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Evaluating behavioral intention to increase classroom Geotechnology usage following geoinquiry implementation

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EVALUATING BEHAVIORAL INTENTION TO INCREASE CLASSROOM GEOTECHNOLOGY USAGE FOLLOWING GEOINQUIRY IMPLEMENTATION

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Approval of Dissertation

We, the faculty supervising the work of Erika S. Klose, affirm that the dissertation *Evaluating Behavioral Intention to Increase Classroom Geotechnology Usage Following GeoInquiry Implementation*, meets the high academic standards for original scholarship and creative work established by the Curriculum and Instruction program and the College of Education and Professional Development. This work also conforms to the requirements and formatting guidelines of Marshall University. With our signatures, we approve the manuscript for publication.

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Dedication

This dissertation is dedicated to my late father, Peter Klose, who believed in the value of education, specifically for me, above all else. He taught me that if you're going to do anything, you need to do it right. I thank God for the gift of time, financial provision, a loving community, and freedom to complete this terminal degree. I take none of these for granted.

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I don’t take for granted the gift of accessible education, or the gift of a love of learning. A terminal degree has been a life-long goal. I look forward to what God has for me next.

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Abstract

As educational practices include foundational and cutting-edge preparation, the value of problem-based instruction employing industry-standard technologies increases. Geospatial technologies (GST), are a group of professional technologies, including GIS (Geographic Information Systems), used by industries to make informed decisions with spatial data. This study investigated educator behavioral intention to use GIS/GST in classroom practice, and the moderating effect, if any, of the GeoInquiry, a curricular resource. The UTAUT framework was employed to evaluate and quantify the factors impacting behavioral intention (performance expectancy, effort expectancy, social influence, and facilitating conditions). These data were examined to identify moderation by GeoInquiry usage. One hundred and two surveys were completed by educators in 27 states. The survey results indicate a moderate statistically significant relationship between each of the factors and behavioral intention. An increase in any factor will increase behavioral intention. The mean response increased for the group that used GeoInquiries in classroom instruction, indicating correlation between each factor and GeoInquiry usage. Statistically significant differences related to using GeoInquiries in classroom instruction were identified for effort expectancy, facilitating conditions, and behavioral intention. Similar results related to the degree of GeoInquiry usage were not found. Implications include professional development for both educators and administrators, the continued development of curricular resources, and an alignment of both professional development and curricular resources to high yield instructional strategies, standards, and student engagement. Recommendations for future research include expanding the number of survey respondents, modifying items, conducting structured interviews, social network analysis, and developing curricular resources, which could impact student learning with digital mapping technology.

Chapter One: Introduction

Advances in technological innovations over the past decade reflect the magnitude of change occurring in our society today. All industries constantly change as technology allows for the periodic modification of practice to meet customers' needs and solve the problems of today's ever-changing world. The value of transdisciplinary, problem-based classroom instruction, which employs industry-standard technologies, is well documented in the research (Baker & Palmer, 2014; Bednarz & Lee, 2019; Charles & Kolvoord, 2016; USDOE, 2010; USDOE, 2017). This instructional practice provides students with valuable experience, allowing them to explore various applications of technological innovations within a developmentally appropriate context.

Geospatial technologies (GST) are a group of professional technologies used across a broad range of industries to bring a spatial (location) component to data and allow industries to evaluate data to make informed decisions. Geographic Information Systems (GIS), or digital mapping technologies, are the backbone of the GST industry. Other technologies that fall into the category of GST include remote sensing, global positioning systems (GPS), and digital globes (Baker et al., 2015).

The US Department of Education has called for the inclusion of professional technologies in classroom instruction to give students both exposure to and experience with the technologies they may encounter in the future. The field of GIS developed in the last 60 years into a robust industry, impacting the globe, and integrating into all modern industries. The GIS education community, and its body of research, has developed along with the technology. The research within this community notes the strength of GIS and GST, which provide data-focused real-world connections to classroom content and allow classrooms to participate in authentic project-based learning experiences (Baker, 2005; Kerski, 2003; Tinker, 1992). For clarity, the acronym

GIS/GST will be used throughout the following chapters to refer to digital mapping and accompanying technologies in classroom instruction.

Background

A GIS is a computer-based system that provides a way for users to combine data from various phenomena at multiple scales (local to global) into thematic layers (i.e., population, vegetation, residential homes, and earthquake epicenters) and provides analysis tools for users to investigate connections within and among these datasets (Baker et al., 2012; USGS, n.d.). These analyses allow users, and in the context presented in this research, students, to discover relationships among datasets, allowing for informed conclusions and decisions (Bodzin et al., 2015; Langran & Baker, 2016). In addition, GIS data can be stored, edited, processed, and prepared for presentation in several different formats (Dastrup, 2022), providing a means for students to master the communication of ideas, analyses, and recommendations.

GIS/GST Research

A robust body of literature related to the uses of GIS and GST demonstrates that over the last 60 years, the GIS/GST discipline has developed a transdisciplinary nature allowing for classroom integrations that straddle the boundaries of nearly all content areas (Baker et al., 2012). Though the value of GIS/GST to education is known and accepted among the GIS/GST education community, the adoption of GIS/GST in traditional classrooms lags (DeMers, 2016; National Research Council, 2006). Despite the lag, GIS research demonstrates the practical application of GIS/GST to a variety of instructional content, from agriculture and economics to earth science and elections (Baker & White, 2003; Bodzin, 2011; Bodzin et al., 2014, 2015, 2016; Bodzin & Anastasio, 2006; Bodzin & Fu, 2014; Favier & van der Schee, 2014; Gutierrez et al., 2002; Jadallah et al., 2017; Kerski et al., 2013; Kerski, 2015, 2016, 2017a, 2017b, 2019, 2020, 2021; Nunes et al., 2020; Walford, 2017). GIS/GST creates an opportunity for students to use and develop thinking skills that are challenging to establish in other instructional settings (Langran & Baker, 2016). Within 20 years, classroom access to GIS/GST software has expanded widely. While authors have developed only a small number of curricular resources for K-12 classrooms, the availability of GIS/GST curricular resources is increasing.

GIS/GST education research currently centers around several applications. Following the research call of Learning to Think Spatially (NRC, 2006), research increased in the area of the development of spatial thinking through the use of GIS/GST in classroom instruction (Baker et al., 2015; Bednarz & Lee, 2011, 2019; Collins, 2018; Hsu et al., 2018; Jo et al., 2016; Lee & Bednarz, 2009, 2012; Perugini & Bodzin, 2020). Research into student acquisition of specific GIS and GST skills demonstrates that GIS is a viable option for career and technical education during the high school years and that K-12 students can effectively use GIS/GST with developmentally appropriate supports (Charles & Kolvoord, 2016; Höhnle et al., 2013, 2016; Jant et al., 2020; Kolvoord et al., 2016; Kolvoord et al., 2019; Peterson et al., 2020; Schubert & Uphues, 2009). One of the most significant areas of current research related to GIS/GST is that of professional development and instructional support for classroom educators and the best practices to increase the implementation of GIS/GST in educator instructional practice (Collins & Mitchell, 2019; DeMers et al., 2021; Hammond et al., 2014; Harte, 2017; Hong & Melville, 2018; Jo, 2016; Kerr, 2016; Kerski, 2003; Lee, 2020; Lee, 2021; Millsaps & Herrington, 2017; Mitchell et al., 2018). Research into the application of GIS to specific content areas demonstrates that GIS/GST is effective across many disciplines, such as STEM, earth science, astronomy, and geography education, around which the largest bodies of research exist (Baker & White, 2003; Bednarz & Lee, 2019; Bednarz, 2004; Bodzin, 2011; Bodzin & Anastasio, 2006; Bodzin &

Cirucci, 2009; Bodzin & Fu, 2014; Cole et al., 2018; Doering & Veletsianos, 2008; Favier & Van der Schee, 2012; Gutierrez et al., 2002; Hall-Wallace and McAuliffe, 2002; Ivan & Glonti, 2019; Jant et al., 2020; Kulo & Bodzin, 2013; Maddox et al., 2018; Newcome, 2017, Steiff & Uttal, 2015; Wai et al., 2010). While there may be a lag in the widespread implementation of GIS/GST in classrooms, the GIS/GST education community is strongly committed to developing the most effective methods to increase implementation with fidelity.

Educator Belief and Educator Change

Beliefs are the filter by which educators screen information (Bonner et al., 2020). Belief is pedagogical if it relates to how educators think about their teaching. Beliefs are values-based if they hinge on whether technology can accomplish the educator's goal for the classroom (Ertmer & Ottenbreit-Leftwich, 2013). Beliefs are demonstrated by how educators operate in their classrooms. Educators with more educator-centered practices perceive technology as less valuable to the classroom, while those whose beliefs are student-centered and constructivist-aligned tend to value technology as key to accomplishing classroom goals (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Ertmer et al., 2012, Tondeur et al., 2017).

Educator beliefs are the lens by which educators make many critical instructional decisions (Perrotta, 2017; Tondeur et al., 2017). Educator belief has been classified as a second-order issue, meaning it is challenging and resistant to change. First-order issues could be equipment, training, and support (Ertmer, 1999), which are structural and reversible. When educators change their beliefs and second-order issues, change is irreversible; the stakes are higher; and perceived risk is more significant (Ertmer, 2005). Teachers are essential in bringing and scaling educational change (Bonner et al., 2020). When teachers change and re-orient their beliefs, it is due to the evidence of student outcomes, and teachers see how a change in their practice affects what students can do (Bonner et al., 2020).

Adopting new technologies, even as technologies become prevalent in all aspects of life, still causes anxiety and uncertainty (Ertmer & Ottenbreit-Leftwich, 2010). Teacher motivation for change matches the utility of the innovative technology (Backfisch et al., 2021), which must increase student engagement or cognition to the degree that a teacher is motivated to change for student learning (Tondeur et al., 2017). These emotional and visceral reactions impacting educator belief and change are the context and framework in which those researching GIS/GST classroom integration operate.

Unified Theory of Acceptance and Use of Technology (UTAUT)

A number of models of technology integration discussed in detail in Chapter Two. These include well-known models such as SAMR (Substitution, Augmentation, Modification, and Redefinition) (Puentedura, 2003), TIM (Technology Integration Matrix) (Harmes et al., 2016), TPACK (Technological Pedagogical and Content Knowledge) (Koehler & Mishra, 2005), and lesser-known models such as TIP (Technology Integration Planning) (Roblyer & Doering, 2013), RAT (Replacement, Amplification, Transformation) (Hughes et al., 2006), and PICRAT (Passive, Interactive, Creative, Replacement, Amplification, Transformation) (Kimmons et al., 2020). Technology integration models tend to focus on the role of the students. While they capture the decisions made by educators, they do not necessarily capture the motivation of the educators in making those decisions. The motivation for educators to change and to decide to integrate technology are significantly more challenging to describe, as evidenced by the literature on educator beliefs and educator change (Backfisch et al., 2021; Daly et al., 2009; Ertmer, 2005; Ertmer et al., 2012; Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017). As summarized in Chapter Two, a limited number of models exist that attempt to capture educator motivation, such as the Diffusion of Innovation (Rogers, 2003), TAM (Technology Acceptance Model) (Burton-Jones & Hubona, 2005; Davis, 1989), and the Stages of Concern (Chen & Jang, 2014; Hall, 2013).

One model with fewer documented applications to education is UTAUT (Venkatesh et al., 2003). UTAUT, the Unified Theory of Acceptance and Use of Technology, models several factors and moderators that influence how individuals, in this case, educators, make decisions regarding changes to their technology practice (Venkatesh et al., 2003). UTAUT was designed to model the adoption of consumer technologies. Still, in the years since its development, the application of this model has expanded to the fields of medicine, fitness, finance, and banking (Bommer et al., 2022; Cimperman et al., 2016; Rahi et al., 2019; Shiferaw et al., 2021). In addition, the application of UTAUT in educational settings is increasing and now includes the adoption of tablets, MOOCs, 3D printing, and online learning (Abbad, 2021; Holzman et al., 2020; Li & Zhao, 2021; Magsamen-Conrad et al., 2015).

The UTAUT model and instrument (Venkatesh et al., 2003) evaluates several constructs to determine their influence on the behavioral intention of the individual to use a specific technology. These constructs are performance expectancy, effort expectancy, social influence, facilitating conditions, self-efficacy, and anxiety (Venkatesh et al., 2003). A meta-analysis of the application of UTAUT over the last 18 years (Blut et al., 2022) indicates that thousands of studies have employed UTAUT to evaluate specific technological innovations, with modifications to the instrument and methodology that range from minor to extreme. For example, in some cases, researchers adapted the UTAUT instrument specific to the innovation in question; in other cases, researchers modified the instrument by adding or excluding constructs to best match the researcher's needs.

The strength of the UTAUT model is that the model informs the researcher regarding the intention of the individual to employ a specific technology. While many models seek to capture educator motivation, this researcher believes that the UTAUT model best captures why educators change their practice regarding a specific educational innovation.

Problem Statement

Despite the work of the GIS/GST education community to provide extensive professional development for educators using many modalities and formats, GIS/GST is limited to a smaller number of classrooms worldwide. While this number grew significantly in recent years as technologies allowed for digital mapping to occur in a web browser, increasing access to the technology by decreasing the need for desktop software, implementing this powerful tool is less broadly employed than other classroom technologies. An influential and formative call for developing approaches to increase spatial thinking and GIS/GST integration in classrooms came in 2006 with the publication of *Learning to Think Spatially* (National Research Council, 2006). This report clarified the value of spatial thinking to multiple learning modalities and suggested developing instructional resources and technologies to support this learning.

As with all innovations and innovative technologies, a pattern of technology diffusion throughout a community commonly develops (Rogers, 2003). In the GIS/GST education community, this pattern has been widely demonstrated as educators using GIS/GST technology can be identified using Rogers (2003) phases of innovation - knowledge, persuasion, decision, implementation, and confirmation (Baker & Kerski, 2014). Much research demonstrates how educators move from one phase of GIS/GST classroom usage to another (Baker, 2018; Curtis, 2020). Given the limited number of educators using the software in classroom instruction, the technology is generally implemented as an optional supplement to the curriculum required by districts. The implementation is most often through personal educator choice. Given the call for increasing technology usage, the limited implementation of a tool with the power to add deep richness to classroom instruction is unfortunate. Still, while the GIS/GST education community widely accepts the intrinsic value of GIS/GST to classroom instruction and beyond, there is a lag in the implementation of GIS/GST as a teaching tool by a substantial number of classroom educators (DeMers, 2016; National Research Council, 2006).

Much research exists related to the barriers to GIS/GST implementation within the GIS/GST education community. As with many novel technologies, there can be a significant hesitancy on the side of the educator to incorporate new curricular aspects into already limited instructional time (Howard & Gigliotti, 2016). The research around the ideas of risk and overcoming risk, as well as that related to educators' belief in their ability to implement new technologies effectively, is significant (Biesta et al., 2015; Bonner et al., 2020; Ertmer, 2005; Ertmer et al., 2012; Ertmer & Ottenbreit-Leftwich, 2010; Howard & Gigliotti, 2016; Jo, 2016; Levin & Wadmany, 2007; Pajas, 1992). Ultimately, the research surrounds the concepts of educator change and the decision-making processes around how educators incorporate innovative technologies (Ertmer & Ottenbreit-Leftwich, 2010; Perrotta, 2017; Tondeur et al., 2017).

