatial Technology, Use, and Support

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Geospatial Technology in High School Geography Education

Definitions to keep in mind:

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Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Aware: Having heard about or are familiar with a topic or application. You are not an expert.

Directions: Answer the following questions by selecting the answer. Note: Some questions will indicate that multiple answers are acceptable. Please base your answers on what you currently know and how you currently teach.

What forms of desktop GIS software are you aware of? (Check all that apply)

- ☐ ESRI ArcView/ArcGIS
- ☐ MapInfo
- ☐ IDRISI
- ☐ MS MapPoint
- ☐ Earth Resources Data Analysis System (ERDAS) Imagine
- ☐ Geographic Resources Analysis Support System (GRASS)
- ☐ SmallWorld
- ☐ Manifold
- ☐ ArcExplorer Java Edition for Educators (AEJEE)
- ☐ InterGraph GeoMedia
- ☐ My World GIS
- ☐ ArcVoyager

Other (please specify)

What forms of Geospatial Technology are you aware of? (Check all that apply)

- ☐ Global Positioning System (GPS)
- ☐ Mapping Games
- ☐ MapQuest
- ☐ Google Earth
- ☐ National Atlas
- ☐ Globalis
- ☐ FieldScope
- ☐ USGS interactive map
- ☐ ArcGIS Explorer
- ☐ ArcGIS Online
- ☐ Remotely Sensed Images (i.e. Aerial Photography, LandSat Photography, Earth Observatory)

Other (please specify)

Prior to this survey, were you aware of geospatial technology (GST)?

- ○ Yes
- ○ No

Geospatial Technology in High School Geography Education

Geospatial Technology Training and Experience

Definitions to keep in mind:
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Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Use: To purposefully engage or put into service some object or tool.

Directions: Answer the following questions by selecting the answer. Note: Some questions will indicate that multiple answers are acceptable. Please base your answers on what you currently know and how you currently teach.

Approximately, how many hours of training in GST have you had over the past 10 years (online or desktop software)?

- ○ I have had no training for GST
- ○ 3-6 hours
- ○ 9-12 hours
- ○ 15-18 hours
- ○ 21 or more hours

Describe the type of GST training you have experienced. (Check all that apply)

- ☐ I have received no training
- ☐ Single Day Teacher Professional Development from the State Geographic Alliance
- ☐ Multiple Day Teacher Professional Development from the State Geographic Alliance
- ☐ Single Day Teacher Professional Development not from a State Geographic Alliance
- ☐ Multiple Day Teacher Professional Development not from a State Geographic Alliance
- ☐ GIS Course at the College Level
- ☐ Online GIS Course not from a College or University
- ☐ Self-taught

Geospatial Technology in High School Geography Education

To what extent did your training teach you how to apply GST when teaching geography?

- ◯ I have not received training in the use of GST.
- ◯ I did not learn how to apply GST in my classroom.
- ◯ I used to help me create lesson plans.
- ◯ Ideas for teaching strategies with GST in geography was given.

Other (please specify)

Through what training or event did you become aware of Geographic Information Systems (GIS)? (Check all that apply.)

- ☐ I am not aware of any GIS.
- ☐ University/College Course
- ☐ Pre-service Training
- ☐ Training using Mapping Our World: GIS Lessons for Educators (book)
- ☐ Professional Development/in-service through a State Geographic Alliance
- ☐ Professional Development/in-service through organizations other than the Alliance

Other (please specify)

Through what training or event did you become aware of ONLINE Geospatial Technology (GST)? (Check all that apply.)

- ☐ I am not aware of any online geospatial technology.
- ☐ University/College Course
- ☐ Pre-service Training
- ☐ Training using Mapping Our World: GIS Lessons for Educators (book)
- ☐ Professional Development/in-service through a State Geographic Alliance
- ☐ Professional Development/in-service through organizations other than the Alliance

Other (please specify)

Available Geospatial Technology, Use, and Support

Geospatial Technology in High School Geography Education

Definitions to keep in mind:
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Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Use: To purposefully engage or put into service some object or tool.

Directions: Answer the following questions by selecting the answer. Note: Some questions will indicate that multiple answers are acceptable. Please base your answers on what you currently know and how you currently teach.

The use of GST in geography education is supported by my: (Check all that apply.)

- ☐ Department Head/Chair
- ☐ Principal
- ☐ Social Studies Supervisor
- ☐ Instructional Technology Specialist

Other (please specify)

The use of GST results in which of the following benefits (Check all that apply)

- ☐ There are no benefits to using GST when teaching geography
- ☐ Helps to teach national, state, or district standards
- ☐ Enhances learning
- ☐ Develops spatial skills
- ☐ Provides an exploratory tool for data analysis
- ☐ Provides employment skills
- ☐ Offers a cooperative learning environment
- ☐ Enhances critical thinking skills
- ☐ Provides real-world relevance to subjects
- ☐ Provides integration of different subjects
- ☐ Enhances the understanding of relationships
- ☐ Provides opportunities to partner with community
- ☐ Enhances motivation and student interest
- ☐ Prepares students to be a 21st century student
- ☐ Offers opportunities to understand spatial data

Other (please specify)

Available Geospatial Technology, Use, and Support

Geospatial Technology in High School Geography Education

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Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Aware: Having heard about or are familiar with a topic or application. You are not an expert.

Use: To purposefully engage or put into service some object or tool.

Directions: Answer the following questions by selecting the answer. Note: Some questions will indicate that multiple answers are acceptable. Please base your answers on what you currently know and how you currently teach.

Currently, I use geospatial technology (GST) to teach geography:

- ◯ Never
- ◯ Once a semester
- ◯ Once a grading period
- ◯ Once a month
- ◯ Once a week
- ◯ 2 or more times a week

In the future, I want to use GST to teach geography:

- ◯ Never
- ◯ Once a semester
- ◯ Once a grading period
- ◯ Once a month
- ◯ Once a week
- ◯ 2 or more times a week

Available Geospatial Technology, Use, and Support

Definitions to keep in mind:
Geospatial technology (GST): A general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Use: To purposefully engage or put into service some object or tool.

Directions: Answer the following questions by selecting the answer. Note: Some questions will indicate that multiple answers are acceptable. Please base your answers on what you currently know and how you currently teach.

Geospatial Technology in High School Geography Education

When did you begin to use Geographic Information Systems (GIS)?

- ◯ Never
- ◯ In the past year
- ◯ 1-2 years ago
- ◯ 3 -5 years ago
- ◯ More than 5 years ago

Other (please specify)

When did you begin to use ONLINE geospatial technology (GST)?

- ◯ Never
- ◯ In the past year
- ◯ 1-2 years ago
- ◯ 3 -5 years ago
- ◯ More than 5 years ago

Other (please specify)

If you do use geospatial technologies, please describe the type of GST used. (Check all that apply.)

- ☐ Online GST
- ☐ Desktop GIS software
- ☐ GPS
- ☐ Remotely Sensed Images

Other (please specify)

Geospatial Technology in High School Geography Education

How do you use GST in your classroom? (Check all that apply)

- [ ] I do not use geospatial technology.
- [ ] Personal use
- [ ] Teacher preparation
- [ ] Teaching
- [ ] Student activities
- [ ] Student products

Other (please specify)

Available Geospatial Technology, Use, and Support

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Geospatial technology (GST): A general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

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Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Aware: Having heard about or are familiar with a topic or application. You are not an expert.

Use: To purposefully engage or put into service some object or tool.

Directions: Answer the following questions by selecting the answer. Note: Some questions will indicate that multiple answers are acceptable. Please base your answers on what you currently know and how you currently teach.

What DISCOURAGES you from using geospatial technology (GST) in your geography classroom? (Check all that apply.)

- [ ] Awareness of available technology
- [ ] Time in the curriculum
- [ ] Instructional time
- [ ] Planning time
- [ ] Lack of technical support
- [ ] Lack of administrative support
- [ ] Available computer time
- [ ] Internet availability
- [ ] Hardware
- [ ] Software
- [ ] Lack of resources
- [ ] Lack of colleague support
- [ ] Few others use this technology in my school
- [ ] Do not know how to use GST
- [ ] Lack of available professional development
- [ ] Time it takes to learn the technology before teaching students
- [ ] Do not know teaching strategies to incorporate GST into a geography classroom

Other (please specify)

What ENCOURAGES the use and/or continued use of GST in your geography classroom? (Check all that apply.)

- [ ] Knowledge of geospatial technology
- [ ] Knowledge of teaching strategies to better incorporate GST in geography education
- [ ] Professional development
- [ ] Administrative support
- [ ] Other teachers use GST
- [ ] Student interest
- [ ] Enhances Learning
- [ ] Develop Spatial skills
- [ ] Student performance
- [ ] Student reasoning skills development
- [ ] Personal benefit
- [ ] Available planning time
- [ ] Appropriate Equipment
- [ ] Appropriate software
- [ ] Access to the Internet

Other (please specify)

Tell Your Story: What is Your Experience with Geospatial Technology

Geospatial Technology in High School Geography Education

Definitions to keep in mind:

Geospatial technology (GST): A general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Use: To purposefully engage or put into service some object or tool.

Directions: For the following questions, type your answers in the space provided. Please base your answers on what you currently know and how you currently teach.

What types of technology have influenced your teaching?

What type of professional development has been most effective with regard to your knowledge of GST?

I am a member of an organization or online group (e.g. blog, listserv, etc.) where I can contact other geography teachers who use GST.

- [ ] Yes
- [ ] No

If "Yes," please list the organizations or groups.

What is the most important thing that would improve the use of GST in your classroom?

Tell Your Story: What is Your Experience with Geospatial Technology

Page 15

Geospatial Technology in High School Geography Education

Definitions to keep in mind:
Geospatial technology (GST): A general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Use: To purposefully engage or put into service some object or tool.

Directions: For the following questions, type your answers in the space provided. Please base your answers on what you currently know and how you currently teach.

What aspects of training (pre- or in-service) are helpful to prepare you to integrate geospatial technology into your geography classroom?

What resources have been instrumental in your use of GST (online or desktop) in the classroom?

Describe the ways you use geospatial technology in your classroom.

Tell Your Story: What is Your Experience with Geospatial Technology

Definitions to keep in mind:
Geospatial technology (GST): A general term used to describe the array of desktop software, mobile technology, and online technology applications that provide for different levels of data interaction –from basic visualization of data, to illustrating and analyzing relationships, and finally to querying data to evaluate and synthesize spatial relations, patterns, and processes. The most common GST includes Geospatial Information Systems (GIS), global positioning systems (GPS), and remote sensing (i.e. satellite imagery).

Geographic Information System (GIS): A system that is designed to store, retrieve, manipulate, and display geographic data. It allows the user to make specific queries and make models to illustrate geographic relationships, patterns, or processes.

Geospatial Technology in High School Geography Education

Online Geospatial Technology: Any visualization or mapping application that is on the Internet. It can be as simple as finding map directions to a more complex analytical online GIS tool.

Use: To purposefully engage or put into service some object or tool.

Directions: For the following questions, type your answers in the space provided. Please base your answers on what you currently know and how you currently teach.

What can the district administration do to support the use of GST in geography?

What can a State Geographic Alliance do/provide to help support your decision to use GST during the school year?

What can the school administration do to support the use of GST in geography?

Available Technology and Geography Education

Geospatial Technology in High School Geography Education

Directions: Read the statements below and determine whether or not the statements are true or false. If the statement is a true statement that reflects your school, check yes. If the statement is a false statement that does not reflects your school, mark no. Please base your answers on what you currently know and how you currently teach.

	No	Somewhat	Yes	Don't Know
Each teacher has a computer in the classroom.	◯	◯	◯	◯
Computer labs are available for teacher use.	◯	◯	◯	◯
Laptop carts are available for teacher use.	◯	◯	◯	◯
The Internet is available with each computer on campus.	◯	◯	◯	◯
The instructional technology specialist is aware of geospatial technology.	◯	◯	◯	◯
The instructional technology specialist is helpful with geospatial technology use.	◯	◯	◯	◯
I have a computer projector for my classroom.	◯	◯	◯	◯
I can check out a computer projector for my classroom.	◯	◯	◯	◯
Understanding patterns is an important part of geographic education.	◯	◯	◯	◯
Understanding processes is an important part of geographic education.	◯	◯	◯	◯
I am aware of the state content standards for Geography.	◯	◯	◯	◯
I am aware of the National technology standards.	◯	◯	◯	◯
I am aware of the National Geography Standards.	◯	◯	◯	◯
Data analysis plays an important role in geographic education.	◯	◯	◯	◯
Spatial awareness plays an important role in geographic education.	◯	◯	◯	◯

Demographic Data

Directions: In the space provided, please answer the questions below regarding your teaching experience, available technology, and geography classroom. By answering these questions, I will gain a better understanding of the learning and teaching environment in your school. Please base your answers on what you currently know and how you currently teach.

***Describe the school at which you teach?**

	Type	Location	Socio-Economic Level
School Description			

Other (please specify)

Geospatial Technology in High School Geography Education

***What is your age?**

- 20 - 25
- 26 - 30
- 31 - 35
- 36 - 40
- 41 - 45
- 46 - 50
- 51 or older

***What is your race? (Select one)**

- Caucasian
- Hispanic
- Asian
- African American
- Native American

Other (please specify)

***What is your gender?**

- Male
- Female

***What degrees have you earned?**

- Bachelor Degree (BA or BS)
- Masters Degree (MA or MS)
- Doctorate Degree (PhD)

Please list the major field of study for each degree.

Demographic Data: Technology

Directions: In the space provided, please answer the questions below regarding your teaching experience, available technology, and geography classroom. By answering these questions, I will gain a better understanding of the learning and teaching environment in your school. Please base your answers on what you currently know and how you currently teach.

***Do you have computers in your classroom?**

- [ ] There are no computers available
- [ ] 1 computer
- [ ] 2 - 3 computers
- [ ] 4 - 5 computers
- [ ] 6 or more computers

***How often do you have access to the computer lab and/or laptop cart.**

- ○ Never
- ○ Once a year
- ○ Once a semester
- ○ Once a grading period
- ○ Once a month
- ○ Once a week
- ○ More than once a week
- ○ Whenever I need it

***Please explain the procedure to use the computer lab and/or laptop cart.**

Students use geospatial technology applications in my classroom?

- ○ Yes
- ○ No

***My state geography content standards include the use of geospatial technologies.**

- ○ Yes
- ○ No

***I look for professional development (training) opportunities in geography beyond what is required by my school or school district?**

- ◯ Yes
- ◯ No

Demographic Data

Directions: In the space provided, please answer the questions below regarding your teaching experience, available technology, and geography classroom. By answering these questions, I will gain a better understanding of the learning and teaching environment in your school. Please base your answers on what you currently know and how you currently teach.

***In what state do you currently teach?**

I am a member of my state Geographic Alliance.

- ◯ Yes
- ◯ No

***In what school district do you currently teach?**

***What is the total enrollment of your school?**

***What is the average geography class size?**

***Including the current year, how many years have you been a teacher?**

- ◯ Pre-Service Teacher
- ◯ 0 - 2 Years
- ◯ 3 - 5 Years
- ◯ 6 - 10 Years
- ◯ 11+ Years

***What grade level(s) do you currently teach?**

- ◯ Grades 9 - 12
- ◯ Grades 6 - 8
- ◯ Grades K - 5

Geospatial Technology in High School Geography Education

***What subject areas and grade levels are you currently certified to teach in Social Studies? (Select All the Apply) Note: If you only hold a Social Studies Composite Teacher Certification please select the first choice.**

- [ ] Social Studies Composite
- [ ] U.S. History
- [ ] World History
- [ ] Economics
- [ ] Government
- [ ] Geography

***What subject areas do you currently teach? (Check all that apply)**

- [ ] World Geography (On level or Pre-AP)
- [ ] AP Human Geography
- [ ] World History
- [ ] US History
- [ ] Civics/Government
- [ ] Economics
- [ ] Psychology
- [ ] Sociology

Other (please specify)

Thank You For Participating In This Survey!!

I appreciate you taking the time to participate in this survey. Your candid responses will give insight to current geography classrooms and inform professional development trainers, academia, and others regarding the reality and challenges of using geospatial technology. Thank you!!

If you are available for and WILLING TO PARTICIPATE IN A PHONE INTERVIEW, please leave your phone number and email so that we can agree to a time that is convenient for you.

Name:

State:

Email Address:

Phone Number:

Geospatial Technology in High School Geography Education

I would like to say THANK YOU!! for participating in this survey by allowing you to enter a drawing for a door prize. In the space provided, IF YOU WANT TO BE ENTERED INTO A DOORPRIZE please enter your address and email address --so I can notify you that you have won.

(This address will be in no way connected to the survey answers. I will have an independent, impartial person compile the emails and randomly select the winners for the drawing.)

Name:

Address:

City/Town:

State:

ZIP:

Email Address:

Appendix B:

National GIS in Education Survey and Results

(Survey used with permission from Joseph Kerski)

(10) How many total hours have you spent in formal GIS training classes? Circle your answer.

A	0	**88**
B	1 – 19	**150**
C	20 – 39	**49**
D	40 – 59	**33**
E	60 – 79	**11**
F	80 or over	**37**

(11) If you use GIS, in which grade level(s) do you do so? Circle all that apply.

A	Grade 9	**117**
B	Grade 10	**121**
C	Grade 11	**169**
D	Grade 12	**171**

(12) If you use GIS, in which subjects do you do so? Circle all that apply.

1 History. **22**

2 Geography. **85**

3 Language Arts. **2**

4 Other Social Studies. **27** Please specify type(s):________________________

5 Science. **167** Please specify type(s): ______________________________

6 Mathematics. **5**

7 Computer Applications or Programming. **36**

8 Other. Please list: **37**__________________________

(13) When did you obtain your first copy of GIS software? Circle your answer.

A	1990 or before	**9**
B	1991 or 1992	**22**
C	1993 or 1994	**51**
D	1995 or 1996	**120**
E	1997 or 1998	**149**
F	I don't know.	**6**

(14) When did you begin using GIS in your classroom?

A	1990 or before	**5**
B	1991 or 1992	**7**
C	1993 or 1994	**31**
D	1995 or 1996	**54**
E	1997 or 1998	**139**
F	I am not using it yet.	**149**

(15) Which choice best describes your use of GIS in your classroom this semester?

1	I do not use GIS at this time and have no plans to do so.	**60**
2	I am planning to use GIS.	**107**
3	I demonstrate GIS on a computer.	**50**
4	I prepare lesson materials using a GIS.	**16**
5	I use GIS in one lesson in one class.	**14**
6	I use GIS in one lesson in more than one class.	**23**
7	I use GIS in more than one lesson in one class.	**29**
8	I use GIS in more than one lesson in more than one class.	**77**

(16) How many teachers at your school are using GIS, including yourself? Circle your answer.

0	No teachers	**115**
1	1 teacher	**141**
2	2 teachers	**51**
3	3 teachers	**18**
>3	More than 3 teachers	**19**
4	Not sure	**12**

(17) What percentage of students in your school are exposed to GIS? Circle your answer.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
104	**149**	**49**	**17**	**9**	**4**	**5**	**3**	**4**	**1**	**6**

(18) To what extent will you use GIS next year compared with this year?

1	2	3
I will decrease my use of GIS next year.	I will maintain my present use of GIS next year.	I will increase my use of GIS next year.
14	**78**	**235**

(19) Briefly describe one lesson in which you use GIS: (For example: "Students use GIS in analyzing population change in neighborhoods around our school from 1970 to 1990.")

(20) How many hours per week are you spending, on average, outside of class time on GIS?

0 hours	1 hour	2 hours	3 hours	4 hours	5 or more hours
127	**103**	**51**	**15**	**11**	**27**

Answer either question 21 or 22, whichever applies to you.

(21) I decided to use GIS because....

246 respondents

(22) I am not using GIS because...

151 respondents

(22) How much does your use of GIS result in these benefits? Circle your answer.

	None		Some		Very Much
Helps teach national, state, or district standards.	1	2	3	4	5
	51	**25**	**85**	**47**	**46**
Enhances learning.	1	2	3	4	5
	17	**6**	**40**	**114**	**96**
Provides exploratory tool for data analysis.	1	2	3	4	5
	22	3	34	87	123

Provides employment skills.	1	2	3	4	5
	40	**25**	**72**	**64**	**62**
Offers team learning environment.	1	2	3	4	5
	28	**18**	**66**	**81**	**73**
Provides real-world relevance to subject.	1	2	3	4	5
	17	**7**	**31**	**80**	**136**
Provides integration of different subjects.	1	2	3	4	5
	21	**14**	**64**	**91**	**80**
Provides opportunities to partner with community.	1	2	3	4	5
	42	**23**	**55**	**65**	**83**
Enhances motivation and student interest.	1	2	3	4	5
	20	**8**	**34**	**110**	**97**

Others (please list):______________________________

____

____

(23) How much is your use of GIS hindered by the following constraints? Circle your answer

	None		Some		Very Much
Complexity of software.	1	2	3	4	5
	6	**22**	**127**	**80**	**89**
Cost of hardware and software.	1	2	3	4	5
	56	**36**	**97**	**63**	**63**
Computers not accessible to my students.	1	2	3	4	5
	68	**41**	**62**	**47**	**92**

	1	2	3	4	5
Computers not capable of handling GIS.	1 **70**	2 **55**	3 **66**	4 **44**	5 **80**
Lack of time to develop lessons incorporating GIS.	1 14	2 **17**	3 **69**	4 **72**	5 **146**
Little administrative support for training.	1 59	2 **56**	3 **72**	4 **50**	5 **73**
Little technical support for training.	1 **44**	2 **53**	3 **75**	4 **65**	5 **76**
Class periods too short to work on GIS-based projects.	1 98	2 **66**	3 **57**	4 **52**	5 **28**
Lack of useful or usable data.	1 95	2 **65**	3 **86**	4 **41**	5 **18**
Lack of geographic skills among students.	1 66	2 **70**	3 **119**	4 **38**	5 **13**
Variable skill levels among students.	1 48	2 **49**	3 **116**	4 **65**	5 **22**

Others (please list):____

(25) The most important thing that would improve my use of GIS in teaching is...

(26) Where are you running your GIS? Circle all that apply.