One of the factors noted throughout the literature is that the time spent by educators using GIS/GST in classroom instruction is pivotal to their continued and expanded usage of the technologies. Research indicates that repeated support and community structures are integral to GIS/GST integration (Baker et al., 2009; Collins & Mitchell, 2019; Daly et al., 2009; Millsaps &

Harrington, 2017; Perrotta, 2017). Additionally, the frequency of both GIS/GST professional development and educator GIS/GST usage indicates continued and expanded use. Kerr (2016) notes,

> I am aware … of the ways that frequent geospatial technology use in context-rich ways allowed them to develop more robust understandings of the potential of geospatial technology in education as well as everyday life. (p. 341)

Increasing access to GIS/GST can potentially increase student achievement across multiple disciplines in K-12 education. Continued research into the many ways to support educators in GIS/GST integration is necessary and is required if the technology will increase in usage.

Purpose of the Study

This study aims to determine the power of the frequent and repeated implementation of a specific GIS/GST curricular support, the GeoInquiry™ (Esri, n.d.), in building educator confidence in GIS/GST technology and educator intention to use GIS/GST technology to a greater degree. Specifically, this study explored whether the frequent and repeated usage of the GeoInquiry will build enough confidence in the value of GIS/GST technology to move the educator from one phase of implementation to a deeper stage of implementation characterized by student-centered use of GIS/GST, data collection, student map creation, StoryMap® creation, etc., as measured by the theoretical framework.

Theoretical Framework

This study explored the behavioral intent of educators to integrate GIS/GST technologies into classroom instruction. Specifically, the study looked at the effects a specific curricular resource, the GeoInquiry, on an educator's behavioral intent to integrate other GIS/GST technologies into classroom instruction. This study modified the UTAUT model (Venkatesh et al., 2003) to measure GIS/GST integration as moderated by educator usage of GeoInquiries. The constructs included in the original UTAUT model are summarized in Table 1.

Table 1

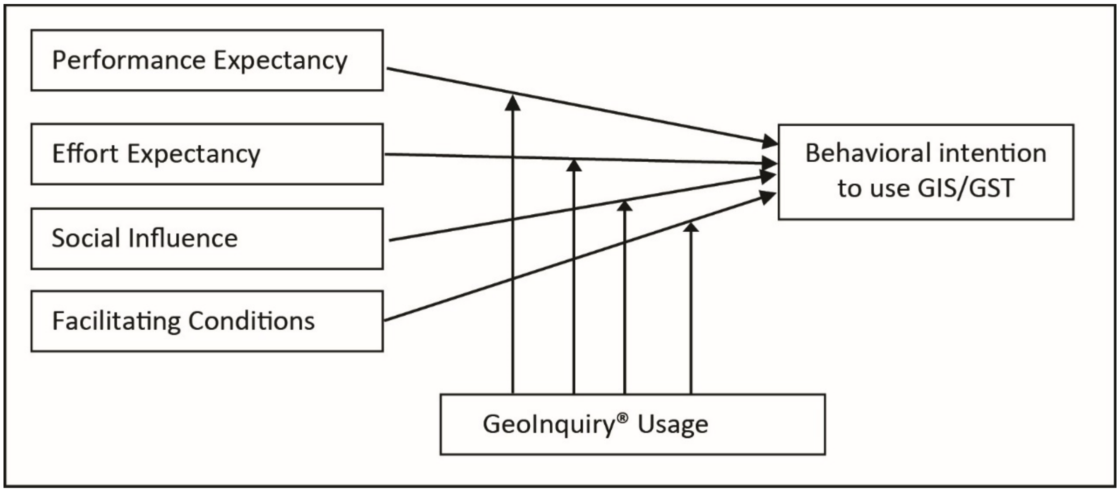
Original UTAUT Constructs

Construct	Definition
Performance Expectancy	The extent to which a user thinks the technology will benefit their performance.
Effort Expectancy	The amount of effort the user thinks will be required to use the technology.
Social Influence	The extent to which users think that others in their social circle believe they should use the new technology.
Facilitating Conditions	Factors in the user's environment that make the technology simple to employ.
Self-Efficacy	The user's belief in their ability to use the technology to attain specific results.
Anxiety	An unease towards using a particular technology.
Behavioral Intention	The user's intention to use the technology in the next <n> months, years, days, etc.

Modifications to the original UTAUT model include using only the performance expectancy, effort expectancy, social influence, and facilitating conditions constructs from the original UTAUT instrument, along with changes to the language of the items to specify GIS/GST integration and the inclusion of items related to GeoInquiry usage. The UTAUT model provided the framework to evaluate the impact of the UTAUT constructs on educator behavioral intention. Additionally, the UTAUT model allowed the researcher a framework to assess the moderating effect of GeoInquiry usage on each of the UTAUT constructs. Figure 1 describes the modified UTAUT framework as employed in this research.

Figure 1

Model of Modified UTAUT Framework Adapted from Venkatesh et al. (2003)



Quantitative data in the form of a survey developed from the modified UTAUT instrument was gathered to answer questions related to each UTAUT construct and how each UTAUT construct is moderated by GeoInquiry usage. The format of the UTAUT model and instrument allows for directly calculating the statistical relationship between each construct and the moderating effect of GeoInquiry use. Through this approach, recommendations were developed for the GIS/GST community for future efforts related to professional development and instructional resource development.

Research Questions

Research questions for this study include:

1. To what extent do performance expectancy, effort expectancy, social influence, and facilitating conditions predict educators' behavioral intention to use GIS/GST technologies in their classrooms?

2. Does GeoInquiry usage moderate the relationships among performance expectancy, effort expectancy, social influence, facilitating conditions, and educators' behavioral intention to use GIS/GST technologies in their classrooms?

Operational Definitions

The following terms are significant to this study and must be associated with the following definitions:

GIS, a Geographic Information System, is a computer-based or web-based **system** that allows for the display and analysis of **informational** datasets and for data to be connected to a specific **geographic** location on the Earth's surface (USGS, n.d.). GIS refers explicitly to the tools for displaying, analyzing, and storing spatial data.

GST, geospatial technology, includes all the technologies employed by the geospatial industry. GST includes GIS as part of a more extensive suite of geospatial technologies, which include remote sensing (RS), global positioning systems (GPS), and digital globes (Baker et al., 2015).

Digital mapping technology, is a generalized term for GIS, or Geographic Information Systems, and is used in this research when the educator audience may not be familiar with the terms GIS and/or GST.

GeoInquiries are lessons in a series of collections developed by Esri (Environmental Systems Research Institute) as part of their K-12 offerings to schools through President Obama's ConnectED Initiative (Baker, 2015; Baker, 2018; National Archives and Records Administration, n.d.). GeoInquiries are designed to replace a lecture with a 15-minute lesson in which a teacher displays a map to their students and follows specific steps, along with guided questions, to have students apply the geographic inquiry process to content instruction.

GeoInquiries are licensed under Creative Commons and are freely available to any K-12 teacher worldwide. GeoInquiry collections exist for the following content areas: American Literature, Earth Science, Environmental Science, Government, Human Geography, Mathematics, Upper Elementary, US History, World Geography, and World History (Esri, n.d.). Example GeoInquiries are included in Appendix G.

Esri, Environmental Systems Research Institute, is a global company that began in 1969 and produces industry-standard GIS mapping software (Esri, n.d.).

GIS/GST technology integration includes student data collection, student access to other publicly available data, student map creation, mapping data analysis, and student StoryMap creation. StoryMaps are an additional web-based mapping project created by Esri, allowing students to use a templated design to create a web-based, map-based, online presentation.

UTAUT, the Unified Theory of Acceptance and Use of Technology model, includes the following constructs: performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), self-efficacy (SE), anxiety (ANX), and behavioral intention (BI) measured using a seven-point Likert scale that included levels ranging from (1) strongly disagree to (7) strongly agree. UTAUT was developed by Venkatesh et al. (2003) and has been applied in many settings related to technology acceptance. Permission is granted to the researcher to use a modified UTAUT instrument in this research (Appendix B).

Usage of GeoInquiries, as indicated by frequency and repetition, refers to how often an educator has used GeoInquiries in classroom instruction. As GeoInquiries are designed to be used as a portion of a class and given that many educators may teach the same lesson multiple times throughout a day, it is possible that an educator could use one GeoInquiry up to six times a day. If an educator uses multiple GeoInquiries throughout the academic year and repeats that cycle for different years, there is a possibility of numerous GeoInquiry classroom implementations.

Significance of the Study

Numerous models of educator professional development demonstrate that more effective implementation of GIS/GST technologies is possible where a community of practice develops as educators complete professional development and where GIS/GST supports are broadly available, for example, in areas surrounding higher education institutions. GeoInquiries are designed to be implemented with no support and allow educators to use GIS/GST technology by following a scripted lesson that includes specific instructions that enable the educator to use the web-based GIS/GST software. The results of this study will inform the GIS/GST education community in the development of future curricular resources for those without access to targeted professional development, a community of practice, or a localized higher education institution.

This study is significant because it provides the GIS/GST education community with measured data for implementing and adopting a well-respected curricular resource. This study quantifies the extent to which frequent and repeated usage of the GeoInquiry gives educators the confidence and experience to move the needle of classroom implementation forward. These results provide data to inform the GIS/GST education community in future efforts to create educative curricular materials that support educators and students in their implementation.

Limitations and Delimitations of the Study

The study’s limitations are the factors that are not within the researcher’s control. In this study, the primary limitation is the survey instrument itself. The survey asked for educator responses to several questions related to educator implementation of GeoInquiries. The survey asked educators to respond using a seven-point Likert scale, and responses were limited to those answers only. Another limitation relates to the dissemination of the study. Members of the GIS education community shared the survey with their listservs. These individuals asked those receiving the survey to share it with those they know have incorporated digital mapping technology and GeoInquiries into their classroom instruction. The number of respondents was controlled by the number of individuals who chose to complete the survey themselves and who shared the study with educators for whom they knew it was applicable.

This study's primary assumption was that educators who received the survey would complete the survey honestly and with fidelity to the survey instrument. A second assumption was that the GIS/GST education community members shared the study with all educators they knew who employ digital mapping technology and/or GeoInquiries in their classrooms.

Delimitations are factors and research boundaries within the researcher’s control and for which the researcher makes intentional decisions to include or not include. In this study, the targeted population is limited to those who self-report using digital mapping technology and GeoInquiries in classroom instruction. The population was accessed through the support of the GIS education community. Additionally, the researcher controlled the survey instrument and its development on the Qualtrics platform.

Chapter Summary

Many factors impact effective classroom instruction. Educators are accountable to state and local constraints, and the community of learners in their classrooms. Balancing the community of learners, their individual needs, instructional practice, and the state and local constraints is not a simple task. Locating the areas for educator choice, change, and creativity within this balancing act is also not straightforward. However, educational success occurs when educators identify and learn to employ innovations that allow them to effectively meet their students' needs as they prepare them for future education and careers. This research evaluated one pathway educators take to employ a technological innovation that can bring about success for students in various educational settings. This research will employ the UTAUT model as a framework for instrumentation to use quantitative survey results to educate the GIS/GST education community as additional instructional supports for educators are developed.

Chapter Two: Literature Review

Incorporating industry-standard technologies into classrooms allows students to experience rich technology integration that mirrors what professionals use, thus permeating the classroom with student engagement and demonstrating future career opportunities. In 2010, the U.S. Department of Education put forth the concept that professional technologies should be used in American classrooms to demonstrate their uses in careers and to engage students in learning (USDOE, 2010). Professional technologies allow students to work to solve real-world challenges while at the same time enabling students to authentically experience professions in the developmentally appropriate educational setting of their own classrooms.

Again, in 2017, the U.S. Department of Education described how through the implementation of technologies in classrooms, learning can be organized and personalized around real-world problems and project-based learning, allowing students to demonstrate competency in multiple modalities (USDOE, 2017). Given the fast-paced nature of the growth of the worldwide economy, it is ever-more important to provide students with exposure to tools that will prepare them to be both college- and career-ready, as well as having developed the thinking skills to allow them to apply their K-12 education to the career competencies required by their chosen life path.

Regarding professional technologies, Geographic Information Systems (GIS) is a technology recognized as the backbone of the geospatial technology, or digital mapping, industry. GIS is accompanied by the more extensive suite of geospatial technologies by remote sensing (RS), global positioning systems (GPS), and digital globes (Baker et al., 2015). The term geospatial technology (GST) includes all the technologies employed by the geospatial industry. The geospatial industry is currently one of the fastest-growing industries in the United States

(Baker & Palmer, 2014; Iyer, 2020). Advancements in geospatial technology indicate that the industry will show significant growth in the coming years. This technology is ingrained in many disciplines such as “archeology, disaster response, urban planning, infrastructure, logistics, retail, transportation and government services” (Iyer, 2020, p. 1) and is growing to ever-increasing importance throughout different industries (Iyer, 2020).

In addition to being professional technology, GIS and GST include components that can contribute to and elevate classroom instruction. While it is possible to teach both GIS and GST as technologies to master, it is also possible to teach with GIS and GST to bring context to content required to be mastered in classrooms. Geospatial “tools and the understanding they can afford users is central to creating globally competent citizens” (Langran & Baker, 2016, p. 373). GIS and GST naturally provide opportunities for activities that involve higher-order thinking skills (Palladino & Goodchild, 1993). By placing content in a context, the learning that occurs epitomizes Hattie and Donoghue’s (2016) definition of deep learning as “seeking meaning, relating and extending ideas, looking for patterns and underlying principles, checking evidence and relating it to conclusions, examining arguments cautiously and critically, and becoming actively interested in course content” (p. 3). Integrating geospatial technologies allows “a balance of surface and deep learning (that) helps students to construct defensible theories of knowing and reality more successfully” (Favier & van der Schee, 2014, p. 234).

One of the earliest proponents of using data and digital maps in K-12 educational settings was Robert Tinker (Baker, 2010). Tinker (1992), referencing this new methodology, made the following statement,

> At TERC, we have adopted a strategy that promises to cause the kind of fundamental change that is needed. Our approach is to focus on the doing of mathematics and science,

> on pushing students and teachers to explore new areas, to formulate new questions, and to search for answers in ways that mirror as closely as possible the experience of practicing mathematicians and scientists. We do not advocate offering this approach exclusively, but argue that a central goal of education should be to prepare students for meaningful exploration. This goal changes many of the aspects of education in ways that are greatly needed and widely advocated by the proponents of educational restructuring - it supports deep, interdisciplinary, collaborative study, it puts the student in charge of his or her own learning, and it makes learning relevant and interesting. (p. 35)

This novel approach demonstrated that, even in 1992, software capabilities were available to accomplish this lofty goal.