1 My own classroom. **227** How many computers are in the class? __________

2 A shared school computer lab. **133** How many computers are in the lab? _______

3 At home on a desktop or laptop computer. **103**

4 No location. **27**

(27) What operating system(s) do you use with your GIS? Circle all that apply.

Macintosh	Windows 95/98	Windows NT	Unix	Not Applicable
105	**231**	**46**	**2**	**10**

(28) Does your school have a computer technical support staffperson(s)?

Yes	No	Yes, I am the technical support staffperson.
263	**47**	**44**

(29) If you have a technical support staffperson, circle how much support you receive from that person for your use of GIS:

1	2	3	4	5
Unaware of GIS	No support for GIS	Little support for GIS	Some support for GIS	Much support for GIS
84	**89**	**46**	**50**	**30**

(30) How much support and/or encouragement do you receive from your administrators for your use of GIS? Please circle.

1	2	3	4	5
Unaware of GIS	No support for GIS	Little support for GIS	Some support for GIS	Much support for GIS
93	**65**	**55**	**86**	**47**

(31) How many district, state, regional, and national educational conferences do you attend each year?

0	1-2	3-4	5-6	7 or more
43	**194**	**99**	**13**	**5**

(32) The most significant thing I have accomplished with GIS in the past year is...

(33) Circle your response to the following statement: "Using a GIS in the curriculum can make a significant contribution to a student's learning."

1 Strongly Disagree	2 Disagree	3 Neither agree nor disagree	4 Agree	5 Strongly Agree
2	**4**	**35**	**131**	**171**

End of survey. Thank you for your participation!

Appendix C:

IRB Email Notification

Date: February 12, 2010

DO NOT REPLY TO THIS MESSAGE. This email message is generated by the IRB online application program.

Based on the information in IRB Exemption Request EXP2010H1514, which you submitted on 02/10/10 12:15:54, your project is exempt from full or expedited review by the Texas State Institutional Review Board.

If you have questions, please submit an IRB Inquiry form:
http://www.txstate.edu/research/irb/irb_inquiry.html

Comments:
No comments.

==

Institutional Review Board
Office of Research Compliance
Texas State University-San Marcos
(ph) 512/245-2314 / (fax) 512/245-3847 / ospirb@txstate.edu / JCK 489
601 University Drive, San Marcos, TX 78666

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Appendix D:

Bracketing Researcher Experience

Both postpositivist quantitative and constructivist qualitative research cultures recognize that researchers' preconceptions, dispositions, experiences and the like may influence the results of their studies. The perspectives of these fields may differ in that quantitative researchers seek to 'bracket' influences on their investigations, while the qualitative researcher may identify the 'lens' for the research (Morrow and Smith 2000; Hoyt and Bhati 2007). The term 'bracket' is widely used in qualitative research as way for researchers to identify their experiences and biases regarding the studied phenomenon. My experiences teaching high school geography, working with GIS professionals and academics, training teachers, and researching geography education influenced my perceptions of geospatial technologies (GST) as valid instructional tools and high school teachers' willingness to use GST tools.

My interest in geospatial technologies as tools for instruction stems from my tenure as a high school social studies teacher. With no background in geography, I was assigned geography courses because I was in the process of earning a composite social studies certification from the State of Texas. When I read the school district's curriculum guide and the state standards for geography education, the *Texas Essential Knowledge and Skills*, I learned that I was expected to teach *with* geospatial technologies, specifically geographic information systems (GIS). I asked more experienced teachers about what a "GIS" was, and I was told "not to worry about it" or to only teach the definition. Everyone at my institution ignored this requirement because teachers did not have the equipment or training and were not held accountable for teaching with GST. My department head acknowledged my interest and sent me to GST trainings with the caveat that I would train our teachers upon my return.

My interest and concern for this important study simply deepened as my professional journey included being a Teacher Consultant for the Texas Alliance for Geographic Education (TAGE), the Grosvenor Scholar for the National Geographic Society, a researcher for the Gilbert M. Grosvenor Center for Geographic Education, and a participant at ESRI ArcGIS teacher trainings. Through professional interactions with both educators and academics, who sought to enhance teachers' GST knowledge and skills in the classroom, the lack of data on this topic was evident. During trainings and conferences, I found teachers resistant to the steep learning curve and the incredible amount of time required to learn desktop GIS; however, they were interested in learning and understanding online GST applications as an instructional tool for geography education.

While many academics and professional GIS trainers support and encourage K-12 educators' use of GIS, some professionals spoke disparagingly of the lack of K-12 educators' technology use. I found that many K-12 geography educators are excited about the new role of technology in enhancing students' understanding of geographic concepts, but faced a number of institutional and technical barriers beyond their control. Their interest stemmed mainly from positive experiences with key GST experts who understand that the heart of a true geography educator wants to excite and engage their students by marrying new and familiar technologies to geographic content. Knowing that these teachers were frustrated because of their inabilities to use new technologies, recognizing that online GST applications may not be commonly used, and experiencing concern that some professionals did not comprehend the full extent of the constraints of the teaching environments, I wanted to make a difference in the future of GST in geography education. Instead of focusing on barriers that impede GST as tools for instruction, I wanted to examine why some teachers use these technologies, despite their barriers. Perhaps by understanding the commonalities among these teachers and their training experiences, recommendations could be made for future pre- and in-service trainings and decisions by key stakeholders. I wanted to conduct a study that explained the situation in schools in the Digital Information Age, allowed educators to express their concerns regarding technologies, determined teachers' awareness of online GST, and explored reasons why some teachers use GST.

Many K-12 geography educators are frustrated because they have no forum to voice their concerns regarding teaching geography, incorporating technology, and the teaching environment. Igniting excitement in students to understand their world and the role of geography is the beating heart of a true geography teacher. These teachers intuitively know the importance of hooking students by connecting unfamiliar concepts with familiar ones.

Some want to engage more GST in their instruction but are constrained by decisions of key stakeholders in the school and/or school district policies. They recognize that students need contemporary life blended with an array of twenty-first-century digital technologies, such as GST. A number of well-documented barriers inhibit uptake, the greatest being the steep learning curve and time (Baker 2005; Milson and Kerski 2012). I am interested in knowing what motivates teachers to move beyond the barriers to incorporate GST as an instructional tool. Additionally, I want to know what characteristics comprise the brave population who choose to use GST.

I expect to find that teachers, in spite of their familiarity and comfort levels with general technology are challenged with desktop GIS, unaware of online GST applications, and untrained in technological pedagogical integration especially within content areas. I believe greater acceptance of technologies is because of a concerted effort by the government to expand technology resources in schools. Teacher comments both in my school district and at trainings reflect a cautious attitude toward desktop GIS and a general lack of awareness for online GST with the exception of Google Earth.

My experience as a geography teacher, a researcher, and a professional development provider aided my data collection and analysis. I am familiar with the general educator culture, state geography education requirements, professional development experiences, typical technology resources and availability, and impediments to technology use in high school settings. Additionally, geography educators in the Alliance community may be more receptive to my study because they have knon me as a Teacher Consultant for TAGE since 2000. All attempts were made to blindly select participants for all phases of this study. Furthermore, as a Grosvenor Scholar, I was familiar with each Alliance Coordinator in the states used in this study and found them willing to help me conduct this investigation. Their involvement created more buy-in from their members and recognized me as a credible researcher. Finally, as a researcher for the Gilbert M. Grosvenor Center for Geographic Education I was very familiar with geography standards and requirements in each of the states in the United States.

Appendix E:

Survey Items Sections

Table A.1. Description of Survey Sections and Items

Survey Section	Survey Items
Awareness and Experience with Technology in Geography Education	• The use of technology (e.g., MS Word, PowerPoint, PhotoStory3, etc.) when teaching is important. • I am confident in my ability to use technology. • I am confident in my ability to use technology to plan lessons. • I am confident in my ability to use technology when teaching. • The use of technology specific to a course of study is important. • I use technology when teaching. • I am aware of teaching strategies to incorporate technology (e.g., PowerPoint, PhotoStory3, etc.) into my lessons. • I am aware of desktop Geographic Information Systems (GIS) software. • I am aware of online geospatial technologies (GST). • I am aware of teaching strategies to incorporate GST into my geography lessons. • I know how to use Geographic Information System (GIS). • Using geospatial technologies is important when teaching geography. • I am comfortable with my knowledge of geospatial technologies (GST). • I am willing to learn more about GST. • I use GST to teach geography. • I feel confident that I can teach students how to use GST. • I am confident in my ability to use geospatial technologies to plan geography lessons. • I am confident in my ability to use online GST when teaching geography. • I am confident in my ability to teach students how to use online GST. • I am confident with my ability to use different teaching strategies to incorporate online GST. • There are professional development opportunities available to me that teach me how to use online GST. • There are professional development opportunities available to me that teach pedagogical strategies for the use of online GST in geography education. • I attend professional development workshops to learn more about online geospatial technologies. • I am interested in using online GST to teach geography.
Training and use of Geospatial Technologies in Geography Education	• I look for GST websites to use when teaching geography. • My students use GST to complete homework and projects. • I look for lessons online for ideas of how to use GST. • I seek out opportunities to learn about GST. • I share my knowledge of general GST and teaching strategies with colleagues. • It is important to participate in training to learn about geospatial technologies. • There are in-service opportunities to train high school teachers about GST. • There are in-service opportunities that inform high school teachers about teaching strategies for geospatial technologies in general. • I am interested in teaching using geospatial technologies (GST). • I am interested in teaching using GIS software. • Using GST has improved student understanding of geography concepts. • Using GST has improved my ability as a geography educator.

Table A.1.-Continued.

Survey Section	Survey Items
Available Geospatial Technologies, Use, and Support	• What resource(s) have been instrumental in your awareness of desktop or online geospatial technologies (GST)? (Check all that apply.) • When did you become aware of ONLINE geospatial technologies (GST)? • When did you become aware of Geographic Information Systems (GIS)? • What forms of desktop GIS software are you aware of? (Check all that apply) • What forms of geospatial technologies are you aware of? (Check all that apply) • Prior to this survey, were you aware of geospatial technologies (GST)? (Skip question. Those who answered 'no' skipped section 4 *Geospatial Technologies Training and Experience*.
Geospatial Technologies Training and Experience	• Approximately how many hours of training in GST have you had over the past 10 years (online or desktop software)? • Describe the type of GST training you have experienced. (Check all that apply) • To what extent did your training teach you how to apply GST when teaching? • Through what training or event did you become aware of Geographic Information Systems (GIS)? (Check all that apply.) • Through what training or event did you become aware of ONLINE geospatial technologies (GST)? (Check all that apply.)
Available Technology and Geography Education	• The use of GST in geography education is supported by my: (Check all that apply.) • The use of GST results in which of the following benefits: (Check all that apply) • Currently, I use geospatial technologies (GST) to teach geography: • In the future, I want to use GST to teach geography: • When did you begin to use Geographic Information Systems (GIS)? • When did you begin to use ONLINE geospatial technologies (GST)? • If you do use geospatial technologies, please describe the type of GST used. (Check all that apply.) • How do you use GST in your classroom? (Check all that apply) • What DISCOURAGES you from using geospatial technologies (GST) in your geography classroom? (Check all that apply.) • What ENCOURAGES the use and/or continued use of GST in your geography classroom? (Check all that apply.) • Each teacher has a computer in the classroom. • Computer labs are available for teacher use. • Laptop carts are available for teacher use. • The Internet is available with each computer on campus. • The instructional technology specialist is aware of geospatial technologies. • The instructional technology specialist is helpful with geospatial technologies usage. • I have a computer projector for my classroom. • I can check out a computer projector for my classroom. • Understanding patterns is an important part of geographic education. • Understanding processes is an important part of geographic education. • I am aware of the state content standards for geography. • I am aware of the national technology standards. • I am aware of the National Geography Standards. • Data analysis plays an important role in geographic education. • Spatial awareness plays an important role in geographic education.

Table A.1.-Continued

Survey Section	Survey Items
Tell Your Story: What is Your Experience with Geospatial Technologies	• What type of professional development has been most effective with regard to your knowledge of GST? • I am a member of an organization or online group (e.g., blog, listserv, etc.) where I can contact other geography teachers who use GST. • What is the most important thing that would improve the use of GST in your classroom? • What aspects of training (pre- or in-service) are helpful to preparing you to integrate geospatial technologies into your geography classroom? • What resources have been instrumental in your use of GST (online or desktop) in the classroom? • Describe the ways you use geospatial technologies in your classroom. • What can district administration do to support the use of GST in geography? • What can a State Geographic Alliance do/provide to help support your decision to use GST during the school year? • What can school administration do to support the use of GST in geography?
Demographic Data	• Describe the school at which you teach? - School Description – Type • Describe the school at which you teach? - School Description – Location • Describe the school at which you teach? - School Description – Socio-Economic Level • What is your age? • What is your race? (Select one) • What is your gender? • What degrees have you earned? • Do you have computers in your classroom? • How often do you have access to the computer lab and/or laptop cart. • Please explain the procedure to use the computer lab and/or laptop cart. • Students use geospatial technologies applications in my classroom. • My state geography content standards include the use of geospatial technologies. • I look for professional development (training) opportunities in geography beyond what is required by my school or school district. • In what state do you currently teach? • I am a member of my state Geographic Alliance. • In what school district do you currently teach? • What is the total enrollment of your school? • What is the average geography class size? • Including the current year, how many years have you been a teacher? • What grade level(s) do you currently teach? • What subject area(s) and grade level(s) are you currently certified to teach in Social Studies? (Select all the apply) Note: If you hold only a Social Studies Composite Teacher Certification, please select the first choice. • What subject area(s) do you currently teach? (Check all that apply)

Appendix F:

Content Analysis Codebook

Guidelines for Conducting the Content Analysis of the "Geospatial technologies (GST) in High School Education" Survey

Table of Contents

1.0. Overview of this Content Analysis

The overall purpose of this content analysis is to identify questions that represent each of Everett Rogers' five stages of an Innovation-Decision Process that an individual goes through when deciding to adopt an innovation. In this study the innovation examined is the use of geospatial technologies in a high school geography classroom. This code book is your manual for content analysis. Instead of using computer software to extract content we are relying on humans to complete this task.

You have been selected as one of the coders because you are a highly trained researcher who has experience with geospatial technologies (i.e., GIS, GSP, remotely sensed images, etc.) and a graduate degree in either geography education or science education, thus you are familiar with the subject matter content for this study. Your familiarity with the subject will aid in your understanding of the questions presented to participants in a questionnaire. Your professional knowledge, experience, and evaluation will provide a more accurate analysis than would computer programs. I encourage each of you to trust your knowledge, experience, and judgment as you assess these questions. Your research skills and understanding of geospatial technologies coupled with the careful use of the instructions and examples in this codebook will produce a high quality, thorough, and valid content analysis.

This is an "identifications" type of content analysis. This means we are simply determining the "category" or "stage" of the Innovation-Decision Process for each survey item represents. This approach is actually one of the simplest forms of content analysis. It will require, however, special attention to be paid to the nuances of each question. At the same time, I must caution you to not over think the items on the questionnaire.

To code the survey you will each receive information regarding Everett Rogers' (2003) Innovation-decision process model, this codebook, and digital coding forms.

Thank you for agreeing to assist in this project. It greatly pleases me to have fine, quality researchers such as yourselves coding this content because I trust and value your professionalism and experience. I look forward to reading the results of your work.

2.0. Goals of this Content Analysis

2.1. **Goal *n*1: To determine the appropriate stage or stages each questionnaire item represents.** The overall goal is to identify the appropriate stage(s) that a survey question "best fits" and record information on the "coding form." The survey items asked participants questions regarding their use of geospatial technologies and general technology (to a lesser extent). It includes items about training to use geospatial technologies as well. For the purpose of this coding exercise, the use of geospatial technologies is the innovation which participants are in the process of deciding to use. There are, however, a few questions regarding general technology use. Each question will be coded in the same manner. Most questions will only represent one stage. In some cases, however, a survey item my represent two stages. You will need to use your skill as a researcher and your professional experience to determine the appropriate category for each question.

3.0. **Objectives of Content Analysis for Rogers' Stages of Innovation-Decision**

Stages of the Innovation-Decision Process will be identified from the wording of each survey item. You are selecting the stage or stages that "best fits" each survey item, with the exception of participant demographic information. All questions to be coded were given to the participants as part of the online survey; no question regarding geospatial or general technology use and training was excluded from this coding project. Some questions are more straightforward than others and will be easier to code.

Each coder will treat questions individually and separately from others when determining the appropriate Innovation-Decision Process stage for a given question.

All responses will be placed into an Excel spreadsheet which will be provided by the researcher responsible for this study. In the Excel document the stages for each question will be recorded in the appropriate cell (row/column) that corresponds to the correct question and Innovation-Decision Process stage.

One of the best guides to determine the appropriate content category will be your initial reaction.

Caution: Take great care to read the definitions for each Innovation-Decision Process stage that is provided in this manual as well as in a separate document that describes Rogers' Diffusion of Innovation and its Innovation-Decision Process model.

Note: Be careful not to use your personal interpretation of the word(s) used in the title for each stage to make your judgments.

3.1. **Objective *n*1: Record STAGES for each individual question.** Each row on the coding form should be used to record stages of the Innovation-Decision Process for one single question, NOT a combination of two or more questions. The stages are each represented by numbers 1 – 5. These numbers should be recorded in the column labeled "Primary Stage." If a question represents more than one stage, than the appropriate number will be recorded in the column labeled "Secondary Stage." Therefore a row may have more than one number present. Be sure to place the correct number for the appropriate stage each question represents in the correct cell (row and column).

Remember the innovation for this study is the use of general technology, to a lesser extent, and geospatial technologies, to a greater extent, in high school geography classroom instruction (including lesson planning, deliver, assignments, and preparation).

The stages used for this study are:

- Stage 1: *Knowledge* (Awareness), represented by a 1 on the coding form.
- Stage 2: *Persuasion*, represented by a 2 on the coding form.
- Stage 3: *Decision*, represented by a 3 on the coding form.
- Stage 4: *Implementation*, represented by a 4 on the coding form.
- Stage 5: *Confirmation*, represented by a 5 on the coding form.

4.0. Everett Rogers' Stages of Innovation-Decision Process Background

Diffusion is the process of the spread of an idea or information through a conversation between the adopters and others through certain communication channels in a social system. Communication is the give and take of ideas that occurs until individuals gain a mutual understanding regarding an innovation. Adopting an innovation is not necessarily a passive role and may involve "tweaking" the innovation in the adoption process. In this case the diffusion of geospatial technologies, which has been communicated using various methods (colleague to colleague, professional development, personal exploration, etc.) is being studied.

The Innovation-Decision Process, according to Rogers (2003. p. 20), "is the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to the formation of an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision. [There are] …five main steps in the Innovation-Decision Process: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation."

5.0. Steps for Conducting the Content Analysis of the Stages of Innovation-Decision Process

Use the following steps to conduct the content analysis for the stages of Innovation-Decision Process represented by each survey item.

- Review and Prepare the files (Section 5.1)
- Conduct an overview of Rogers' Innovation-Decision model (Section 5.2)
- Conduct an overview of the questionnaire (Section 5.3)
- Record basic information onto the coding form (Section 5.4)

5.1. Step 1: Review and Prepare Data Entry Files

Each coder will receive both a paper and digital copy of the following: A single Excel file containing the coding form, a copy of the original survey, and an explanation of Everett Rogers' Diffusion of Innovation and the stages of Innovation-decision process model including definitions for each stage. All final coding documents will be digital and must be returned to the researcher via email. Paper copies of the documents are provided to coders for your personal using during this coding exercise.

5..1.1 **Open and review each document**: Note the *file names* for each document is as follows:

- **Excel Coding Form:** *StagesCodingForm.xls*
  In the Excel document there is a worksheet labeled "coded stages." Record all coding information on this worksheet. In "Column A" on the left-side of the "stages" worksheet you will find all questions items from the survey that need to be coded. The headings in "Row 1" provide for the "Primary Stage" and the "Secondary Stage" of the 5 stages of Innovation-Decision Process, as well as a heading for coders' notes. Remember, save your document regularly. Do not modify the file except to enter data and notes in the appropriate places on the Excel document.
- **Original Survey:** *OriginalSurvey.pdf*
  A copy of the original survey is provided as a resource only. Note that your copy of the survey has hand-written numbers next to each item to provide a continuous numbering system for easy reference. The first question begins with the number "2" to correspond to the Excel document. All items to be coded are provided in the Excel Coding Form: *StagesCodingForm.xls.*
- **Stages of Innovation-Decision Process Model:** *Rogers_InnovDecProcess.pdf*
  This Word document provides background information regarding Rogers' Diffusion of Innovation and the stages of Innovation-Decision Process model. Each stage is well defined for reference. Use this document to help determine the stage that "best fits" each survey item.

5..1.2. **Change the Excel Coding Form:** Rename the Excel document to a new name using the following protocol:

- *StagesCodingForm_LastNameFINAL.xls*
  Note: Where the file name states "LastName," please type in your last name. This is the document you will return to the researcher when your coding is complete.

5.2.Step 2: Conduct an overview of Rogers' Innovation-Decision Process model

- Review the document labeled "Stages of Innovation-Decision Process Model" which provides an overview for Everett Rogers'Diffusion of Innovations as well as an explanation for the stages for his Innovation-Decision Process. Make sure this document is read prior to beginning coding. This document will be discussed in detailing during training as well. The stages explained in this document will be the criteria to use to judge each survey item.

5.3.Step 3: Conduct an overview of the questionnaire

- Prior to beginning coding, review the questionnaire sent to high school geography teachers. This document will be discussed during training. Questions that were not included for coding include mostly demographic data. This document is mainly included for the coder as a resource. All questions necessary for coding will be provided for coding in an Excel document labeled "Excel Coding Form."