What Is GIS Software, Really?

Digital mapping technology is a generalized term for GIS, or Geographic Information Systems. A GIS is a computer-based system that allows for the display and analysis of datasets and for data to connect to a specific location on the Earth's surface (USGS, n.d.). A GIS system provides a means for a user to bring together digital mapping data of various phenomena, at various scales (local to global) (Baker et al., 2012). GIS software permits the user to organize datasets into thematic layers (i.e., population, vegetation, residential homes, and earthquake epicenters). It then provides analysis tools for users to investigate connections within and among these datasets. These analyses can lead the user or student to discover relationships among datasets, allowing for informed conclusions and decisions (Bodzin et al., 2015; Langran & Baker, 2016). Additionally, data in a GIS can be stored, edited, processed, and prepared for presentation in several formats (Dastrup, 2022), permitting students to master the communication of ideas, analyses, and recommendations.

Numerous companies and organizations have developed GIS software that is capable of handling spatial data (a data point's location), as well as its attribute data (data about the location). These companies and organizations each have specialties rendering them more or less accessible to educators for use in their classrooms (Dastrup, 2022). The Environmental Systems Research Institute (Esri) is a GIS software developer. Esri produces several GIS software options contained in a suite of software called ArcGIS (Esri, n.d.). ArcGIS is considered the industry-standard GIS software package. In recent years, Esri has moved considerable GIS capabilities to the ArcGIS browser-based online platform, allowing access to software capabilities without installing desktop software. Many educators are familiar with Google Earth and Google Maps. While these two products do contain mapping capabilities, they are not considered full-GIS software packages due to limitations in storage, data editing and data analysis (Dastrup, 2022). QGIS is an example of an open-source GIS software supported by the open-source geospatial community. Full GIS software, in addition to allowing for the creation of maps, holds the ability to manage a database of both spatial and attribute data that can then be utilized to create additional information and to allow high-level analysis (Dastrup, 2022).

In recent years, the use of digital mapping technologies by educators and availability of digital mapping technologies for educators has grown due to large investments of support and software by Esri. In 2014, then President Obama announced the ConnectED initiative with a goal of increasing access to technology and training for educators. This federal / private partnership included assurances from companies like Adobe, Apple, Esri, Prezi, and Verizon to provide their materials and services to schools (DeMers, 2014; National Archives and Records Administration, n.d.). As part of the ConnectED campaign, Esri made available, for no cost, an ArcGIS Online account to every school in the United States. This was estimated to potentially impact 115,000 schools with an estimated total financial investment of $1 billion (Esri, 2019). Esri now provides this no cost software bundle to schools worldwide. Every public, private, home school, and club that serves youth can receive access to this bundle at no cost (Esri, n.d.). With the access barrier to GIS capabilities removed by Esri, for all educators, the GIS education community, made up of educators in K-12, higher education, and Esri staff, responded with the development of classroom resources, learning activities, and educational research into best practices for using GIS in instruction.

Who Uses GIS?

A short answer to the question of "Who uses GIS?" is a simple, "everyone." Given the availability of GPS-enabled devices that most with access to cell service now carry with them, most global citizens are now GIS users, whether they know it or not. This means that the need to develop applications and provide data for each of these GPS-enabled users has grown exponentially. A review of a current list of available jobs related to GIS and GST demonstrates the breadth of current career opportunities in which some aspect of geospatial technologies is used. A recent search on LinkedIn for the keyword "GIS" yields results in local, city, state, and national governmental agencies. Additionally, positions were available in agricultural organizations, data management organizations, technology companies, companies that support elections, organizations related to natural resources and energy, retail organizations that move goods, organizations that work with the oceans and marine resources, and even a GIS job with a Native American tribe in Idaho (LinkedIn, n.d.). Additionally, a review of the industries that use GIS software, such as is reported on Esri's (2022) website, under Solutions, demonstrates that GIS is a technology that is widely used in business management, government management, and industry. Given that GIS is so widely used and is becoming a software standard in most industries, it is logical that students are, at the minimum, exposed to GIS through classroom instruction.

How Is GIS Used in Schools?

The driving force for GIS in k-12 education is individual teachers.

-Joseph Kerski, quoted by Michael DeMers

GIS, as a software, has existed for about 50 years. When GIS software developed to a point where it could be utilized on a standard school-available computer, the accessibility of the software for educators grew. According to DeMers (2016),

> … a major shift occurred roughly in the 1990s when professional versions of both remote sensing and GIS software began to appear in college and university classrooms for use in laboratory exercise creation. The access to the higher-end professional software spelled a change in focus of the pedagogy from theory—the underlying computer science and tools—to application—the solution of geographic problems with geographic data. Disciplines outside geography also began to model how to use the software. The focus in most geography departments shifted from theory about GIS to application of GIS. The geographic principles essential to understanding the results of GIS analysis cannot be ignored, with most geospatial technology instruction remaining within geography departments, rather than moving to computer science. (p. 23)

An ever-growing body of literature exists surrounding the uses of Geographic Information Systems (GIS) and other digital mapping technologies in the classroom. Over the last 50 years, the GIS discipline developed its transdisciplinary nature, which provides the perfect hub for classroom activities that straddle the boundaries of "geography, mathematics, literacy, Earth science, cartography, remote sensing, cognitive psychology, biology, computer science, education, and other fields" (Baker et al., 2012, p. 258).

While the value of GIS to education is widely known and accepted among the GIS education discipline and community, there is a lag in the adoption of GIS as a teaching tool by a substantial number of elementary and secondary educators (DeMers, 2016; National Research Council, 2006). Despite the lag, the GIS community has demonstrated the application of GIS to most areas of content instruction, from agriculture and economics to earth science and elections (Baker & White, 2003; Bodzin, 2011; Bodzin et al., 2014, 2015, 2016; Bodzin & Anastasio, 2006; Bodzin & Fu, 2014; Favier & van der Schee, 2014; Gutierrez et al., 2002; Jadallah et al., 2017; Kerski et al., 2013; Kerski, 2015, 2016, 2017a, 2017b, 2019, 2020, 2021; Nunes et al., 2020; Walford, 2017). Within the GIS community, it is widely accepted that GIS creates the perfect foundation for "issue-based, standards-based, and student-centered education" (Kerski et al., 2013, p. 232). When educators use GIS in their classrooms, the most effective implementations are those where the GIS is used to assist in learning content and allowing for authentic learning experiences to occur (Baker, 2005). GIS and digital mapping software technologies used in the classroom require students to "utilize critical thinking skills, to locate, display, and analyze geographic information and make sense of the increasing amount of emerging place-based data" (Langran & Baker, 2016, p. 373). GIS is a tool to enable the critical thinking students require in the 21st century.

While much literature exists to describe the implementation of GIS in both American and global classrooms throughout the early 21st century (Baker, 2005; Baker, 2010; Kerski, 2003; Kerski et al., 2013), Kholoshyn et al. (2021) recently reviewed how GIS has been applied globally in schools. The authors divided the movement to bring GIS to classrooms into a series of stages. The first stage, occurring from the 1970's to 1990's centers around the development of initial GIS training programs. As curriculum began to be developed specifically for classrooms (mid 1990's to early 2000's), the second stage was indicated by GIS integration in developed countries globally. The third stage (2005 – 2012) occurred as GIS in schools moved into Eastern Europe, Asia, Africa, and Latin America. The fourth, and current, stage (2012 – present) is indicated by GIS curriculum, to some extent, in most countries. The authors also note that this growth is indicative of a growth of a system of professional development, conferences, and meetings within many countries for educators to develop skills with GIS software (Kholoshyn et al., 2021).

This influx of software availability, noted above in the third and fourth stage by Kholoshyn et al. (2021) led to the integration of this technology into many classrooms, worldwide, by a group of educators classified by the technology community as "early adopters," those teachers who have little fear when adopting a new technology, and who demonstrate a willingness to try new things without fear (Aldunate & Nussbaum, 2013). Like many new technologies, "early adopters" took to the classroom implementation of GIS with fervor. However, despite the recommendations of early adopters and the demonstration of the efficacy of the use of digital mapping technology in the classroom, there is still not a widespread use of digital mapping technologies worldwide in K-12 classrooms (Aldunate & Nussbaum, 2013).

While a review of the literature reveals a strong recommendation for the implementation of GST in classroom instruction, the lack of widespread use is tied to a specific barrier to implementation – a lack of training for educators (DeMers, 2016). This specific barrier is repeated throughout the literature, and bodies of literature exist related to GIS professional development for educators, which has occurred primarily for in-service educators (Collins &

Mitchell, 2019). Collins and Mitchell (2019) recommend significant pre-service training in teaching with GIS, the development of follow up coaching models for each professional development, and the inclusion of GIS in academic standards. The authors believe that in order to increase the usage of GIS in classroom instruction to a significant degree, each of these recommendations must be taken. A review of the literature related to GIS professional development can be found later in this chapter.

Currently Available Curricular Resources

Resources that allow educators to incorporate GIS/GST into their classrooms fall into two categories, instructional resources that are directed at supporting students as they learn to use GIS/GST and instructional resources that are directed at guiding students through learning content with GIS/GST as an instructional tool. A web search for GIS instructional resources will yield results from higher education consortiums (University Consortium for Geographic Information Science, n.d.), resources from industry (Esri, n.d.), resources from GIS/GST educational community members (Duke, n.d.; Kerski, n.d.), resources specifically for K-12 educators (Science Education Resource Center, 2021), a publishing company specifically related to GIS education (GISetc, 2021), and resources from states with strong GIS educational support (Minnesota Department of Education, n.d.; West Virginia Department of Education, n.d.). A review of these resources includes published books, open educational resources, resources in creative commons, and freely available web-based activities. One specific curricular resource produced by Esri is described in the section to follow.

GeoInquiries

GeoInquiries are curricular lessons in a collection developed by Esri (Environmental Systems Research Institute) as part of their K-12 offerings to schools through President Obama's

ConnectED Initiative (Baker, 2015, 2018). GeoInquiries are licensed under Creative Commons and are freely available to any K-12 teacher worldwide. GeoInquiry collections exist for numerous content areas (Baker, 2015), including American Literature, Earth Science, Environmental Science, Government, Human Geography, Mathematics, Upper Elementary, US History, World Geography, and World History (Esri, n.d.). GeoInquiry topics include those like shoreline erosion (Math), tuberculosis (American Literature), and gerrymandering (Government) (Baker, 2015). Each GeoInquiry lesson follows a geographic inquiry process in which students examine data, ask questions, acquire additional data, analyze data, interpret data, argue from evidence, and revise arguments.

GeoInquiries are designed to replace a lecture with a 15- to 20-minute lesson in which a teacher displays a map to their students, and then follows specific steps, along with guided questions, to have students apply the geographic inquiry process to content instruction (Baker, 2015). The key aspect of the GeoInquiry is that each step of the lesson is scripted, from the steps an educator will take to manipulate the map to the questions the educator will ask as students interact with the map. Most importantly, GeoInquiries are designed so that educators can teach *with* GIS without prior knowledge of the GIS interface (Esri, 2017). As such the GeoInquiries are an educative curriculum in that while teaching with the GeoInquiry, the educator is also learning how to use the GIS technology interface (Davis & Krajcik, 2005; Drake et al., 2014). At the same time, the GIS technology exists in the background of the lesson, in service to the content presented by the educator. Examples of GeoInquiries are included in Appendix F.

How Is GIS Education Researched?

A review of the literature into GIS education through geospatial technologies (GST) reiterates the history of the development of the field, and of GIS education as its own research area. A seminal call for developing methodologies to broadly increase spatial thinking and GIS technologies in classrooms came in 2006 with the publication of *Learning to Think Spatially*, from the National Research Council. According to the National Research Council (2006),

> Hidden behind many of the daily operations of everyday life, the workplace, and science, spatial thinking is integral to successful problem solving…The key to spatial thinking is a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning. It is the concept of space that makes spatial thinking a distinctive form of thinking…By expressing relationships within spatial structures (e.g., maps, multidimensional scaling models, computer-assisted design [CAD] renderings), we can perceive, remember, and analyze the static and, via transformations, the dynamic properties of objects and the relationships between objects. We can use representations in a variety of modes and media (graphic [text, image, and video], tactile, auditory, kinesthetic, and olfactory) to describe, explain, and communicate about the structure, operation, and function of objects and their relationships. (p .12)

Spatial thinking is the cognitive skillset that can be developed through the use of GIS and GST, which can then be applied to many domains of knowledge.

Baker et al. (2015) developed two similar descriptions of spatial thinking to describe the specific skill sets that are developed through GIS, as opposed to those developed through other instructional activities. Spatial thinking is

> a set of abilities to visualize and interpret location, position, distance, direction, relationships, movement, and change through space. Spatial thinking and reasoning involve cognitive processing of spatial data. This locational, positional, and measurement

data is encoded and stored in memory, and can be represented externally by visualizations. (p. 120)

This definition is further refined into a description of geospatial thinking as

> a specialized form of spatial thinking that is bound by Earth, landscape, and environmental scales. Geospatial reasoning skills are higher-order cognitive processes that provide a means to manipulate, interpret, and explain information, solve problems or make decisions at geographic scales. (p. 120)

The development of spatial and geospatial thinking skills is one area in which GIS in education is researched. While *Learning to Think Spatially* (NRC, 2006) called for the inclusion of spatial thinking in US K-12 education, Baker et al. (2012) described the need for a specific research agenda, as advancement in the field would be dependent upon sound research. Baker et al. (2015) identified four specific research areas, based on identified gaps in the research, that frame a research agenda the authors proposed in 2012. These are, "(1) connections between GST and geospatial thinking; (2) learning GST; (3) professional development with GST; and (4) curriculum and student learning through GST" (Baker et al., 2015, p. 118).

A 2021 systematic review of 26 research studies on the use of GIS for instruction published between 2005 and 2014 (Schulze, 2021), echoes similar research areas. The author notes four themes within the research surrounding learning GIS and learning with GIS, namely those related to: "(a) subject-specific knowledge and skills; (b) cognitive skills and processes; (c) motivational-affective aspects of GIS learning; along with (d) various pedagogical and curricula issues" (Schulze, 2021, p. 797). The author also noted that within GIS research there is a distinctive diversity of research in this area. Given that GIS can be employed across numerous content areas and in varied instructional settings, many study designs become incomparable as they are based on so many different learning situations and populations. Schulze (2021) provides several recommendations for the field of GIS education research, specifically,

> First, it appears worthwhile to work on validating the reported impacts of GIS for teaching and learning to arrive at a formulation of evident moderator variables, such as gender, cognitive process, and type of instruction, which can guide the effective implementation of GIS in certain learning environments…Second, empirical GIS educational research needs to be more systematic in terms of generating consistent, replicable, and applicable results across studies... Finally, future research needs to focus more on the very essence of learning through geographic information systems. (p. 799-800)

Both Baker et al. (2015) and Schulze (2021) provide frameworks for moving the field of GIS education forward. For the purposes of this literature review, this chapter includes the documentation of current research classified by the areas of need suggested by Baker et al. (2015). This documentation demonstrates trends in current research efforts and the development of understanding within these areas.

Spatial Thinking and GST

Research into spatial thinking and geospatial technologies deals with two concepts – that of the effectiveness of teaching the actual geospatial technology, and that of developing the spatial thinking capabilities of students. Recent research into teaching geospatial technologies and the effect of that instruction on spatial thinking is summarized in the section below. Of important note in the current research is the development of methods to assess spatial thinking acquisition in students.

Spatial Thinking Ability Test (STAT)

Bednarz and Lee (2019) are the authors of STAT, the Spatial Thinking Ability Test, developed to meet the need for a research instrument that could assess spatial thinking. STAT addresses spatial thinking through a lens of geography and earth science content and is a revised version of the Spatial Skills Test (SST) (Bednarz & Lee, 2011; Lee & Bednarz, 2009, 2012). The authors (Bednarz & Lee, 2019) completed a review of 22 studies that used STAT to evaluate the effectiveness of GIS learning on increasing spatial thinking ability, as well as the effectiveness of other interventions. The review demonstrates that there is a positive relationship between GIS learning and an increase in spatial thinking ability, as well as a positive relationship between most GIS teacher training and student spatial thinking.

Jo et al. (2016) compared world geography instruction at the collegiate level with web-based GIS to world geography instruction without GIS. In this research, out of five instructors included, two taught with a web-based GIS and three without. Students were administered the STAT spatial thinking test developed by Lee and Bednarz (2012) pre-instruction and post-instruction. Of the eight item types administered in the state only three showed statistically significant improvement with web-based GIS. The authors argue, however, that this indicates that there is a benefit to teaching with web-based GIS and that improvements needed to be made to better align the pedagogical practices among all five instructors to allow for greater comparability among the results.

Collins (2018) utilized STAT to assess the difference between using paper-based maps and web-based GIS maps in an instructional unit related to specific map skills (measurement, direction, symbology, etc.) and subsequent map use (determining appropriate location for a new cell tower based on specific criteria). Collins reports that those who used the web-based GIS maps increased in their correct responses on the STAT test, but not to a statistically significant degree over those who used paper maps. The author notes a common limitation appearing in the current research, namely that GIS over a short period of instructional time does not significantly change spatial thinking skills (Collins, 2018; Hsu et al., 2018; Perugini & Bodzin, 2020).

Learning Geospatial Technologies (GST)

Within the GIS education community, there is regular discourse regarding the differences between learning content with GIS/GST and learning GIS/GST software. While integration of GIS into content area K-12 classrooms is recognized as important, the explicit teaching of the uses of GIS technology is recognized as an area of importance, as well. In 2010, the US Department of Education affirmed professional technologies should be used in US classrooms as a demonstration of their use in careers and to promote student learning (USDOE, 2010). In the context of professional technologies, GIS mapping technology is recognized as the backbone of the geospatial industry, which is one of the fastest growing industries in the United States (Baker & Palmer, 2014). There is also a quickly growing movement within secondary and career and technical schools for students to graduate high school with professional certifications (Konopelko, 2020). While this has long been standard in career and technical schools, these professional certifications are also moving into regular high schools, with the goal of equipping high school students with career recognized credentials prior to entering college or the workforce. Demarest and Gehrt (2015) argue that students that participate in Career and Technical Education (CTE) type programs are more "engaged, perform better, and graduate at higher rates than their counterparts in traditional high school programs" (p. 26). The Association for Career and Technical Education reports that greater than 70% of students that complete a

CTE program continue to higher education (Demarest & Gehrt, 2015). Learning a professional skill in a supportive high school environment has become a new normal.

Current research around the learning of GIS and geospatial technologies, independent of a specific content area, but for the specific sake of learning GIS and geospatial technologies centers around several factors. Research currently being conducted related to GIS technologies in US high schools focuses on the models being used to bring this technology to Grade 9-12 students, as well as the development of specific competencies for high school students (Schubert & Uphues, 2009). Another area of current research is related to how GIS is currently being taught in programs around the world. Lastly, a body of research revolves around developing certificates and certification exams in GIS and geospatial technologies.

The Geospatial Semester (GSS) is a cooperative dual enrollment project between James Madison University and high schools local to the University (Kolvoord et al., 2016; 2019; Peterson et al., 2020). Begun in 2005, the GSS was built upon the premise that teaching GIS would support students in "gaining real-world skills, addressing important problems, anticipating the transitions to work, higher education, or the military" (Kolvoord et al., 2019, p. 4). The GSS, as an instructional model, operates in the classrooms of social studies, science, and CTE educators who all receive summer training, as well as in-class support throughout the year. Students in the class receive dual enrollment credit through the University. Kolvoord et al. (2019) note that the GSS is now a self-sustaining program, and that it allows for greater connections between the University and local high schools. A review of the GSS both indicates that the program is expanding to other universities and develops spatial thinking skills in student participants (Charles & Kolvoord, 2016; Jant et al., 2020; Kolvoord et al., 2012).

In parallel development to dual credit programs such as the GSS, work is being done by the AP GIS&T Study Group (2018), under the College Board, to develop an AP course in GIS. This course, if completed with a high enough score on an AP exam, would allow for college credit at participating institutions of higher education. The AP GIS&T Study Group (2018) reviewed 451 undergraduate programs in GIS to develop a set of knowledge areas and topical units for the AP course. While the course itself is still under review with the College Board, the research by the AP GIS&T Study Group (2018) demonstrates the concepts and skills required for GIS, as well as the large need for course programming in GIS.

A review of the current research into the teaching of GIS outside of the United States reveals similar initiatives for exploration. While much of the current research internationally is around the teaching of GIS in higher education, some is in K-12 education. Walford (2017) discusses factors relating to enrollment in GIS programs in the UK and posits three factors that explain the observed enrollment changes noted by the authors, which are fewer initial undergraduates and more post graduate certificates. These three factors are (1) an increased professionalized GIS community worldwide, (2) the increase in technological familiarity among undergraduates, and (3) changes to undergraduate degree financing in the UK. While two out of the three factors are related to GIS, the author also notes that including geography in the "A level" exams speaks to its importance to the British economy.

Rida and Kamil (2021) investigated the impact of an update to the Indonesian national geography curriculum to include specific language related to map making, which would best be accomplished using GIS instruction. The authors note that while the technology is available and the students understand the value of the technology and its implications for sustainability and risk assessment, GIS is not taught with fidelity. A call for increased professional development and purposeful GIS instruction was made by the authors. A similar case study out of South Africa notes that while GIS is “regarded as the center of all modern spatial decision-making tools” (Mkhongi & Musakwa, 2020, p. 1), GIS is taught in a limited fashion and that an increase in both professional development for educators, as well as increased access to technology, is needed to increase GIS instruction.

Professional Development with GST

Much of the research surrounding GIS in education revolves around effective professional development for educators. Generally, the effectiveness of professional development is measured by how educators self-assess their comfort with GIS, or by the results of a student assessment related to the concept in question. Research around teacher professional development in GIS revolves around several themes, namely (1) professional development related to geospatial technologies, (2) professional development related to specific content areas, (3) professional development for pre-service teachers, and (4) professional development related to technology integration models and frameworks.

PD Related to GST

While much of the research surrounding professional development is tied to specific content areas and lessons, there is a body of research centered around geospatial technologies, in general. Early professional development for educators was focused on software and its potential use in classrooms. The first national survey of GIS implementation in schools (Kerski, 2003) found that of the 1,520 schools that owned GIS software in 1999, which made up 3% of the nation’s schools, less than half of the schools had teachers using GIS. This same implementation survey found that 88% of teachers believed that GIS would provide a great benefit to learning, but of those convinced of the benefit of GIS about 15% actively used GIS. Kerski (2003) noted

> Teaching with GIS provides the opportunity for issues-based, student-centered, standards-based, inquiry-oriented education, but its effectiveness is limited primarily by social and structural barriers. Technological barriers to the adoption of GIS, such as limited hardware and software, were found to be less significant than time required to develop GIS-based lesson modules, inadequate student access to computers, inadequate training, and pressure to teach a given amount of content during each term. (p. 134)

A study conducted in a similar vein of research (Baker et al., 2009) surveyed teachers who had attended one of 24 GIS professional development events prior to the 2003 school year. The Baker et al. (2009) study included some of the same questions as Kerski (2003). This survey of GIS-trained teachers indicated that half of the respondents used GIS in their classrooms once in the most recent semester. Those who did use the software indicated that they spent at least two hours each week creating GIS-based lessons. These results indicate that those who responded to the survey had either become GIS users, or not. The authors made the following recommendations, such as, training opportunities needed to include support staff as well as teachers; training should include content specific lessons as well as pre-built instructional materials incorporating GIS; training should include assessment strategies; and training should include specific pedagogy related to GIS-enabled instruction.

DeMers et al. (2021) made a strong statement regarding GIS professional development, “Little primary research focusing on the effectiveness of … (GIS) professional development to enhance the use of the technology as a tool to teaching exists, yet the use of GIS in education is almost as old as the use of GIS itself” (DeMers et al., 2021, p. 1). DeMers et al. completed an exhaustive study of one specific professional development, the Teachers Teaching Teachers GIS (T3G) institute, which included eight cohorts of intensive week-long PD for educators in GIS.

This PD, which had a goal of developing educators who could also deliver PD, was a successful initiative. The T3G participants reported that they were sharing GIS, teaching with GIS, developing materials in GIS, communicating about GIS, and teaching GIS to other educators. The authors of this research made several recommendations, such as a specific need for research into the effect of PD on educators, as opposed to students; a need for a common rubric for the GIS education community to use to evaluate professional development; and a need to develop models for best practices in effective PD.

Content Area Professional Development

When professional development is related to specific content areas, the focus of the training opportunities narrows. Hong and Melville (2018) describe a specific four-day workshop for eight social studies educators from a single district in Georgia. The authors reported that while their workshop received strong evaluations from participants, and those participants created strong lessons to use following the workshop, only two of the educators implemented the lessons, demonstrating a need for continuous support and professional development. This tie between a change in teacher practice and continuous professional development is noted by Mitchell et al. (2018) who emphasize that professional development in GIS with educators will always take longer than planned; that developing understanding of geographic concepts must occur along with technological competencies in professional development; and that GIS should be demonstrated as a tool that allows cross-curricular connections to increase relevance to both teachers and students.

An ITEST NSF-funded study related to science instruction looked at five factors the authors proposed were key to the implementation of GIS in the classroom – community, empowerment, relevance, comfort, and competence (Moore et al., 2016). The results of the study indicate a strong correlation between teacher's perception of their own preparation to use GIS and the use of GIS in their classrooms. This research centered around a hybrid professional development that was conducted over a lengthy period of time. The authors note the value of time and flexibility in delivering professional development in this manner. Collins and Mitchell (2019) also note that follow up to teacher professional development must be continuous and include regular coaching to develop educator confidence. A review of geospatial integration and professional development in North Carolina (Osborne et al., 2020) reports strong teacher interest in GIS and GST technologies, but a lack of teacher professional development. The authors note a widely reported need for pedagogical instruction related to the inclusion of GIS and GST in classroom instruction, as opposed to technological skill development in GIS and GST for teachers.

Pre-Service Educator Preparation

A review of research related to pre-service teachers and geospatial technologies demonstrates a number of interesting research directions. Hammond et al. (2014) note that geospatial technologies are used most broadly in the main core content areas of teacher preparation (science, social studies, math, and English language arts). A 2016 CITE special issue related to Geospatial Technologies in Teacher Education included a thorough review of prior research related to geospatial technologies in pre-service programs (Kerr, 2016). Kerr makes a statement of note in this review,

> I cannot claim with any certainty that teacher candidates in these courses will (effectively) use geospatial technologies in their future practice. I am aware, however, of the ways that frequent geospatial technology use in context-rich ways allowed them to

develop more robust understandings of the potential of geospatial technology in education as well as everyday life. (p. 341)

Research prior to 2016, as well as current research indicate the value of “frequent geospatial technology use” (Kerr, 2016, p. 341) in pre-service teacher programs to develop skills with GIS and GST, as well as the critical thinking skills we note in students.

Jo (2016) investigated the results of the incorporation of Web-based GIS lessons into a methods course for pre-service social studies educators. The author discusses that in order to develop the confidence and dispositions required by educators to comfortably incorporate technologies such as GIS into their teaching, these pre-service educators need to be exposed to many examples of effective technology integration and to be given multiple occasions to reflect upon the value that they see in the adoption of such technologies related to student learning. In Jo’s (2016) study educators received seven specific opportunities to engage with GIS and with the concept of the development of spatial thinking. The research indicated that educators did demonstrate positive dispositions toward including GIS in their social studies classrooms, and that future exploration related to how the development of positive dispositions affected classroom planning.

Shin et al. (2016) used the STAT assessment (Lee & Bednarz, 2009, 2012) to evaluate the spatial thinking abilities of students in a teacher preparation program, compared to those in a geography program. Additionally, the researchers used an instrument that looked at the attitudes of educators related to spatial thinking. The results demonstrate that the spatial skills and attitudes of pre-service teachers lack the self-assessed confidence of geography majors. Given the importance of including GIS and GST in classroom instruction, specific efforts to include these in teacher preparation programs will support the dispositions of these teachers to use GIS and GST in their own classrooms.

Using the Technological Pedagogical Content Knowledge (TPACK) model developed by Koehler and Mishra (2005), Harte (2017) provided opportunities for secondary pre-service teachers to engage with GIS and GST, while evaluating their own comfort and dispositions related to the technology multiple times over the course of instruction, and demonstrated the teacher's confidence, knowledge, and use of GIS/GST increased through this process. A study with pre-service teachers in South Korea demonstrated that using GIS/GST, specifically the Esri StoryMap platform, increased preservice geography teachers' own awareness of geographic concepts as well as provided a personalization of the content for these pre-service educators (Lee, 2020). The importance of narrative-based geography education is highlighted as an area in which there is a strong match with GIS/GST, and where GIS/GST can naturally fit into the instructional sequence.

GIS and GST in pre-service teacher preparation programs is, like other instructional technologies, aligned with the ideas of Pope et al. (2002) who describe a digital divide "the knowledge and skills preservice teachers have acquired through the required technology course, and the knowledge and skills they are expected to possess to successfully integrate technology" (p. 1). Research by Millsaps and Herrington (2017) indicated that there is a benefit to even presenting very short professional developments on GIS (2 hours). The authors' time-sensitive and flexible professional development framework, though developed for pre-service teachers, is adaptable to in-service teachers. Current research indicates that in terms of pre-service teacher preparation, teaching with GIS and GST is preferential to teaching GIS and GST without context (Millsaps & Herrington, 2017).

Technology Integration Models and Frameworks

While research related to general technology integration by educators will be covered in greater detail later in this literature review, current research related to technology integration models and GIS professional development does exist. This research relates to established technology integration frameworks such as TPACK (Curtis, 2020; Oda et al., 2020) and Roger's Diffusion of Innovation (Curtis, 2020), as well as newly developed frameworks that define effective professional development (Höhnle et al., 2016).