5.4.Step 4: Record basic information onto the coding form

Using the document labeled "Excel Coding Form," record all codes for the survey questions. In "Column A" on the left-side of the "stages" worksheet you will find all questions items from the survey. The headings in "Row 1" provide for the following columns: "Primary Stage", "Secondary Stage", and "Notes." These heading appear in the first cell for columns B, C, and D respectively. In the columns labeled "Primary Stage" and "Secondary Stage" you will place a number 1, 2, 3, 4, or 5 to represent each of the 5 stages of the Innovation-decision process. Use the original survey to review questions that have multiple answers indicated by words like "check all that apply." These questions may be dual coded. In the column titled "Notes," coders should place anything they feel is pertinent regarding their decisions. Coders should not feel that they must write notes for each decision. This column is simply provided should you need it. All notes are to be written as concisely as possible.

The stages used for this study are:

- Stage 1: *Knowledge* (Awareness), represented by a 1 on the coding form.
- Stage 2: *Persuasion*, represented by a 2 on the coding form.
- Stage 3: *Decision*, represented by a 3 on the coding form.
- Stage 4: *Implementation*, represented by a 4 on the coding form.
- Stage 5: *Confirmation*, represented by a 5 on the coding form.

6.0.Example Coding: Stages of Innovation-Decision

Below is a description for each stage and a "survey example" where survey wording examples are given and described for each stage of the Innovation-Decision Process. The examples do not list every possible statements and or topics appropriate for each stage. They are simply to give coders an idea of what to look for when evaluating each survey item.

6.1.Stage 1 Example:

- Stage 1 represents the *Knowledge* or *Awareness* stage, which, according to Rogers (2003, p. 169), "occurs when an individual is exposed to an innovation's existence and gains an understanding of how it functions."

- *Survey Example:* These questions include statements such as those that express awareness of any technology. They will using include wording such as "I am aware…" or "when did you become aware…".

6.2.Stage 2 Example:

- Stage 2 represents the *Persuasion* stage, which, according to Rogers (2003, p. 169), "occurs when an individual forms a favorable or an unfavorable attitude towards the innovation."
- *Survey Example:* These questions include statements such as those that express attitude for or against use of GST which could use words such as "interest" or "willingness."

6.3.Stage 3 Example:

- Stage 3 represents the *Decision* stage, which, according to Rogers (2003, p. 169), "takes place when an individual engages in activities that lead to a choice to adopt or reject the innovation."
- *Survey Example:* These questions include statements such as those that express use of (or a decision to use) geospatial technologies or the development of technology knowledge and skills.

6.4.Stage 4 Example:

- Stage 4 represents the *Implementation* stage, which, according to Rogers (2003, p. 169), "occurs when an individual puts a new idea into use."
- *Survey Example:* These questions include statements such as those that express use of geospatial technologies with an outcome or coupled with another action in a new way beyond simple, individual use of the innovation.

6.5.Stage 5 Example:

- Stage 5 represents the *Confirmation* stage, which, according to Rogers (2003, p. 169), "takes place when an individual seeks reinforcement of an innovation-decision already made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation."
- *Survey Example:* These questions include statements such as those that express participants' future action, desire for more opportunities with the technology, participation with other groups, and action to shares information with others.

6.6.*Survey questions that could be dual coded:*

- Many questions will not be dual coded. There are some questions, however, that may provide data that "best fits" 2 stages. These survey items may include some questions that illustrate confidence in some knowledge or skill set, actions by participant, knowledge about or participation in some professional development opportunities, and/or attitudes. Dual coded questions are determined based on the wording of the question and are not as straightforward as some of the survey items are for stages 1 – 5.

7.0. Entering Data on Code Sheet

Survey Items	Primary Stage	Secondary Stage	Notes
The use of technology when teaching is important.	**2**		
I am confident in my ability to use technology when teaching.	**4**		
I use technology when teaching.	**3**		
I am aware of general technology such as Word, PowerPoint, and Photostory3.	***1***		
I look for lesson plans that incorporate technology into instruction.	***5***		

Sample coding sheet has been truncated for the purposes of fitting this sheet for an example. This example uses general technology as the innovation to code; coders will, however, use geospatial technologies survey items as the innovation to code using stages 1 – 5. The last two survey items in the example do not appear in the actual questionnaire participants received. Examples of dual coded questions are not provided in order to not place undue influence on coders' decisions regarding the "types of items" to dual code.

7.1. Caution about Interpretation

The stages for each of the questions may not be evenly distributed. Do not feel compelled to make sure there are an equal number of questions for each stage.

Please exercise care when entering data into the coding form. Be sure to use the appropriate number for the desired Innovation-decision process stage. Take care not to over think the stage(s) for each survey item.

Be sure to judge each survey item on its own merits, and do not compare to others. Do not be influenced by patterns that may emerge as you enter your codes.

8.0. Final Words

Manual content analysis is not an exact science, but relies on the content and research experience and expertise of the coders. In this case, your knowledge and expertise as a researcher coupled with your experience with using geospatial technologies as a student, as an educator, or both is more than enough to equip you to appropriately code the survey items. Please carefully follow the guidelines I have provided for you. As you can see from the design of the coding form, it is necessary for you to use your professional judgment when evaluating the survey items. I am pleased that you have agreed to participate in this coding project because I trust your professionalism and experience. I look forward to reviewing your results**.**

Appendix G:

Code Sheet

Survey Questions	Primary Stage	Secondary Stage	Notes
The use of technology (i.e., MS Word, PowerPoint, PhotoStory3, etc.) when teaching is important.			
I am confident in my ability to use technology.			
I am confident in my ability to use technology to plan lessons.			
I am confident in my ability to use technology when teaching.			
The use of technology specific to a course of study is important.			
I use technology when teaching.			
I am aware of teaching strategies to incorporate technology (i.e., PowerPoint, PhotoStory3, etc.) into my lessons.			
I am aware of desktop Geographic Information Systems (GIS) software.			
I am aware of online geospatial technologies (GST).			
I am aware of teaching strategies to incorporate GST into my geography lessons.			
I know how to use Geographic Information System (GIS).			
Using geospatial technologies is important when teaching geography.			
I am comfortable with my knowledge of geospatial technologies (GST).			
I am willing to learn more about GST.			
I use GST to teach geography.			
I feel confident that I can teach students how to use GST.			
I am confident in my ability to use geospatial technologies to plan geography lessons.			
I am confident in my ability to use online geospatial technologies (GST) when teaching geography.			

Survey Questions	**Primary Stage**	**Secondary Stage**	**Notes**
I am confident in my ability to teach students how to use online GST.			
I am confident with my ability to use different teaching strategies to incorporate online GST.			
There are professional development opportunities available to me that teach me how to use online GST.			
There are professional development opportunities available to me that teach pedagogical strategies for the use of online GST in geography education.			
I attend professional development workshops to learn more about online geospatial technologies.			
I am interested in using online GST to teach geography.			
I look for GST Websites to use when teaching geography.			
My students use GST to complete homework and projects.			
I look for lessons online for ideas of how to use GST.			
I seek out opportunities to learn about GST.			
I share my knowledge of general GST and teaching strategies with colleagues.			
It is important to participate in training to learn about geospatial technologies.			
There are in-service opportunities to train high school teachers about geospatial technologies.			
There are in-service opportunities that inform high school teachers about teaching strategies for geospatial technologies in general.			
I am interested in teaching using geospatial technologies (GST).			
I am interested in teaching using geographic information systems (GIS) software.			

Survey Questions	**Primary Stage**	**Secondary Stage**	**Notes**
Using GST has improved student understanding of geography concepts.			
Using GST has improved my ability as a geography educator.			
What resource(s) have been instrumental in your awareness of desktop or online geospatial technologies (GST)? (Check all that apply.) - State Geographic Alliance Trainings, School Professional Development, Online Tutorials, Mapping Our World: GIS Lessons for Educators, Other			
When did you become aware of ONLINE geospatial technologies (GST)?			
When did you become aware of geographic information systems (GIS)?			
What forms of desktop GIS software are you aware of? (Check all that apply)			
What forms of Geospatial technologies are you aware of? (Check all that apply)			
Prior to this survey, were you aware of geospatial technologies (GST)?			
Approximately, how many hours of training in GST have you had over the past 10 years (online or desktop software)?			
Describe the type of GST training you have experienced. (Check all that apply)			
To what extent did your training teach you how to apply GST when teaching geography?			
Through what training or event did you become aware of Geographic Information Systems (GIS)? (Check all that apply.)			
Through what training or event did you become aware of ONLINE Geospatial technologies (GST)? (Check all that apply.)			
The use of GST in geography education is supported by my: (Check all that apply.) - Department Head/Chair, Principal, Social Studies Supervisor, Instructional Technology Specialist, other			

Survey Questions	Primary Stage	Secondary Stage	Notes
The use of GST results in which of the following benefits (Check all that apply)			
Currently, I use geospatial technologies (GST) to teach geography: Never, once a semester, once a grading period, once a month, once a week, 2+ times a week			
In the future, I want to use GST to teach geography: Never, once a semester, once a grading period, once a month, once a week, 2 + times a week			
When did you begin to use Geographic Information Systems (GIS)?			
When did you begin to use ONLINE geospatial technologies (GST)?			
If you do use geospatial technologies, please describe the type of GST used. (Check all that apply.)			
How do you use GST in your classroom? (Check all that apply) - I do not use geospatial technologies.			
How do you use GST in your classroom? (Check all that apply) - Personal use			
How do you use GST in your classroom? (Check all that apply) - Teacher preparation			
How do you use GST in your classroom? (Check all that apply) - Teaching			
How do you use GST in your classroom? (Check all that apply) - Student activities			
How do you use GST in your classroom? (Check all that apply) - Student products			
What DISCOURAGES you from using geospatial technologies (GST) in your geography classroom? (Check all that apply.)			
What ENCOURAGES the use and/or continued use of GST in your geography classroom? (Check all that apply.)			
What types of technology have influenced your teaching? - Open-Ended Response			

Survey Questions	Primary Stage	Secondary Stage	Notes
What type of professional development has been most effective with regard to your knowledge of GST? - Open-Ended Response			
I am a member of an organization or online group (e.g., blog, listserv, etc.) where I can contact other geography teachers who use GST. - Yes/No			
What is the most important thing that would improve the use of GST in your classroom? - Open-Ended Response			
What aspects of training (pre- or in-service) are helpful to prepare you to integrate geospatial technologies into your geography classroom? - Open-Ended Response			
What resources have been instrumental in your use of GST (online or desktop) in the classroom? - Open-Ended Response			
Describe the ways you use geospatial technologies in your classroom. - Open-Ended Response			
What can the district administration do to support the use of GST in geography? - Open-Ended Response			
What can a State Geographic Alliance do/provide to help support your decision to use GST during the school year? - Open-Ended Response			
What can the school administration do to support the use of GST in geography? - Open-Ended Response			

Appendix H:

Background: Everett Rogers' (2003) Innovation-Decision Process

Stages of Innovation-Decision Process Model

Diffusion is the process of an idea or information spreading through a conversation between the adopters and others engaging in certain communication channels in a social system. In this case the diffusion of geospatial technologies, which has been communicated using various methods (colleague to colleague, professional development, personal exploration, etc.) is being studied.

The Innovation-Decision Process, according to Rogers (2003. p. 20), "is the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to the formation of an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision. [The] …five main steps in the Innovation-Decision Process: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation." Rogers states that these stages usually take place in a time-ordered sequence.