Curriculum and Student Learning Through GIS/GST

Geospatial technologies have applications across many content areas and disciplines. A review of current research demonstrates that the GIS and geospatial communities are developing research projects in several different areas, such as in earth science course work, geography courses, and even astronomy (Baker & White, 2003; Bednarz, 2004; Bodzin, 2011; Bodzin & Anastasio, 2006; Bodzin & Cirucci, 2009; Bodzin & Fu, 2014; Choi, 2021; Cole et al., 2018; Collins, 2018; DeMers, 2016; Doering & Veletsianos, 2008; Favier & van der Schee, 2014; Gutierrez et al., 2002; Hall-Wallace & McAuliffe, 2002; Hong & Melville, 2018; Hsu et al., 2018; Jadallah et al., 2017; Kerski, 2017, 2019, 2020, 2022; Kolvoord et al., 2019; Kulo & Bodzin, 2013; Leydon et al., 2017; Maddox et al., 2018). Another current area of research is in the application of spatial thinking to the larger STEM (science, technology, engineering, and math) fields of study (Bednarz & Lee, 2019; Charles & Kolvoord, 2016; Metoyer & Bednarz, 2017; Newcome, 2017, Steiff & Uttal, 2015; Uttal et al., 2013; Wai et al., 2010). A closer look at the current research in each of these areas follows.

STEM

Success in the fields of STEM varies based on several factors, as the skills and competencies needed for STEM vary among disciplines. Longitudinal studies indicate that spatial abilities are predictors of success in STEM careers in differing capacities to mathematical and verbal abilities. Wai et al. (2010) stated that "spatial ability plays a critical role in developing expertise in STEM and suggest, among other things, that including spatial ability in modern talent searches would identify many adolescents with potential for STEM who are currently being missed" (p. 817). The authors state,

> First, spatial ability is a salient psychological characteristic among adolescents who subsequently go on to achieve advanced educational and occupational credentials in STEM. Second, spatial ability plays a critical role in structuring educational and occupational outcomes in the general population as well as among intellectually talented individuals. Third, contemporary talent searches miss many intellectually talented students by restricting selection criteria to mathematical and verbal ability measures. (p. 827)

This research was followed by research on the "malleability" of spatial skills (Uttal et al., 2013), namely that,

> … spatial skills are malleable. Even a small amount of training can improve spatial reasoning in both males and females, and children and adults. Spatial training programs therefore may play a particularly important role in the education and enhancement of spatial skills and mathematics and science more generally. (p. 370)

To develop spatial skills, students must be presented with opportunities to practice those skills, in addition to opportunities to develop the mathematical and verbal skills that are more commonly provided in educational settings. A study of the development of a 21st Century Thinking Skills (Charles & Kolvoord, 2016) assessment rubric demonstrated that the project-based nature of GIS learning led to the development of these transferable skills.

Recent studies confirm that spatial thinking abilities improve achievement for students in STEM fields (Bednarz & Lee, 2019; Metoyer & Bednarz, 2017; Newcome, 2017; Steiff & Uttal, 2015). Steiff and Uttal (2015) present the following argument:

> STEM problem solving relies primarily on spatial thinking; therefore, success in STEM relies primarily on a student's spatial ability. There is some merit to this argument as STEM problem solving quite often requires students to reason about spatial information. For example, math students routinely quantify geometric relationships in three-dimensional solids, and geology students characteristically describe how land masses move over centuries. (p. 608)

Further discussion of the application of spatial thinking within various disciplines by Newcome (2017) makes the distinction between two types of spatial thinking through two historical examples. Comparing Rosalind Franklin's x-ray diffraction image of the structure of DNA and John Snow's map of cholera cases in London, Newcome (2017) makes the point that both these types of spatial thinking, involving objects and those involving physical space, are linked to STEM achievement, and thus vital to instruction. The direct instruction of spatial skills, as well as a movement to "spatialize the curriculum," hold value in the development of spatial skills for STEM students.

Jant et al. (2020) describes the development of a methodology to evaluate STEM-relevant spatial thinking. The authors developed a set of hypothetical scenarios (described as Transfer Questions) to assess spatial thinking. Transfer Questions tasked students with applying learned problem-solving skills to a real-world scenario. Student answers to these questions were evaluated for the presence of "spatial words, as an indicator of spatial thought, and coded using a rubric to assess problem solving skills" (Jant et al., 2020, p. 23). In each case, students could answer with or without spatial words, but the presence of these spatial words indicated STEM-relevant spatial thinking. The authors compared a group of students who had received specialized geospatial coursework (through the Geospatial Semester, Kolvoord et al., 2019) with a control group who had not. The geospatial students used a greater number of spatial strategies to solve the problems presented in the Transfer Questions. The research demonstrates that GIS instruction in the classroom has the power to develop specific types of thinking in students that can lead to a different set of problem-solving skills necessary for success in many science and engineering disciplines.

Earth Science

Given that GIS is so heavily incorporated, professionally, into the fields of earth science, much literature exists on GIS in earth science education (Baker & White, 2003; Bednarz, 2004; Bodzin, 2011; Bodzin & Anastasio, 2006; Bodzin & Cirucci, 2009; Bodzin & Fu, 2014; Doering & Veletsianos, 2008; Gutierrez et al., 2002; Hall-Wallace & McAuliffe, 2002; Kulo & Bodzin, 2013). Therefore, it is not surprising that a great deal of current research exists on incorporating GIS into earth science instruction. A synthesis of recent research in GIS in earth science education is below.

Bodzin et al. (2015) developed a series of Web GIS investigations designed to augment a generalized middle school curriculum, specifically to allow students to investigate concepts surrounding topics related to earthquakes, volcanoes, plate boundaries, heat flow in the mantle and the age of the ocean floor. These lessons were based on previous work by Bodzin et al.

(2014) and demonstrated that students using GIS increased both their knowledge of tectonics and their geospatial thinking and reasoning to a statistically significant degree using these lessons. Bodzin et al. (2016) present comparable results in an introductory earth science course indicating that scaffolded GIS instruction within earth science courses is highly effective in understanding geospatial concepts and patterns. In the same vein, Hammond et al. (2018) demonstrated the success of socio-environmental investigations in a high-needs urban public high school to develop spatial thinking skills, along with science content.

Current research also deals with specific content and pedagogical applications of GIS. For example, using geospatial tools to support geology students in understanding the three-dimensional nature of structural geology has been researched. Giorgis (2015) demonstrates that Google Earth is effective in supporting structural geology students in their ability to visualize hidden geologic structures. Perugini and Bodzin (2020) report data from an AP Environmental Science class investigation of hurricane science instruction. The authors report that while knowledge increased, the brief instructional time using GIS (four class periods) did not increase students spatial thinking ability. The results led to the recommendation that web-based GIS classroom usage occurs throughout a semester or an academic year. Hsu et al. (2018) reported positive results of using Google Earth in a classroom as a supplement to regular topographic map instruction. The results, though, did also indicate that teaching with GIS over a limited instructional period did not increase the spatial thinking capabilities of students. A study by Choi (2021) investigated the relationship between success in the geography questions on the NAEP (National Assessment of Educational Progress) test and technology usage at home and in the classroom. While the questions related to GIS and geography vary, in the years studied there is not a direct relationship between technology usage and GIS/geography scores on the NAEP test.

The authors note that specific GIS instruction was not measured, but the results indicate further research is needed into practices to increase student learning outcomes in geography education.

A study out of Portugal details spatial web-map based instruction regarding natural hazard risks. Nunes et al. (2020) described the implementation of a curriculum which demonstrated that when risk is presented spatially, students are better able to apply the perception of risk to their own locale, as opposed to abstract locations. Similar work by Xiang and Meadows (2020) purports that given the complex and variable future of our natural world and the anticipated human-induced environmental change, students must prepare to be citizens that can effectively deal with change. The authors report that including geospatial visualizations in classroom instruction includes a range of perspectives to prepare change-ready citizens.

Like the development of change-ready citizens in Portugal, a team of researchers evaluated a series of “TechCamps” held for U.S. and international students in three international (Bolivia, South Africa, and Panama) locations (Solis et al., 2019). These experiences walked students through a ten-day PBL process using geospatial technologies to collect, analyze, and present conclusions. The focus of this research was on whether the intense geospatial technology usage changed the perception of students, particularly female students, regarding careers in technology and STEM. The authors indicate what is reflected in much of the literature, that incorporating as much experiential technological learning as possible has the power “to overdetermine the outcome in favor of advancing girls’ confidence and participation in our fields” (Solis et al., 2019, p. 169). These authors note that GIS is an effective tool for teaching earth science, but to effectively increase spatial thinking, GIS must be used regularly and throughout the times of instruction.

Astronomy

While applications of spatial thinking and GIS in education are common in earth science, little research exists for the application of GIS in education to astronomy. However, Cole et al. (2018) describes the necessity of spatial thinking for those studying astronomy.

> Astronomy also requires the ability to recognize patterns, to understand cardinal directions, and to reason about external representations of astronomical phenomena, as represented in diagrams, maps, three-dimensional (3D) animations, virtual reality displays, and classroom demonstrations with physical objects. These abilities are examples of spatial thinking skills, which we define as the perceptual and cognitive processes that enable humans to create and manipulate mental representations of the spatial properties that exist within and between physical or imagined objects, structures and systems. (p. 1)

Having made the case for the importance of spatial thinking in astronomy, the authors then put forth a call for research in astronomy-specific spatial thinking instruction. This call included both a challenge to astronomy educators to understand their own spatial thinking skills, but also how to incorporate spatial thinking effectively in their own classroom instruction (Cole et al., 2018).

Geography Education

Geography instruction has been the standard educational setting for GIS instruction. Recent research into the incorporation of GIS/GST into geography education, though, includes a strong global component. Gonzalez and Torres (2020) recently compared conventional geography instruction using traditional textbook instruction to instruction using the Digital Atlas for Schools developed by a team of secondary and higher education educators in Spain. The Digital Atlas for Schools is aligned to the Spanish national geography curriculum and includes maps wrapped in a storyline format to allow simple access by students. The study utilized a learning progression model to measure student progress. The authors report that the Digital Atlas was a significant improvement over traditional methods of instruction. Ivan and Glonti (2019) describe the impact of GIS integration on eleventh grade geography students in Romania. These researchers looked at student engagement related to student perception of GIS classified as useful, original, and/or interesting. The research demonstrates that the use of modern GIS-enabled tools for student learning developed a student-centered classroom that was well-received among students and demonstrated effective instruction. Maddox et al. (2018) describe the development and implementation of a pilot problem-based geographic inquiry unit taught in a seventh grade US classroom. The example of inquiry-based instruction focused on civics instruction that requires “ethical decision making” around social issues (Maddox et al., 2018).

Recent research also demonstrates the effectiveness of using GIS in developing the geography skills of elementary school students. Moorman and Crichton (2018) noted the power of Google Earth to develop geospatial literacy skills in elementary age students. In an investigation conducted with fifth grade students in an urban Midwestern school district, Jadallah et al. (2017) explored pre-test and post-test data on both spatial thinking and general geography questions with students who had received GIS-based instruction as compared to groups of control students who had not. Similar to the work of Ivan and Glonti (2019), the students were highly engaged, and the authors note that both students and teachers were excited by the use of GIS in the classroom. While the results of their study did not indicate a statistically significant increase in scores on a test of spatial ability and questions drawn from NAEP tests, the authors noted that several factors external to the use of GIS impacted the data. One important conclusion from this research is that students in elementary school are sufficiently capable of using GIS for instructional purposes.

Research from the Netherlands (Favier & van der Schee, 2014) looked at geography instruction related to water-related spatial planning issues. The authors compared two sets of instructional units. In the control group, classroom activities surrounded readings, pictures, and maps in a textbook, supplemented with videos and articles. Student activities mainly centered around assignments in a workbook. Students in the experimental group completed a series of lessons involving geospatial technologies, including a technology-based “geogame,” *The Water Manager,* developed for secondary students, followed by assignments using a web-based atlas for secondary students in which they apply skills learned in the game. The game and the web-based atlas are freely available to teachers in the Netherlands. The text given to students at the end of the series of lessons involved spatial thinking, earth systems, map skills, and geographic thinking. The results of the investigation report a “low to moderate effect” (Favier & van der Schee, 2014, p. 233) for the experimental group over the control group. Students in the experimental group also self-reported for engagement and self-reported that they felt they had constructed more knowledge in this type of learning.

> Nevertheless, using geospatial technologies is not always easy for students. The huge amount of geographic information and the interactive tools can only be an advantage for students whose actions are guided by good research questions. Also, students have to be able to investigate the challenges in the world around us in a systematic way, and be able to use the tools in a sensible way. Geography education with geospatial technologies should therefore follow a step-by-step approach, giving attention to the development of subject knowledge, inquiry skills, thinking skills and motivation. Teachers should

> provide feedback on the learning process, and organize whole class discussions on the content. (p. 235)

As the recent research conducted indicates, though geography courses are the natural place for GIS/GST instruction, there is still research needed to inform the best practices of GIS/GST implementation in geography classroom settings, along with other disciplines.

Classroom Technology Integration

Technology integration into classrooms has been a subject of research since the introduction of the personal computer. In the early 1980's, research into how technologies, such as personal computers, could be used in classrooms became a focus of educational research. Cuban (1986) concluded that unless technologies are easily implemented into direct instruction, implementation will be slow. Rogers (2003) concluded that the degree to which a technology can be observed in the classroom indicates how much it will be integrated. Recent research continues the search for effective models that capture both the implementation, as well as the motivation, for classroom technology integration. Cuban, in Cuban and Jandric (2015), made the following recommendation related to current research into technology integration,

> Theories that look more closely at the features of the innovation and the context in which the innovation is placed make a great deal of sense to me. The interaction between innovation characteristics and the conditions present in particular settings needs to be investigated without blaming who does the implementation or how it unfolds in particular settings. (p. 428)

Models of educator technology integration have been developed by multiple researchers with a goal of capturing the decisions that educators make regarding how technology is integrated into their classrooms. These technology integration frameworks are applied in many different settings, both in pre-service educator preparation programs, and in professional development with in-service educators. Some models, or frameworks, are used to assess the level of technology integration of a lesson or unit. Most of the existing models are very student-focused and are evaluative of what the students are doing with the technology at a given time, thus indicating the curriculum choice of the classroom educator. A summary of published technology integration models is found in Table 2.