1. **Knowledge:** *Stage 1* represents the *Knowledge* or *Awareness* stage, which, according to Rogers (2003, p. 169), "occurs when an individual is exposed to an innovation's existence and gains an understanding of how it functions."

- Knowledge at this level includes being awareness of the innovation, understanding how the innovation works, and understanding the functioning principles of how and why the innovation works. At this phase knowledge about "what the innovation is and how and why it works" (p. 21) is sought by an individual.

2. **Persuasion:** *Stage 2* represents the *Persuasion* stage, which, according to Rogers (2003, p. 169), "occurs when an individual forms a favorable or an unfavorable attitude towards the innovation."

- In this phase, an individual is evaluating the innovation and seeks to know its advantages and disadvantages to determine whether to adopt or reject the innovation. This level of the decision process is heavily influenced by the affective domain, meaning the individual's feelings towards the innovation. Individuals are also influenced by their own uncertainty about the innovation and by the opinions of others (peers, colleagues, etc.).

3. **Decision:** *Stage 3* represents the *Decision* stage, which, according to Rogers (2003, p. 169), "takes place when an individual engages in activities that lead to a choice to adopt or reject the innovation."

- Individuals at this stage make a decision to either adopt, meaning to fully use "an innovation as the best course of action available," or reject the innovation, meaning "not adopt an innovation" (Rogers, 2003, p. 177). In this phase, an individual continues evaluating an innovation and is likely to be influenced by other's opinions.

4. **Implementation:** *Stage 4* represents the *Implementation* stage, which, according to Rogers (2003, p. 169), "occurs when an individual puts a new idea into use."

- Subjective evaluations by others may continue to influence individual's opinions. In this phase, individuals are putting the innovation into practice.

5. **Confirmation:** *Stage 5* represents the *Confirmation* stage, which, according to Rogers (2003, p. 169), "takes place when an individual seeks reinforcement of an innovation-decision already made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation."

- Subjective evaluations by others may continue to influence individual's opinions. In this phase, individuals are seeking support for their decision. Although they may reject the innovation, most of the action in this stage is positive with the intent to confirm their decision to adopt the innovation.

Appendix I:

Final Variable Codes

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
1. Awareness and Experience with Technology in Geography Education	The use of technology (i.e., MS Word, PowerPoint, PhotoStory3, etc.) when teaching is important.	tek_imp	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Decision Stage	Technological Pedagogical Content Knowledge (TPCK)
	I am confident in my ability to use technology.	tek_con	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Decision Stage	Technological Content Knowledge (TCK), TPCK *Note: Some variables are dual coded.*
	I am confident in my ability to use technology to plan lessons.	teklpcon	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementation Stage	TCK TPCK
	I am confident in my ability to use technology when teaching.	tektchco	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response	Implementation Stage	TPCK

				1 = Positive Response		
Survey Section	**Survey Items**	**Variable Name**	**Variable Values: Original Data Recoded for Descriptive Statistics**	**Variable Values: Original Data Recoded with Binary Codes**	**Variable Name: Innovation-Decision Stages**	**Variable Name: Technological Pedagogical Content Knowledge**
Awareness and Experience with Technology in Geography Education Con't	The use of technology specific to a course of study is important.	tek_csim	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TPCK
	I use technology when teaching.	tekutch	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementation Stage	TPCK
	I am aware of teaching strategies to incorporate technology (i.e., PowerPoint, PhotoStory3, etc.) into my lessons.	tektsaw	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TPCK
	I am aware of desktop Geographic Information Systems (GIS) software.	gis_aw	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Awareness and Experience with Technology in Geography Education Con't	I am aware of online geospatial technologies (GST).	gsto_aw	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK
	I am aware of teaching strategies to incorporate GST into my geography lessons.	gst_tsaw	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TPCK
	I know how to use Geographic Information System (GIS).	gis_knou	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Decision Stage	TCK TPCK
	Using geospatial technologies is important when teaching geography.	gstimgeo	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Awareness and Experience with Technology in Geography Education Con't	I am comfortable with my knowledge of geospatial technologies (GST).	gst_comf	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TCK TPCK
	I am willing to learn more about GST.	gst_wlg	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TCK TPCK
	I use GST to teach geography.	gst_utch	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TPCK
	I feel confident that I can teach students how to use GST.	gstcostu	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementation Stage Confirmation Stage	TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Awareness and Experience with Technology in Geography Education Con't	I am confident in my ability to use geospatial technologies to plan geography lessons.	gst_colp	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementat ion Stage	TPCK
	I am confident in my ability to use online geospatial technologies (GST) when teaching geography.	gsto_tch	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementat ion Stage	TPCK
	I am confident in my ability to teach students how to use online GST.	gststuco	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementat ion Stage	TPCK
	I am confident with my ability to use different teaching strategies to incorporate online GST.	gst_cots	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementat ion Stage	TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Awareness and Experience with Technology in Geography Education Con’t	There are professional development opportunities available to me that teach me how to use online GST.	gst_pdav	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage Persuasion Stage	TCK TPCK
	There are professional development opportunities available to me that teach pedagogical strategies for the use of online GST in geography education.	Gst_pdps	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage Persuasion Stage	TPCK
	I attend professional development workshops to learn more about online geospatial technologies.	gst_gopd	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Confirmatio n Stage	TPCK
	I am interested in using online GST to teach geography.	gst_int	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
2. Training and Us of Geospatial technologies in Geography Education	I look for GST Websites to use when teaching geography.	gstlkweb	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Confirmation Stage Persuasion Stage	TPCK
	My students use GST to complete homework and projects.	gst_hmwk	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementation Stage	TPCK
	I look for lessons online for ideas of how to use GST.	gstlpweb	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage Confirmation Stage	TPCK
	I seek out opportunities to learn about GST.	gst_seek	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage Confirmation Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Training and Use of Geospatial technologies in Geography Education (Con’t)	I share my knowledge of general GST and teaching strategies with colleagues.	gstshare	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Confirmatio n Stage	TPCK
	It is important to participate in training to learn about geospatial technologies.	gstpdimp	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage Confirmatio n Stage	TCK TPCK
	There are in-service opportunities to train high school teachers about geospatial technologies.	gst_insv	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TCK TPCK
	There are in-service opportunities that inform high school teachers about teaching strategies for geospatial technologies in general.	gst_ints	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage Persuasion Stage	TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Training and Use of Geospatial technologies in Geography Education (Con't)	I am interested in teaching using geospatial technologies (GST).	gstinst	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TPCK
	I am interested in teaching using geographic information systems (GIS) software.	gisuint	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TPCK
	Using GST has improved student understanding of geography concepts.	gstimpvs	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementat ion Stage	TPCK
	Using GST has improved my ability as a geography educator.	gstimpvt	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree	*Recoded Values:* 0 = 1 – 3 1 = 4 – 5 0 = Non-Positive Response 1 = Positive Response	Implementat ion Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
3. Available Geospatial technologies, Use, and Support	What resource(s) have been instrumental in your awareness of desktop or online geospatial technologies (GST)? (Check all that apply.) *Each response is a separate variables.* – State Geographic Alliance Trainings – School Professional Development – Online Tutorials (i.e., ESRI free online tutorials) – Mapping Our World: GIS Lessons for Educators – Other	gst_resc _SAtrg _SchPD _Otut _MOWGLE _othr	0 = Not selected as an answer choice 1 = Selected as an answer choice "Other:" Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK
	When did you become aware of ONLINE geospatial technologies (GST)?	gsta_tm	0 = I am not aware of GIS 1 = Within the last 12 months 2 = 1 – 3 years 3 = 3 – 5 years 4 = 7 -9 years 5 = 10 years or greater	*Recoded Values:* 0 = 0 1 = 1 – 5 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Geospatial technologies, Use, and Support (Con't)	When did you become aware of geographic information systems (GIS)?	gisa_tm	0 = I am not aware of GIS 1 = Within the last 12 months 2 = 1 – 3 years 3 = 3 – 5 years 4 = 7 -9 years 5 = 10 years or greater	*Recoded Values:* 0 = 0 1 = 1 – 5 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK
	What forms of desktop GIS software are you aware of? (Check all that apply) *Each response below is a separate variables.* – ESRI ArcViewGIS – MapInfo – IDRISI – MS MapPoint – Earth Resource Data Analysis System (ERDAS) Imagine – Geographic Resources Analysis Support System (GRASS) – SmallWorld – Manifold – ArcExplorer Java Edition for Educators (AEJEE) – InterGraph GeoMedia – My World GIS – ArcVoyager – Other	gis_form _ESRI _MapInfo _IDRISI _MSmappt _ERDAS _GRASS _SmallWld _Manifold _AEJEE _GeoMedia _MyWld _ArcVoy _othr	0 = Not selected as an answer choice 1 = Selected as an answer choice "Other:" Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Geospatial technologies, Use, and Support Con't	What forms of Geospatial technologies are you aware of? (Check all that apply) *Each response below was identified as separate variables.* – Global Positioning System (GPS) – Mapping Games – MapQuest – Google Earth – National Atlas – Globalis – FieldScope – USGS Interactive map – ArcGIS Explorer – ArcGIS Online – Remotely Sensed Images – Other	gst_form _GPS _Mapgms _MapQ _GE _NatAtlas _Globalis _FS _USGSmaps _ArcExp _ArcGIS _RS _othr	0 = Not selected as an answer choice 1 = Selected as an answer choice "Other:" Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK

Survey Section	**Survey Items**	**Variable Name**	**Variable Values: Original Data Recoded for Descriptive Statistics**	**Variable Values: Original Data Recoded with Binary Codes**	**Variable Name: Innovation-Decision Stages**	**Variable Name: Technological Pedagogical Content Knowledge**
Available Geospatial technologies, Use, and Support Con't	Prior to this survey, were you aware of geospatial technologies (GST)? (Skip question. Those who answered know skipped section 4 *Geospatial technologies Training and Experience*.	gsta_sur_skip	0 = No 1 = Yes	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK
4. Geospatial technologies Training and Experience	Approximately, how many hours of training in GST have you had over the past 10 years (online or desktop software)?	tgst_tm_SK	0 = I have had no training for GST 1 = 3 – 6 Hours 2 = 9 – 12 hours 3 = 15 – 18 hours 4 = 21 or more hours	*Recoded Values:* 0 = 0 1 = 1 – 4 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
4. Geospatial technologies Training and Experience Con't	Describe the type of GST training you have experienced. (Check all that apply) *Each response below was identified as separate variables.* – I have received no training – Single Day Teacher Professional Development from the State Geographic Alliance – Multiple Day Teacher Professional Development from the State Geographic Alliance – Single Day Teacher Professional Development not from the State Geographic Alliance – Multiple Day Teacher Professional Development not from the State Geographic Alliance – GIS Course at the College Level – Online GIS Course not from a College or University – Self-taught	tgst_typ _none_SK _1daySA_SK _mdaySA_SK _1dayNoSA_SK _mdayNoSA_SK _GISuniv_SK _OGIStry_SK _self_SK	0 = Not selected as an answer choice 1 = Selected as an answer choice	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage Confirmation Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Geospatial technologies Training and Experience (Con't)	To what extent did your training teach you how to apply GST when teaching?	tgst_app_SK tgst_app_othr_SK	0 = I have not received training in the use of GST 1 = I did not learn how to apply GST in my classroom. 2 = I used to help me create lessons 3 = Ideas for teaching strategies with GST in geography was given. 0 = Other	*Recoded Values:* 0 = 0 1 = 1 – 3 0 = Non-Positive Response 1 = Positive Response	Implementation Stage Persuasion Stage	TCK TPCK
	Through what training or event did you become aware of Geographic Information Systems (GIS)? (Check all that apply.) *Each response below is a separate variables.* – I am not aware of any GIS – University/College Course – Pre-service Training – Training using Mapping Our World" GIS Lessons for Educators (book) – Professional Development/In-service through a State Geographic Alliance – Professional Development/In-service through organizations other than the Alliance – Other	tgis_awr _unawr_SK _highed_SK _preserv_SK _MOWGLE_SK _Pdgeoall_SK _PDothr_SK	0 = Not selected as an answer choice 1 = Selected as an answer choice "Other:" Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Geospatial technologies Training and Experience (Con't)	Through what training or event did you become aware of ONLINE Geospatial technologies (GST)? (Check all that apply.) *Each response is a separate variables.* – I am not aware of any online geospatial technologies – University/College Course – Pre-service Training – Training using Mapping Our World" GIS Lessons for Educators (book) – Professional Development/In-service through a State Geographic Alliance – Professional Development/In-service through organizations other than the Alliance – Other	tgsto_aw _unawr_SK _highed_SK _preserv_SK _MOWGLE_SK _Pdgeoall_SK _PDothr_SK	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:" Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Knowledge Stage	TCK TPCK

Survey Section	**Survey Items**	**Variable Name**	**Variable Values: Original Data Recoded for Descriptive Statistics**	**Variable Values: Original Data Recoded with Binary Codes**	**Variable Name: Innovation-Decision Stages**	**Variable Name: Technological Pedagogical Content Knowledge**
5. Available Technology and Geography Education	The use of GST in geography education is supported by my: (Check all that apply.) *Each response is a separate variables.* – Department Head/Chair – Principal – Social Studies Supervisor – Instructional Technology Specialist – Other	gst_sup _DH _princ _Ssup _IT _othr	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:” Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Technology and Geography Education Con't	The use of GST results in which of the following benefits (Check all that apply) *Each response is as separate variables.* – There are no benefits to using GST when teaching geography – Helps to teach national, state or district standards – Enhances Learning – Develops spatial skills – Provides an exploratory tool for data analysis – Provides employment skills – Offers a cooperative learning environment	gst_ben _none _tchstand _enLM _devspatsk _dataAnl _emply _coopLM	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:" Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage Implementation Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Technology and Geography Education Con't	GST Benefit Variable – Enhances critical thinking skills – Provides real-world relevance to subjects – Provides integration of different subjects – Enhances the understanding of relationships – Provides opportunities to partner with community – Enhances motivation and student interest – Prepares students to be a 21st century student – Offers opportunities to understand spatial data – Other	gst_ben _enCritThk _realWld _Interdis _enUndRel _comphrs _enMotint _21stStu _undData	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:" Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage Implementation Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Technology and Geography Education Con't	Currently, I use geospatial technologies (GST) to teach geography:	gstu_tm	0 = Never 1 = Once a semester 2 = Once a grading period 3 = Once a month 4 = Once a week 5 = 2 or more times a week	*Recoded Values:* 0 = 0 1 = 1 – 5 0 = Non-Positive Response 1 = Positive Response	Implementation Stage	TCK TPCK
	In the future, I want to use GST to teach geography:	gstfu_tm	0 = Never 1 = Once a semester 2 = Once a grading period 3 = Once a month 4 = Once a week 5 = 2 or more times a week	*Recoded Values:* 0 = 0 1 = 1 – 5 0 = Non-Positive Response 1 = Positive Response	Decision Stage	TCK TPCK
	When did you begin to use Geographic Information Systems (GIS)?	gisu_tm	0 = Never 1 = In the past year 2 = 1 – 2 years ago 3 = 3 – 5 years ago 4 = More than 5 years ago 0 = Other	*Recoded Values:* 0 = 0 1 = 1 – 4 0 = Non-Positive Response 1 = Positive Response	Decision Stage Implementation Stage	
	When did you begin to use ONLINE geospatial technologies (GST)?	gstuo_tm	0 = Never 1 = In the past year 2 = 1 – 2 years ago 3 = 3 – 5 years ago 4 = More than 5 years ago 0 = Other	*Recoded Values:* 0 = 0 1 = 1 – 4 0 = Non-Positive Response 1 = Positive Response	Decision Stage Intermediate Stage	TCK TPCK

Survey Section	**Survey Items**	**Variable Name**	**Variable Values: Original Data Recoded for Descriptive Statistics**	**Variable Values: Original Data Recoded with Binary Codes**	**Variable Name: Innovation-Decision Stages**	**Variable Name: Technological Pedagogical Content Knowledge**
Available Technology and Geography Education Con't	If you do use geospatial technologies, please describe the type of GST used. (Check all that apply.) *Each response below is a separate variables.* – Online GST – Desktop GIS software – GPS – Remotely Sensed Images – Other	gstu_typ _OGST _DeskGIS _GPS _RS	0 = Not selected as an answer choice 1 = Selected as an answer choice	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Implementation Stage	TCK TPCK
	How do you use GST in your classroom? (Check all that apply) *Each response below is a separate variables.* – I do not use geospatial technologies – Personal Use – Teacher Preparation – Teaching – Student activities – Student products – Other	gstcl_no gstcl_pu gstcl_tp gstcl_t gstcl_sa gstcl_sp gstcl_o	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:" Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Decision Stage – I do not use geospatial technologies – Personal Use Implementation Stage – Teacher Preparation – Teaching – Student activities – Student products	TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Technology and Geography Education Con’t	What DISCOURAGES you from using geospatial technologies (GST) in your geography classroom? (Check all that apply.) *Each response below was identified as separate variables.* – Awareness of available technology – Time in the curriculum – Instructional time – Planning time – Lack of technical support – Lack of administrative support – Available computer time	gstu_dis _awtec _tmCur _tmIns _tmPlan _noTKsup _noAdmsup _avcomp	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:” Not recoded for this study.	*Recoded Values:* 0 = 0 1 = 1 0 = Non-Positive Response 1 = Positive Response	Persuasion Stage Confirmation Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Technology and Geography Education Con't	Variable: Discourages Use Con't – Internet availability – Hardware – Software – Lack of resources – Lack of colleague support – Few others use this technology in my school – Do not know how to use GST – Lack of available professional development – Time it takes to learn the technology before teaching students – Do not know teaching strategies to incorporate GST into a geography classroom – Other	gstu_dis _avweb _hdwr _sftwr _noRes _noColsup _fewuse _klgUse _noPD _tmLmtk _klgTS	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:" Not recoded for this study.		Persuasion Stage Confirmation Stage	TCK TPCK
	What ENCOURAGES the use and/or continued use of GST in your geography classroom? (Check all that apply.) *Each response below is a separate variables.* – Knowledge of geospatial technologies – Knowledge of teaching strategies to better incorporate GST in geography education	gstu_enc _klgGST _klgTS	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:" Not recoded for this study.		Persuasion Stage Confirmation Stage	TCK TPCK

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Technology and Geography Education Con't	Variable: Encourages Use – Professional development – Administrative support – Other teachers use GST – Student interest – Enhances learning – Develop spatial skills – Student performance – Student reasoning skills development – Personal benefit – Available planning time – Appropriate equipment – Appropriate software – Access to the Internet – Other	gstu_enc _pd _admin _othTch _stuint _enlm _devsk _stuper _stureas _prsnl _avplan _equip _sftwr _web	0 = Not selected as an answer choice 1 = Selected as an answer choice Other:" Not recoded for this study.		Persuasion Stage Confirmation Stage	TCK TPCK
	Each teacher has a computer in the classroom.	comp_cls	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Computer labs are available for teacher use.	clab_av	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Technology and Geography Education (Con't)	Laptop carts are available for teacher use.	lopt_av	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	The Internet is available with each computer on campus.	web_av	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	The instructional technology specialist is aware of geospatial technologies.	itsp_awr	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	The instructional technology specialist is helpful with geospatial technologies use.	itsp_hlp	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	I have a computer projector for my classroom.	cpro_cls	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	I can check out a computer projector for my classroom.	cpro_chk	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Understanding patterns is an important part of geographic education.	geo_pat	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Available Technology and Geography Education Con't	Understanding processes is an important part of geographic education.	geo_proc	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	I am aware of the state content standards for Geography.	ststd_aw	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	I am aware of the National technology standards.	ntkst_aw	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	I am aware of the National Geography Standards.	ngstd_aw	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Data analysis plays an important role in geographic education.	geo_data	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Spatial awareness plays an important role in geographic education.	geo_spat	1 = No 2 = Somewhat 3 = Yes 4 = Don't Know	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
6. Tell Your Story: What is Your Experience with Geospatial technologies	What types of technology have influenced your teaching?	tech_inf	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What type of professional development has been most effective with regard to your knowledge of GST?	pd_eff	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	I am a member of an organization or online group (e.g., blog, listserv, etc.) where I can contact other geography teachers who use GST. *Response below is a separate variable.* If "yes," please list the organizations or groups	gst_org gst_org1	0 = No 1 = Yes "String" = List of organizations or groups (String means a text or open-ended response data was collected.)		Persuasion Stage Confirmation Stage	TCK TPCK
	What is the most important thing that would improve the use of GST in your classroom?	gstu_imp	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What aspects of training (pre- or in-service) are helpful to prepare you to integrate geospatial technologies into your geography classroom?	tgst_hlp	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What resources have been instrumental in your use of GST (online or desktop) in the classroom?	gstres_im	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Describe the ways you use geospatial technologies in your classroom.	gstu_way	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What can the district administration do to support the use of GST in geography?	sup_dist	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Tell Your Story: What is Your Experience with Geospatial technologies (Con't)	What can a State Geographic Alliance do/provide to help support your decision to use GST during the school year?	sup_all	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What can the school administration do to support the use of GST in geography?	sup_schl	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
7. Demographic Data	Describe the school at which you teach? - School Description – Type	sch_typ	1 = Public 2 = Private 3 = Vocational/Technical 4 = Parochial	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Describe the school at which you teach? - School Description – Location	sch_loc	1 = Urban 2 = Suburban 3 = Rural	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Describe the school at which you teach? - School Description – Socio-Economic Level	sch_seco	1 = Low 2 = Middle 3 = High 0 = Other	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What is your age?	tch_age	1 = 20 – 25 2 = 26 – 30 3 =- 31 – 35 4 = 36 – 40 5 = 41 – 45 6 = 46 – 50 7 = 51 or older	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Demographic Data Con't	What is your race? (Select one)	tch_race	1 = Caucasian 2 = Hispanic 3 = Asian 4 = African American 5 = Native American 6 = Other	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What is your gender?	tch_gend	1 = Male 2 = Female	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What degrees have you earned? Bachelor Degree (BA or BS) Master's Degree (MA or MS) Doctorate Degree (PhD)	 tch_ba tch_ma tch_phd	0 = Not selected 1 = Selected	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Response below was identified as separate variable. Please list the major field of study for each degree	tch_majr	"String" = Major field of study (String means a text or open-ended response data was collected.)			
	Do you have computers in your classroom?	cocls_num	0 = There are no computers available 1 = 1 computer 2 = 2 – 3 computers 3 = 4 – 5 computers 4 = 6 or more computers	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Demographic Data Con't	How often do you have access to the computer lab and/or laptop cart?	comp_acc	0 = Never 1 = Once a year 2 = Once a semester 3 = Once a grading period 4 = Once a month 5 = Once a week 6 = More than once a week 7 = Whenever I need it	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Please explain the procedure to use the computer lab and/or laptop cart.	co_proc	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	Students use geospatial technologies applications in my classroom?	gst_stap	0 = No 1 = Yes	*No recoding required.*	*No recoding required.*	*No recoding required.*
	My state geography content standards include the use of geospatial technologies.	gst_stsd	0 = No 1 = Yes	*No recoding required.*	*No recoding required.*	*No recoding required.*
	I look for professional development (training) opportunities in geography beyond what is required by my school or school district?	pd_beynd	0 = No 1 = Yes	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Demographic Data Con't	In what state do you currently teach?	state *** One of three variables establishing criteria for participants' participation in study.*	*0 = Any place other than 5 states accepted for the study.* *1 = MN* *2 = MS* *3= TX* *4 = SD* *5 = UT*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	I am a member of my state Geographic Alliance.	all_mem	0 = No 1 = Yes	*No recoding required.*	*No recoding required.*	*No recoding required.*
	In what school district do you currently teach?	sch_dist	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What is the total enrollment of your school?	sch_enr	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What is the average geography class size?	cls_size	*Open-ended Response*	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Demographic Data Con't	Including the current year, how many years have you been a teacher?	tch_yrs	1 = Pre-service Teacher 2 = 0 – 2 Years 3 = 3 – 5 Years 4 = 6 – 10 Years 5 = 11+ Years	*No recoding required.*	*No recoding required.*	*No recoding required.*
	What grade level(s) do you currently teach?	tch_grad ***One of three variables establishing criteria for participants' participation in study.*	1 = Grades 9 – 12 2 = Grades 6 – 8 3 = Grades K - 5	0 = 2 – 3 1 = 1	*No recoding required.*	*No recoding required.*
	What subject areas and grade levels are you currently certified to teach in Social Studies? (Select All the Apply) Note: If you only hold a Social Studies Composite Teacher Certification please select the first choice. *Each response below is a separate variables.* – Social Studies Composite – U.S. History – World History – Economics – Government – Geography	tch_cert _sc _ush _wh _eco _gov _geo	0 = Not selected as an answer choice 1 = Selected as an answer choice	*No recoding required.*	*No recoding required.*	*No recoding required.*