Table 2

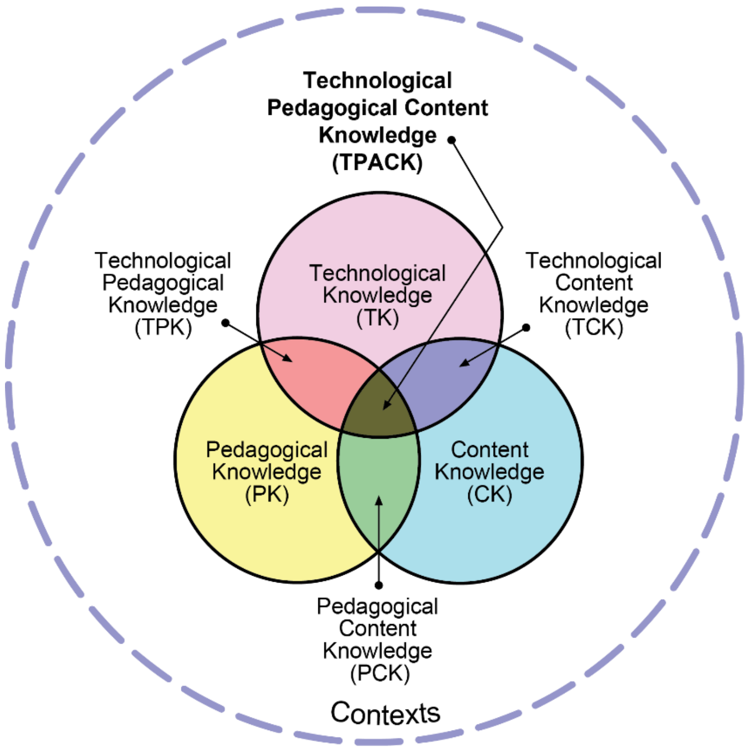
Summary of Technology Integration Frameworks from the Literature

Model	Design and Focus	Reference
LoTi	Levels of Teaching Innovation. Designed to locate a balance among instruction, assessment, and technology integration. Designed to measure educator implementation of technology integration. Focus is on educator- or student-directed learning, and problem- or practices-based activities. Technology integration is characterized as (0) Non-use, (1) Awareness, (2) Exploration, (3) Infusion, (4) Integration: mechanical or Integration: routine, (5) Expansion, or (6) Refinement.	Moersch (1995)
RAT	Designed to evaluate the pedagogical and curricular end goal of an activity that seeks to understand the specific motivation for educators' choice. Framework based upon the concepts of Replacement, Amplification, and Transformation. Focus is partially on educator choice and is a tool for educator self-assessment of their own technology integration.	Hughes, Thomas, & Scharber (2006)
PICRAT	Designed to build upon RAT, PICRAT is designed to highlight student functions in using technology – passive, interactive, and creative. Model also includes teacher's use of technology (Replacement, Amplification, and Transformation). PICRAT forms a matrix in which the most effective technology integration occurs at the junction of Creativity for students and Transformation for Teachers. Focus is on student role, in addition to teacher level of integration.	Kimmons, Graham, & West (2020)

Model	Design and Focus	Reference
SAMR	Designed to evaluate how the technology is used in the classroom. SAMR stands for Substitution, Augmentation, Modification, and Redefinition. The SAMR model supports teachers in the design of classroom activities with a framework to allow educators to move along a continuum culminating in redefinition in which students are completing tasks that were not possible without the technology. Focus is on what students are doing, and how that is different from instruction without technology.	Puentedura (2003)
TIM	Designed to help educators evaluate how technology is integrated into their classrooms. Technology Integration Matrix (TIM) incorporates two areas – the learning environment (active, collaborative, constructive, authentic, and goal-directed) and the level of technology integration (entry, adoption, adaptation, infusion, and transformation). A 5 by 5 matrix of these two areas allows educators to describe the use of technology integration in classrooms. Focus is on the technology decisions made in the context of a lesson.	Harmes, Welsh, & Winkelman (2016)
TIP	Designed to demonstrate to educators how to develop a classroom culture where technology effectively enhances learning. As opposed to a model that is focused on lessons, TIP (Technology Integration Planning Model) is used to develop a classroom environment where technology is used for learning purposes. Focus is on technology decisions and how they impact classroom procedures and processes.	Roblyer & Doering (2013)
TPACK	Designed around the concept that pedagogy and content must be the foundation for the technological choices that educators use in their classrooms and the transactional choices that are made as teachers navigate these choices and the transactional relationship that exists among Content (CK), Pedagogy (PK), and Technology (TK). The model clarifies the various levels of knowledge that exist in an educator effectively integrating technology. Figure 2 illustrates the multiple types of knowledge demonstrated in TPACK. Focus is on technology decisions and how they are impacted by pedagogical knowledge that incorporates content knowledge and technology knowledge. "It is not only about what technology can do, but also, and perhaps more importantly, what technology can do for them as teachers" (Mishra & Koehler, 2005, p.132).	Koehler & Mishra (2005); Mishra & Koehler (2006); Koehler & Mishra (2009); Voithofer et al. (2019)

Figure 2

TPACK Model



Note: From TPACK.ORG, by M. Kohler and P. Mishra, 2012 (http://tpack.org/). Copyright 2012 by tpack.org. This image demonstrates the overlapping types of knowledge included in TPACK and the transactional nature existing among the types.

The models summarized in the table above focus on the role of the students and while they do capture the decisions made by educators, they do not necessarily capture the motivation of the educators in making those decisions. The reasons why educators decide to integrate a technology, save for when those decisions are mandated by a district or school, are significantly more challenging to describe, as evidenced by the literature on educator beliefs and educator change. Some models do reach into this realm of research. Four models that move into this area are summarized in Table 3.

Table 3

Summary of Behavioral-Focused Technology Integration Models

Model	Design and Focus	Reference
Diffusion of Innovation	Designed to evaluate how a technology diffuses through a community after it has been adopted. This model suggests a linear progression through the stages of (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. Rogers (2003) explained this progression as "an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation" (p. 172) Focus is on large group diffusion, but keyed to individual user adoption. Users are classified as innovators, early adopters, early majority, late majority, and laggards. "An innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12). "Consequences are the changes that occur in an individual or a social system as a result of the adoption or rejection of an innovation" (Rogers, 2003, p. 436).	Rogers (2003)
TAM	The Technology Acceptance Model (TAM) was designed to evaluate the factors that determine how likely one will be to use a new technology. Focus is on the behavioral intention leading to the technology integration and not the actual use of the system. Technology decisions are based on perceived ease of use and perceived usefulness.	Davis (1989); Burton-Jones & Hubona (2005)
Stages of Concern	Designed to investigate technology through the lens of seven stages of progressive responses to a new technology – awareness, informational, personal, management, consequence, collaboration, and refocusing. Focus is on how educators change their beliefs after incorporating new technologies.	Chen & Jang (2014); Hall (2013)
UTAUT	Designed to determine the factors that directly impact user acceptance of a technology and the technology usage. The	Venkatesh et al. (2003);

Model	Design and Focus	Reference
	following factors are included in the model – performance expectancy, effort expectancy, social influence, and facilitating conditions. While not initially developed for use with educational technologies, UTAT has now been used in educational research studies. Focus is on behaviors and attitudes related to technology adoption, as well as the complexity of the contexts in which the technology is adopted.	Venkatesh et al. (2012)
TIQ	The Technology Implementation Questionnaire (TIQ) consists of 33 belief-related items that fall under broad motivational and perception-based categories – expectancy of success, value of technology use, and cost of technology use. Focus is on subjective teacher characteristics and conditions within the school environment.	Wozney et al. (2006)

Recent research within the areas of technology integration and geospatial technologies has led to the development of several instruments that are specifically tailored to the geospatial technologies' realm. Curtis (2019, 2020) developed a survey (Geospatial Technology in High School Geography Education) related to Roger's Diffusion of Innovation and TPACK with questions drawn from several previous research studies. Curtis' (2019) research classified educators according to three categories (GST-Ready, GST-Primed, and GST-Limited). Curtis' work (2020) defined educators as being in different stages of GST readiness, which correlated to Roger's stages - (1) GST knowledge, (2) GST persuasion, (3) GST decision, (4) GST implementation, and (5) GST confirmation. Curtis (2020) noted

> Participants did not conform to Rogers' (2003) linear innovation adoption model when deciding whether to use geospatial technologies as instructional technologies in high school geography classrooms. In this case, knowledge construction occurred simultaneously through actions in the GST Persuasion, Implementation, and

> Confirmation stages as reflected in the GAP diagram. Additionally, the concurrent operations evaluating the innovation reflects teachers as problem solvers who use the experiences with geospatial tools to refine their knowledge and professional practice to benefit teaching and student learning. (p. 156)

Curtis (2020) also noted, “Clearer insight to what motivates geography educators to use specific forms of GST can be leveraged to inform teachers of their relative advantage and compatibility” (Curtis, 2020, p. 156). This call for research into specific forms of GST is important given the variety of GST applications. Oda et al.’s (2020) research on professional development for pre-service teachers using a TPACK model confirmed the effectiveness of the model within the GIS research arena and called for further research, using the TPACK model, as the technologies related to GST adapt and evolve.

Research related to the diffusion of GST in Uganda (Eria, 2019), noted an alignment to Rogers’ Diffusion of Innovation Theory and UTAUT, while also noting the influence of change agents, opinion leaders, social network links, and champions. The author’s research clarified the power of change agents within the group of GST users to influence adoption, along with collaboration with an opinion leader. Those with more than three social network connections to other users were more likely to use GST, as were those who had a champion within their own organization.

The Unified Theory of Acceptance and Use of Technology Model

The Unified Theory of Acceptance and Use of Technology model, UTAUT, is of particular interest to this research as it has the potential to model several factors and moderators that influence how educators make decisions regarding changes to their education practice

(Venkatesh et al., 2003). The constructs included in the original UTAUT model are summarized in Table 4 below.

Table 4

UTAUT Constructs

Construct	Definition
Performance Expectancy	The extent to which a user thinks that the technology will benefit their performance.
Effort Expectancy	The amount of effort the user thinks will be required to use the technology.
Social Influence	The extent to which a user thinks that others in their social circle think they should use the new technology.
Facilitating Conditions	Factors in the user's environment that make the technology simple to employ.
Self-Efficacy	A user's belief in their own ability to use the technology to attain specific results.
Anxiety	An unease towards using a particular technology.
Behavioral Intention	The user's intention to use the technology in the next <n> months, years, days, etc.

A review of current research that employed the UTAUT model yielded applications to a cross section of areas in which novel technologies were employed. Within medicine, the acceptance of older users' home telehealth (Cimperman et al., 2016) was researched, along with the acceptance of telemedicine during COVID (Shiferaw et al., 2021), and the acceptance of fitness trackers (Mishra et al., 2021). In finance, UTAUT was employed to measure acceptance of Internet banking (Rahi et al., 2019) and eWallet banking (Bommer et al., 2022). UTAUT measured how drivers responded to advanced driver assistance technology in their new vehicles (Rahman et al., 2017).

Recently, UTAUT has been applied to several educational innovations and implementations such as tablet adoption (Magsamen-Conrad et al., 2015), MOOC attendance (Li & Zhao, 2021), 3D printing (Holzman et al., 2020), e-learning with Moodle (Abbad, 2021), elearning with Blackboard (Sultana, 2020), virtual reality (Noble et al., 2022), and mobile learning (Chao, 2019; Hu et al., 2020). Additionally, researchers investigated social isolation and the acceptance of a learning management system in instruction (Raza et al., 2021), the intention of educators to use a flipped classroom model for instruction (Abd Rahman et al., 2021), and the intention of educators to continue to employ mobile learning technologies post-COVID (Al-Adwan et al., 2022).

Research into the use of UTAUT related to GST yielded only a single application of the model to GST (Eria, 2019). At the time of this writing, there were no applications of UTAUT to GST technology in education. However, as described in the section above, Eria (2019) employed UTAUT (Venkatesh et al., 2003) and Rogers' (2003) Diffusion of Innovation to investigate the dispersion of GST throughout Uganda. In Eria's (2019) study, the UTAUT model was able to quantify the role of opinion leaders, social influence, and champions, in the movement of GIS technology throughout the country. Additionally, UTAUT was also able to allow Eria to quantify the effect of the facilitating conditions present in the model on usage behavior and behavioral intention. The author reports that the model effectively allowed a view into how deeply GIS has become embedded in Uganda, and highlighted sectors in which little penetration of the technology had occurred.

Educator Belief

> People regulate their level and distribution of effort in accordance with the effects they expect their actions to have. As a result, their behavior is better predicted from their beliefs than from the actual consequences of their actions.
>
> -Albert Bandura, *Social Foundations of Thought and Action*

Pajas (1992) stated that future research into teacher effectiveness practices would be the focus of research into beliefs. Beliefs are the filter by which educators screen information (Bonner at al., 2020). When discussing educator beliefs, the literature contains several ways of defining beliefs. A belief is classified as pedagogical if it relates to how educators think about their own teaching. Beliefs are classified as values-based if they hinge on the idea of whether a technology can accomplish a goal that the educator has for the classroom (Ertmer & Ottenbreit-Leftwich, 2013).

An educator's beliefs can also be classified related to how the educator operates in the classroom. Educators with more educator-centered practices and beliefs tend to not perceive technology as valuable to the classroom, or essential for students to learn. Educators whose beliefs result in more student-centered and constructivist practices tend to see technology as both valuable and key to accomplishing classroom goals (Ertmer, 2005; Ertmer et al., 2012, Tondeur et al., 2017). In general, teachers with more traditional beliefs will implement more traditional or "low-level" technology uses, whereas teachers with more constructivist beliefs will implement more student-centered or "high-level" technology uses. (Ertmer & Ottenbreit-Leftwich, 2010).

Key to the discussion of the power of educator beliefs is that educator belief becomes the lens by which many key instructional decisions are made (Perrotta, 2017; Tondeur et al., 2017). Educator belief has been classified, along with educator-student roles and curricular emphasis, as a second-order issue. Second order-issues are much more challenging and resistant to change than first-order issues. Examples of first order issues could be equipment, training, and support (Ertmer, 1999). First order issues are structural and reversible, but when educators make changes in their beliefs, their personal second-order issues, change is irreversible, the stakes are higher, and perceived risk is greater (Ertmer, 2005). Biesta et al. (2015) discussed the role of teacher beliefs on teacher agency, i.e., making decisions in the classroom, and the authors note that teacher beliefs are very much oriented towards the "here and now" of educational policy (first-order change) and lacking in the broader purposes and meanings of traditional education. The authors believe that educators would be better in position to effect change with a greater discourse about teaching and the purposes of education, as opposed to instructional resources and district mandates.

What is clear from the literature is that integrating innovative technology is rarely ever about technology. Ertmer et al. (2012) describes specific purposes for technology that aligned with the beliefs of educators who had made specific changes to incorporate more technology, (1) using "technology to deliver content and reinforce skills", (2) "technology to complement or enrich the curriculum", and (3) "technology to transform teaching and learning" (Ertmer et al., 2012, p. 430). The integration of new technology is also time-dependent in that often educators need 5-6 years to gather the evidence to effect change in their own practice (Perrotta, 2017). A study into the use of 3D printing in the classroom (Holzmann et al., 2020), considered a novel technology, led to the development of a variation on the UTAUT model for integration. This model included the following as variables that impacted how 3D printers were incorporated: performance expectancy (the degree to which an educator believed 3D printers would enhance instruction), effort expectancy (the degree of ease the educator associates with 3D printing), social influence (the degree to which others think 3D printing is important), anxiety (the degree of perceived apprehension related to 3D printing), degree of overall affective reaction (enjoyment) of an individual to using the technology, and the presence of supporting organizational and technical infrastructure (facilitating conditions) (Holzman et al., 2020). This multifaceted model is an example of the many factors included in the complexity of technology integration.