Survey Section	Survey Items	Variable Name	Variable Values: Original Data Recoded for Descriptive Statistics	Variable Values: Original Data Recoded with Binary Codes	Variable Name: Innovation-Decision Stages	Variable Name: Technological Pedagogical Content Knowledge
Demographic Data (Con't)	What subject areas do you currently teach? (Check all that apply) *Each response below was identified as separate variables.* – World Geography (On level or Pre-AP) – AP Human Geography – World History – US History – Civics/Government – Economics – Psychology – Sociology – Other	tch_sub _wg _aphg _wh _ush _gov _eco _psy _soc _othr ***One of three variables establishing criteria for participants' participation in study.*	0 = Not selected as an answer choice 1 = Selected as an answer choice	Coding for the following variables: World Geography & AP Human Geography 0 = 0 1 = 1 All other subjects: 0 = 0 & 1	*No recoding required.*	*No recoding required.*

Appendix J:

Telephone Interview Protocol

Geospatial technologies include an array of online applications and desktop software that provide visualization tools and interactive datasets that allow users to evaluate data simply (visualization) or in a more complex manner (GIS or simple GIS applications) to assess and analyze relationships among data.

1. According to the survey taken last spring, your response to the question, "I use GST to teach geography" using the Likert Scale answers of Strongly Agree to Strongly Disagree was _______. Has this answer changed any in the past year? If so, how?

Using GST in the Geography Classroom:

2. What geospatial technologies do you use? (Personally and professionally)
3. How can GST be used in the classroom?
4. What is your school's vision for using technology? How does GST fit into this vision?
5. On a scale of 1 – 10 rank your knowledge of geospatial technologies. (1 = lowest, 10 = highest)
6. If you include GST in your lessons, do you mainly teach *about* GST or *with* GST?
7. Do you feel you know teaching strategies for the use of GST in your classroom?
    a. If yes, explain.
        i. Were you taught specific teaching strategies to use when incorporating GST? (If so, what are some examples?)
            1. Describe how you came to know how to use GST in the classroom.
        ii. Without knowing specific teaching strategies, how did you learn to teach with GST in geography?
    b. If no, what more can be done to help you know how to use GST in the classroom?

Noting and Overcoming GST Barriers:

8. According to the survey, you noted the following barriers ________. Do these barriers still exist? Are there other barriers?
    a. Have these barriers been overcome? Please explain.
    b. What is the greatest challenge to using GST in your instruction?
    c. Why do you value GST enough to work past the barriers?
9. According to the survey, you responded that you are willing to use GST. Has this changed?
    a. Even though you indicated in your response to the survey that you were willing to use GST, some of your colleagues may not wish to use GST in their instruction.
        i. Do you know what reasons your colleagues have for not using GST?

ii. Is this "no" absolute? What would be a compelling reason to change their mind?

Value of Geospatial Technologies:

10. What do you think is the greatest or most important value of GST for instruction?
11. Do high school Social Studies teachers in your district value using GST? Geography teachers?
12. Was there any particular experience(s) that helped you to value GST as an instructional tool to use in your geography classroom?
    a. If so, what was it and how did it influence you?
13. Was there any particular experience(s) that were negative and made you question the use of GST in high school geography? Please explain.

Final Thoughts:

a. What are your concerns, if any, with incorporating GST into your instruction?
b. Is there anything else you would like to share?

Appendix K:

Telephone Interview Participant Data

Participant	The use of technology (i.e., MS Word, PowerPoint, PhotoStory3, etc.) when teaching is important.	I am aware of desktop Geographic Information Systems (GIS) software.	I am aware of online geospatial technologies (GST).	I am aware of teaching strategies to incorporate GST into my geography lessons	I am confident in my ability to use online geospatial technologies (GST) when teaching.	It is important to participate in training to learn about geospatial technologies.	I am willing to learn more about GST.	I seek out opportunities to learn to use GST.	I use GST to teach geography.	The use of GST in geography education is supported by my:	What is your age?	What is your gender?	What degrees have you earned?	What subject areas and grade levels are you currently certified to teach in Social Studies?	Including the current year, how many years have you been a teacher?	In what state do you currently teach?
1	A	A	N	N	N	A	A	N	N	-	51+	F	Bachelor Degree, Education	Social Studies Composite, History	11+	TX
2	SA	A	A	A	A	SA	A	A	A	Dept. Head	51+	F	BA, History M.Ed.	Social Studies Composite	11+	TX
3	SA	SA	SA	SA	A	A	A	N	SA	-	41-45	F	BA, Russian, GT/CUIN M.Ed. MS, Geoscience	Social Studies Composite	11+	TX
4	SA	A	A	A	D	SA	SA	A	D	Social Studies Super-visor	41-45	F	Bachelor Degree	Social Studies Composite	11+	TX
5	A	A	A	A	A	N	A	N	N	-	46-50	M	Bachelor Degree, Geography	Social Studies Composite	11+	TX

Participant	The use of technology (i.e., MS Word, PowerPoint, PhotoStory3, etc.) when teaching is important.	I am aware of desktop Geographic Information Systems (GIS) software.	I am aware of online geospatial technologies (GST).	I am aware of teaching strategies to incorporate GST into my geography lessons	I am confident in my ability to use online geospatial technologies (GST) when teaching.	It is important to participate in training to learn about geospatial technologies.	I am willing to learn more about GST.	I seek out opportunities to learn to use GST.	I use GST to teach geography.	The use of GST in geography education is supported by my:	What is your age?	What is your gender?	What degrees have you earned?	What subject areas and grade levels are you currently certified to teach in Social Studies?	Including the current year, how many years have you been a teacher?	In what state do you currently teach?
6	SA	SA	A	SA	A	SA	SA	A	SA	Dept. Head Principal Social Studies Super-visor	51+	F	Bachelor Degree, History and Philosophy	Social Studies Composite	6 -10	TX
7	SA	A	A	A	A	A	SA	A	A	-	26-36	F	BA, History BA, Geography Enrolled in Master's Degree program, geography	Social Studies Composite	3-5	TX
8	SA	SA	SA	SA	SA	SA	SA	A	A	-	51+	F	Bachelor Degree, Biology, history, education	US History World History	6-10	TX

Participant	The use of technology (i.e., MS Word, PowerPoint, PhotoStory3, etc.) when teaching is important.	I am aware of desktop Geographic Information Systems (GIS) software.	I am aware of online geospatial technologies (GST).	I am aware of teaching strategies to incorporate GST into my geography lessons	I am confident in my ability to use online geospatial technologies (GST) when teaching.	It is important to participate in training to learn about geospatial technologies.	I am willing to learn more about GST.	I seek out opportunities to learn to use GST.	I use GST to teach geography.	The use of GST in geography education is supported by my:	What is your age?	What is your gender?	What degrees have you earned?	What subject areas and grade levels are you currently certified to teach in Social Studies?	Including the current year, how many years have you been a teacher?	In what state do you currently teach?
9	SA	SA	SA	SA	SA	SA	SA	A	SA	Dept. Head Principal Social Studies Super-visor	31 - 35	M	Bachelor Degree	Social Studies Composite	3-5	TX
10	SA	A	A	A	A	SA	SA	SA	A	Dept. Head Principal Social Studies Super-visor	41 - 45	F	Master’s Degree	Social Studies Composite	11+	TX
11	SA	SA	A	A	A	SA	A	A	SA	-	41 - 45	F	Bachelor Degree, Liberal Arts	Social Studies Composite	11+	TX

Participant	The use of technology (i.e., MS Word, PowerPoint, PhotoStory3, etc.) when teaching is important.	I am aware of desktop Geographic Information Systems (GIS) software.	I am aware of online geospatial technologies (GST).	I am aware of teaching strategies to incorporate GST into my geography lessons	I am confident in my ability to use online geospatial technologies (GST) when teaching.	It is important to participate in training to learn about geospatial technologies.	I am willing to learn more about GST.	I seek out opportunities to learn to use GST.	I use GST to teach geography.	The use of GST in geography education is supported by my:	What is your age?	What is your gender?	What degrees have you earned?	What subject areas and grade levels are you currently certified to teach in Social Studies?	Including the current year, how many years have you been a teacher?	In what state do you currently teach?
12	SA	SA	SA	A	A	SA	SA	D	A	Dept. Head Principal	51+	M	BA, Political Science MS, Special Education Enrolled in Ph.D., Education Leadership program	Social Studies Composite	11+	TX
13	SA	A	A	A	A	A	A	N	A	Dept. Head Principal Social Studies Super-visor	51+	M	BS, History MS, Geography	Social Studies Composite	11+	UT

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