Teachers are the most important agents in bringing about educational change and in scaling educational changes (Bonner at al., 2020). When teachers do change, and re-orient their beliefs, it is due to the evidence of student outcomes, and teachers see how a change affects what students can do (Bonner at al., 2020).

Educator Change

Change requires tremendous sophistication as well as some risk taking.

-Michael Fullan

When educators make changes to their beliefs it results in changes to their practice, but those changes are dependent on the educator's sense of self-efficacy, their own belief that they can teach with technology and that the technology has the intended instructional value. The adoption of new technologies, even as technologies become prevalent in all aspects of life, still cause anxiety and uncertainty (Ertmer & Ottenbreit-Leftwich, 2010). Teacher motivation for change is critical and is directly tied to utility of the innovative technology (Backfisch et al., 2021). The innovative technology must increase student engagement or cognition to a degree that a teacher is motivated to change for the purpose of student learning.

A literature review by Daly et al. (2009) led to the following statement regarding the use of technology:

> The core issue to emerge from the review is that teachers need to be at the centre of their own learning if they are to change their deep-seated beliefs and habits regarding the use of technology. Otherwise, surface-level adoption occurs, by which teachers just have time to learn how to use a technology without deep consideration of how it might be used to address context-specific learning needs of students. Rather than deepening and consolidating understanding of how to use the technology for enhancing learning, teachers frequently find they have to move on to learn how to use another technology or address another priority. (p. 6)

It is well-defined in the literature that technology integration in specific classrooms is not conditional upon the actual technology itself (Ertmer et al., 2012; Perrotta, 2017). While different technologies allow educators and students to accomplish classroom activities differently, the determining factor in technology integration is the personal beliefs of the educators themselves. These beliefs drive the decisions educators make regarding what happens in their classrooms (Tondeur et al., 2017). Student achievement and classroom performance closely tie to a teacher's understanding of their own strengths, belief in their ability to accomplish a task, and their educational values system (Backfisch et al., 2021).

Recent research by Tarling and Ng'ambi (2016) into the use of emerging technologies in South African schools and their catalytic role in transforming pedagogies led to the development of a "map" of educator's use of emerging technologies, called the Teaching Change Frame. This framework includes information related to the level of Bloom's Taxonomy that educators use in instructional practice (low order thinking skills to high order thinking skills), the use of technology on a continuum from mechanical use of technology to a reflective use of technology, and from a learner-centered pedagogic approach to a teacher-centered pedagogic approach. The creation and usage of the Teaching Change Frame demonstrated several mitigating factors related to educator change but observed that for teachers to use emerging technologies in a meaningful way in their classrooms, something greater than increased access to the technology or a directive to use the technology was required. Namely, the authors note that, "Deliberately scaffolding the use of ETs (emerging technologies), HOTS (high order thinking skills) and fostering nonregulated dispersed interaction between learners, content and teachers, were identified as key drivers of change and are pursued in the testing and refinement of the change process" (Tarling & Ng'ambi, 2016, p. 570). This echoes the understanding that teachers need to believe that technology will make effective use of instructional time to make the effort to change their practice. Levin and Wadamy (2007) observed that belief systems are dynamic and that "educational change involving technology is an individual process, unique to each teacher" (p. 172). This personal aspect of educator change is reflected in the author's statement that belief change is a "consequence of teachers' continuous inquiry into their instructional decisions and practices, and that it is an integral aspect of teachers' lives" (Levin & Wadmany, 2007, p. 175). Teacher motivation to change is the driver of change (Backfisch et al., 2021). Change must be driven by purpose.

Howard and Gigliotti (2016) describe the concern that teachers have about technology as "confidence using technology and beliefs about teaching and technology; but it is also about how teachers feel about taking risks and experimenting in their practice" (Howard & Gigliotti, 2016, p. 1352). The concept of how teachers feel is perceived risk, which the authors go on to describe as "an estimation of possible risk, what might happen and what a person believes to be at stake" (p. 1353). These emotional and visceral reactions to incorporating innovative technologies are the context and the framework in which those researching GIS/GST classroom integration operate within.

Literature Review Summary

Though the GIS/GST education research community is small, it is a research community that is highly motivated to understand the best practices of integration of this technology into classrooms in an effective manner. Current research in GIS/GST education indicates that several areas of investigation are continuing to develop. Namely, the methods of understanding spatial thinking development and assessment, using GIS/GST instruction are evolving. Additionally, research branches into an area related to actual GIS/GST instruction, and an area related to student learning through GIS/GST. The distinction of teaching GIS/GST and teaching *with* GIS/GST is well-documented and continues to be a boundary among researchers to this day.

A large area of research, which continues to grow, is that of professional development in GIS/GST for both in-service and pre-service educators. Research in this area covers many aspects of professional development, but there is a constant drive by the GIS/GST community to understand the best methodologies to use with teacher professional development to ensure that GIS/GST is integrated into classroom instruction following the teacher professional development.

Research continues to be conducted into best practices regarding teaching *with* GIS/GST in different curricular areas. While the importance of spatial thinking to the larger group of STEM fields is a critical area of current research, those who specialize in specific content areas are continuing the research into how each area is best served by GIS/GST integration. Though many current areas of integration are those that most educators would expect, geography and earth science, it is gratifying to see the research continue to grow as GIS/GST is now seen as applicable to instruction in many new content areas, such as astronomy.

Research into the integration of any new or novel technology cannot be conducted without the application of one or more models of classroom integration. Though many models have been developed over the years, current research is seeking to refine those models, and to search out new ways to use models to specifically measure the many aspects of technology integration, namely student technology usage, educator beliefs and self-efficacy, and educator's motivation for change.

It is the desire of this researcher to understand how a specific GIS/GST curricular resource, the GeoInquiry, and classroom implementation of this resource supports educators in their own beliefs about their own ability to use GIS/GST technologies and how these same curricular resources impact educators to see the value in GIS/GST and therefore make changes into how GIS/GST is integrated into classroom instruction. While much research exists around professional development in GIS/GST and the power of the professional development to increase educator self-efficacy and educator decisions, little research exists into the scaffolding effect of specific curricular resources to bring about changes in how teachers feel and believe related to GIS/GST technologies and how that plays out in the technology integration choices of these educators.

Chapter Three: Research Methods

Chapter Two presented a summary of the current and historical research regarding GIS/GST integration, the history of GIS/GST professional development, technology integration models, recent research regarding educator change, and current research regarding educator choice. This chapter includes the research methods employed in this research study. This research study investigated the technology acceptance of GIS/GST classroom integration by educators as moderated by GeoInquiry usage in classroom instruction through descriptive survey research. Usage is defined as the frequent and repetitive implementation of GeoInquiries in classroom instruction. This study used a modification of the Venkatesh et al. (2003) UTAUT (Unified Theory of Acceptance and Use of Technology) survey instrument to analyze the GIS/GST technology acceptance of US educators. The UTAUT model is described in Chapter Two. In addition, this study explored the moderating factor of GeoInquiry use on GIS/GST classroom integration. The research methods that comprise this chapter include in-depth descriptions of the following: research design, population and participants, instrumentation, data collection procedures, and data analysis.

Research Design

This study uses descriptive survey research centered around a non-experimental quantitative data collection activity. The study uses two research questions to investigate educators' behavioral intention to use GIS/GST technology integration in classroom instruction.

Research Questions

1. To what extent do performance expectancy, effort expectancy, social influence, and facilitating conditions predict educators' behavioral intention to use GIS/GST in their classrooms?

2. Does GeoInquiry usage moderate the relationships among performance expectancy, effort expectancy, social influence, facilitating conditions, and educators' behavioral intention to use GIS/GST in their classrooms?

The dependent study variable in this research study is the core construct (criterion variable) of the UTAUT models, i.e., the measured level of educator's behavioral intention to use GIS/GST classroom integration. The independent study variables are the predictor variables of the UTAUT instrument, performance expectancy, effort expectancy, social influence, and facilitating conditions, with the frequency of educator usage and experience with GeoInquiries as a moderating variable. Research into the effect of contextual moderating variables on the UTAUT constructs was called for by Venkatesh et al. (2016) and is increasing in prevalence in the literature (Alghamdi, 2020; Chao, 2019; Hu et al., 2020; Li & Zhao, 2021; Raza et al., 2021).

Research Hypotheses

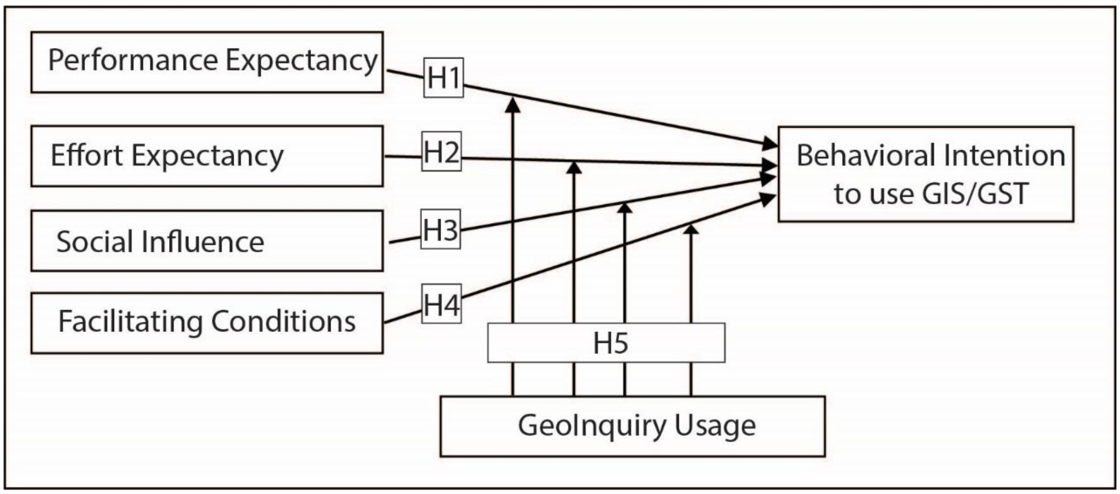
The research hypotheses for this study are:

1. H1: Performance expectancy positively affects educators' behavioral intent to use GIS/GST classroom integration.
2. H2: Effort expectancy positively affects educators' behavioral intent to use GIS/GST classroom integration.
3. H3: Social influence positively affects educators' behavioral intent to use GIS/GST classroom integration.
4. H4: Facilitating conditions positively affect educators' behavioral intent to use GIS/GST classroom integration.
5. H5: GeoInquiry usage has a moderating effect on the behavioral intent of educators to use GIS/GST classroom integration.

Figure 3 illustrates the research hypotheses for this study, demonstrating the analysis of the moderating effect of GeoInquiry usage. This image depicts the relationship among each of the variables included in the modified UTAUT instruments, as well as the hypotheses that predict the effect of each variable on behavioral intention to use GIS/GST.

Figure 3

Model of Hypothesized Relationships Adapted from Venkatesh et al. (2003)



Population and Participants

This research study's target population is US educators who use GIS/GST with a particular focus on those who have used Esri GeoInquiries, a supplemental curricular resource in classroom instruction. Educators who use GeoInquiries have made the personal choice to incorporate these supplemental resources into their classroom instruction. Many of these educators are members of a mailing list maintained by Esri Education; will be colleagues of or will be on listservs maintained by participants in T3G, the Teachers Teaching Teachers GIS Institute, an Esri professional development held between 2009 and 2019; or will be educators who have encountered Esri education staff at a professional conference for educators, such as the National Science Teaching Association (NSTA), American Association of Geographers (AAG), or the State Educational Technology Directors Association (SETDA). The Esri education newsletter goes to approximately 25,000 individuals. The T3G listserv goes to approximately 400 individuals. These listservs may include retired educators and educators who are not actively teaching in classrooms; therefore, the size of these listserv memberships is not indicative of the population that chose to complete the survey. Lastly, the population includes those on a listserv of West Virginia educators who received training and expressed interest in teaching with GIS/GST technologies.

Using purposive sampling, the group of educators completing the survey were intended to be from US public and non-public schools, teaching many subjects and working in classrooms serving many grade levels. The survey consent email included a statement that if the participant knew an educator for whom it would be appropriate to complete the survey, then they were asked to forward the communication.

Survey completion was voluntary, and the identity of the respondents will be kept anonymous. However, the survey instrument did include queries related to the state in which educators taught, their total years of teaching experience, and their gender. In addition, the instrumentation section of this chapter includes information regarding the instrument's creation.

Instrumentation

The survey that was used to collect data for this study is the *Quantitative Study of the Acceptance of Digital Mapping Technologies in the K-12 Classroom Using the Unified Theory of Acceptance and Use of Technology (UTAUT) Survey* (Appendix C). This survey is based upon and modified from the UTAUT instrument (Venkatesh et al., 2003) with permission from the author (Appendix B). The UTAUT instrument was adapted to explore GIS/GST technology integration in K-12 classrooms as moderated by the usage of GeoInquiries in classroom instruction. UTAUT, the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003), was initially developed to research the variables influencing user acceptance of specific innovative technologies. The original UTAUT model followed the evaluation of the following technology acceptance theories – the diffusion of innovation theory (Rogers, 2003), social cognitive theory (Bandura, 1986), technology acceptance model (Davis, 1989), theory of planned behavior (Ajzen, 1991), the motivational model (Davis et al., 1992), a model combining the technology acceptance model and theory of planned behavior (Taylor & Todd, 1995), and the theory of reasoned action (Fishbein & Ajzen, 1975), along with a model of personal computer usage (Thompson et al., 1991). Blut et al. (2021) reviewed thousands of UTAUT implementation instances since the original model's development in 2003. This dissertation study seeks to apply the UTAUT model in the field of GIS and GST education with a new type of moderating effect, that of GeoInquiry usage by respondents (Li & Zhao, 2021).

Section one of the *GeoInquiry Usage Impact Survey* includes items seeking demographic information from educators, including participant's gender, years of classroom experience (*ranging from 0-4 years, 5-9 years, 10-14 years, 15-19 years, or 20 or more years*); level of education (*Bachelors, Masters, Specialist, Doctorate, or Other*); grade level currently taught (*K-2, 3-5, 6-8, 9-12*); content area currently taught (*Elementary, Math, Science, Social Studies, English, CTE, Technology, Computer Science*); the state currently teaching; and a question on formal professional development related to GIS/GST technology integration. The items in Section one of the instrument are intended to define the survey population sufficiently.

Section two of the survey includes modified versions of the original UTAUT items, including performance expectancy (4 items), effort expectancy (4 items), social influence (4 items), facilitating conditions (4 items), and behavioral intention to use GIS/GST technology in classroom instruction (4 items). Section two uses a seven-point Likert scale ("1 = strongly disagree" and "7 = strongly agree") for each item, according to UTAUT protocols. Table 5 provides an example of four of the original UTAUT (Venkatesh et al., 2003) items from the performance expectancy section and the modified items included in this survey.

Table 5

Comparison of Original UTAUT Items and Modified Items

Item Code	Original UTAUT	Modified
PE1	I would find the system useful in my job.	I believe that digital mapping technology will be beneficial for the students in my classroom.
PE2	Using the system enables me to accomplish tasks more quickly.	Digital mapping technology enables me to accomplish instruction more effectively in my classroom.
PE3	Using the system increases my productivity.	Digital mapping technology increases my productivity in my classroom.
PE4	If I use the system, I will increase my chances of getting a raise.	Using digital mapping technology in my classroom instruction increases my chance of professional advancement.

Section three focuses on the implementation of GeoInquiries in participants' classrooms. Educators are asked the number of individual GeoInquiries taught in their classroom instruction (*1, 2, 3, 4, 5, 6 or more*). As a point of reference, the question includes a link to the GeoInquiries website in the event that educators need to reference the list of GeoInquiries. The survey then asks the number of times in the last year that the educator has used GeoInquiries (*1-5, 6-10, 11-15, 16-20, 26-30, 31 or more*). An explanation of the calculation of the number of times used is provided. A question is included to ask the number of years that educators have used GeoInquiries in their classroom, along with the average number of times that GeoInquiries are used. The purpose of the items in section three was to allow for the description of the moderating effect of GeoInquiry usage on the modified UTAUT constructs as defined in section two.

Validity and Reliability

Venkatesh et al. (2003) completed a longitudinal study to verify the utility of the UTAUT instrument. The results of this study indicated that the UTAUT instrument described a strong level of variance (R^2 – 0.69) in the behavioral use of technology, where R^2 is the proportion of the variance in the dependent variable predicted by the independent variable. Venkatesh et al. (2003) reported that this variance is more substantial than any of the models preceding UTAUT. UTAUT has received much support, as shown by the many studies that have employed the original version of UTAUT or modified the UTAUT in the years since the UTAUT instrument was published (Venkatesh et al., 2016).

Several methods validated the survey used in this study. First, a panel of experts reviewed the survey instrument items for face validity and content validity, using a methodology demonstrated by Elangovan (2021), to ensure that the language used by the survey would best elicit reliable responses from the surveyed population. This panel of experts, drawn from the field of GIS education, reviewed the survey instrument and made recommendations related to the structure of the survey and associated items, as well as the content of the items (Carmines & Zeller, 1991; Maul, 2017). Specific feedback from the panel of experts included using the phrase “digital mapping technologies” in the survey instead of “GIS/GST integration.” Additionally, the experts gave feedback on language to best define the usage of GeoInquiries. The list of the panel of experts and the questions asked of the panel of experts is found in Appendix E.

The researcher implemented a pilot study with a group of West Virginia educators who have participated in an Earth and Space Science professional development during the summer of 2016, which included basic instruction in digital mapping technology integration. The pilot study, which included 10 educators, was employed also to establish content validity (Frankel et al., 2015; Litwin, 1995; Straub & Gefen, 2004; van Teijlingen & Hundley, 2001). Those who completed the survey were asked to provide feedback related to survey design and content via email. No suggestions were provided, so no further revisions were made to the survey instrument.

Cronbach's Alpha

A reliability analysis was conducted with a sample (n=104) from the population to examine the internal consistency of the 24 survey items modified from UTAUT (Venkatesh et al., 2003) and the questions related to GeoInquiry usage using Cronbach’s alpha coefficients. An alpha coefficient greater than $\alpha = 0.70$ indicates that an instrument is reliable with regard to the instrument’s internal consistency (Salkind, 2017). Table 6 includes the Cronbach’s alpha calculation for the complete dataset. The Cronbach’s Alpha for the twenty-four survey items is .933, indicating the instrument is reliable.

Table 6

Cronbach’s Alpha – UTAUT Items

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.933	.944	24

Data Collection Procedures

Upon approval by Marshall University’s IRB, survey data was collected using Qualtrics®, an online survey tool provided to students and faculty of Marshall University for the purposes of survey research. IRB approval is included in Appendix A. The Qualtrics® platform is simple to navigate, and the survey was accessed by a simple link in an anonymous consent email (Appendix D). The platform required a web browser to complete the survey and could be completed on various devices, including mobile phones and tablets. The expected time to complete the survey was 10 to 15 minutes.

In preparation for survey deployment, the researcher reached out to the K-12 education staff at Esri. These Esri staff agreed to support the researcher in disseminating the survey to the K-12 GIS/GST education community.

The survey link and the anonymous consent email was posted on the Esri community website (https://community.esri.com/) in the K12 education community. Esri shared the survey link and anonymous consent letter via email to the Esri K-12 newsletter. The anonymous consent email included a statement asking participants to share the survey with those in their local GIS communities. As the literature indicates that this practice does increase participant response rates (Jacob & Jacob, 2012; Yu et al., 2017), as an incentive for survey completion, participants who provided their email addresses were included in a drawing for a $10 Amazon gift card. Ten randomly selected participants were awarded the $10 gift card upon the survey's closing.

An email was sent to a listserv of educators in WV, both in K12 and higher education with an interest in GIS/GST and digital mapping technologies. This listserv includes 387 members. Personal emails were sent by the researcher to multiple colleagues in the GIS/GST and digital mapping technology community. These emails each included the text of the anonymous consent form (Appendix D).

The survey was open for nearly three months to cover time between the initial listserv calls for participation and the monthly publication schedule of the Esri education newsletter. A second reminder email was sent on the listservs, as recommended in the literature, to elicit additional responses (Van Mol, 2017).

This study is a cross-sectional survey study that gathered online survey data at a single point in time. Qualtrics adheres to General Data Protection Regulation (GDPR) requirements, is ISO 27001 certified and FedRAMP authorized, and provides secure data transmission and encryption of all data collected from survey respondents. (Qualtrics, 2022). Following the survey's close, data was downloaded from Qualtrics and stored on a locking hard drive. Data will be stored for five years.

Data Analysis

The Statistical Package for Social Sciences (SPSS), version 25, was used to answer each research question through the analysis of each hypothesis and to accept or reject the null hypotheses. The researcher employed descriptive and inferential statistics to analyze the survey results. These methods allowed for the interpretation of the data around specific variables and the significance of the relationships among the many variables evaluated in the survey.

To evaluate the first research question (RQ1. To what extent do performance expectancy, effort expectancy, social influence, and facilitating conditions predict educator’s behavioral intention to use GIS/GST in their classrooms?), multiple regression analysis was employed to evaluate how performance expectancy, effort expectancy, social influence, and facilitating conditions predict educator's behavioral intention to use GIS/GST in their classrooms. Descriptive statistics were calculated for each factor (performance expectancy, effort expectancy, social influence, facilitating conditions, behavioral intention, and GeoInquiry usage). The relationship between behavioral intention to use GIS/GST (dependent variable) and performance expectancy, effort expectancy, social influence, and facilitating conditions (the independent variables) was measured in terms of statistical significance ($p<.05$). This statistical significance was used to identify the effect of each of the independent variables on the educator's behavioral intention to use GIS/GST in their classrooms.

To evaluate the statistical value of the moderating effect of the use of GeoInquiries on the four predictors of behavioral intention (performance expectancy, effort expectancy, social influence, and facilitating conditions) (research question 2), moderation analysis was employed in SPSS. A moderator is essentially a third variable used to examine the strength of the relationship between the independent and dependent variables. A moderator defines the degree of change between independent and dependent variables through linear regression. This analysis allowed the researcher to demonstrate the effect of GeoInquiry usage on the other predictors of behavioral intention.

Chapter Summary

This chapter included a discussion of the research design employed in this investigation. Information on the population participants, the methods for recruitment and survey distribution, and the development of the survey instrument were provided. In addition, the specific data collection procedures and a description of the methods and statistical tools used to analyze the data were identified. The results of this study are reported in Chapter Four.

Chapter Four: Data Analysis

The purpose of this quantitative study was to investigate the moderating effect of the frequent and repeated implementation of a specific GIS/GST curricular support, the GeoInquiry™ (Esri, n.d.), in building educator confidence in, and educator intention to use, GIS/GST technology to a greater degree. Specifically, this study explored the technology acceptance of digital mapping technology in classrooms through the UTAUT framework (Venkatesh et al., 2003) and whether that technology acceptance was moderated by the frequent and repeated usage of the GeoInquiry. The survey, which included UTAUT items modified for the implementation of digital mapping technology in the classroom, demographic questions, and questions related to GeoInquiry usage (see Appendix C) was administered via Qualtrics, which is provided to Marshall University students.

This chapter presents the results guided by two research questions:

1. To what extent do performance expectancy, effort expectancy, social influence, and facilitating conditions predict educators' behavioral intention to use GIS/GST technologies in their classrooms?
2. Does GeoInquiry usage moderate the relationships among performance expectancy, effort expectancy, social influence, facilitating conditions, and educators' behavioral intention to use GIS/GST technologies in their classrooms?

This chapter includes a discussion of the data analysis completed following data collection. Data were analyzed using SPSS (version 28) in addition to the PROCESS macro developed by Hayes (2022). Both descriptive and inferential analyses were completed for the modified UTAUT items, and the responses related to GeoInquiry usage. Moderation analysis was performed to evaluate the effect, if any, of GeoInquiry usage on behavioral intention to use digital mapping technologies in the classroom.

Survey Administration

The survey questionnaire was distributed through Qualtrics between September 2022 and December 2022 using three main methods of distribution. The initial distribution occurred through posts in the Esri community (K12instruction) which included a copy of the anonymous consent form. This initial post can be viewed in Appendix H. This post was followed by a second post by an Esri staff member, sharing the initial post, in the Esri Community (Education Blog). This second post is included in Appendix I.

The second method of distribution was through email communication. An email was shared through a small listserv maintained by Esri of individuals that had participated in T3G, a GIS professional development opportunity offered over several years. This email can be found in Appendix J. An email was also sent to a listserv of educators, both in K12 and higher education in WV, with an interest in digital mapping technologies. This listserv includes 387 members. Personal emails were sent by the researcher to multiple colleagues in the digital mapping technology community throughout the US. These emails each included the text of the anonymous consent form (Appendix D).

Lastly, in December 2022, the survey was distributed by Esri through their “Esri News for K-12 Schools” newsletter. This newsletter reaches approximately 25,000 individuals with an Esri-reported 3% click rate of individuals expected to click one of the many links in an issue of the newsletter. The number of educators for whom this survey is appropriate is small. Given the Esri-reported click rate of this specific newsletter (2%), it can be inferred that this population is not one that commonly engages through email newsletters and may be reluctant to respond to a survey request.

Data Preparation and Screening

In the process of data preparation and screening, each survey was assigned a case number or code number by Qualtrics. No identifying information is assigned to the survey responses. A codebook of variables, values, and columns was developed from the file exported from Qualtrics to bring into SPSS. This codebook is included in Appendix G.

A total of 152 educators began the survey. A total of 104 educators began and completed the survey. Of the 104 completed surveys, 102 were able to be used in the inferential analysis. Surveys were eliminated because they included incomplete responses to multiple UTAUT construct sections, rendering the survey responses useless to this investigation.

Participant Demographic Information

An analysis of the demographic information collected is included in the section below. A total of 102 participants responded to the demographic questions. In some cases, participants did not answer a demographic question. In some cases, such as with the content area taught and the grade level taught, participants selected multiple responses, resulting in greater than 102 responses for a specific question. The demographic information collected is presented in Tables 7 and 8, and includes information for all respondents, as well as information separated by those who responded that they used GeoInquiries, and those who responded they did not use GeoInquiries. Of the 102 complete surveys, 100 responded to the question regarding GeoInquiry usage. Of those who responded, 42 did not use GeoInquiries and 58 used GeoInquiries.

The grade level, indicated by grade band, was collected for each participant. Of these participants, 63% taught in grades 9-12 (*n*=72); 23% in grades 6-8 (*n*=23); 11% in grades 3-5 (*n*=9); and 5% in grades K-2 (*n*=5). The majority of the respondents are teaching in a high school setting, and the smallest number of responses came from those teaching elementary school.

The content area taught was reported by each survey participant, as shown in Table 7. A total of 168 responses were reported by the 102 participants who responded to this question. This indicates that multiple teachers reported teaching more than one content area. Of the content areas taught by participants, 4% were elementary (*n*=6); 7% taught math (*n*=12); 29% taught science (*n*=49); 27% taught social studies (*n*=45); 5% taught English (*n*=9); 5% taught CTE (*n*=9); 12% taught technology (*n*=20); and 6% taught computer science (*n*=8). Six percent of participants reported that they taught a content area other than those specified in the survey (*n*=10). The majority of respondents taught science and social studies.

The years of teaching experience of the participants is reported in Table 7. Of those who responded to this question, 4% had 0-4 years of experience (*n*=4); 12% had 5-9 years of experience (*n*=12); 22% had 10-14 years of experience (*n*=23); 21% had 15-19 years of experience (*n*=20); and 42% reported teaching for 20 or more years (*n*=44). The majority of respondents teaching with digital mapping technologies have 20 or more years of experience.

The level of education of the participants, indicated by the degree reported, was collected for each survey participant, as shown in Table 7. Of these participants, 15% had a bachelor's degree (*n*=6); 75% had a master's degree (*n*=78); 4% had an education specialist degree (*n*=4); and 6% had a doctoral degree (*n*=6). This indicates that the largest majority of respondents are those with advanced degrees (master's and higher).

Table 7

Demographic Characteristics of the Survey Population

Baseline Characteristics	All Respondents		GeoInquiries		No GeoInquiries	
	n	%	*n*	%	*n*	%
Grade Level Taught						
K-2	6	5	2	4	4	6
3-5	10	9	4	9	6	9
6-8	26	23	14	30	12	18
9-12	72	63	27	57	45	67
Content Area Taught						
Elementary	6	4	3	4	3	3
Math	12	7	7	9	5	5
Science	49	29	24	32	25	27
Social Studies	45	27	20	27	25	27
English	9	5	3	4	6	6
CTE	9	5	2	3	7	7
Technology	20	12	5	7	15	16
Computer Science	8	5	5	7	3	3
Other	10	6	5	7	5	5
Years Teaching						
0-4	4	4	1	2	3	5
5-9	12	12	6	13	6	10
10-14	23	22	14	31	9	15
15-19	21	20	7	16	14	24
20+	44	42	17	38	27	46
Level of Education						
Bachelors	16	15	11	25	5	8
Masters	78	75	32	71	46	78
Specialist	4	4	1	2	3	6
Doctorate	6	6	1	2	5	8

Respondents were asked if they had received professional development related to digital mapping technology (see Table 8). The majority of respondents had received professional development, at 79% (*n*=82). The percentage of respondents reporting professional development received holds true for those who reported using GeoInquiries (71%), and those who reported not using GeoInquiries (85%). Of those who did not use GeoInquiries, 14% more reported not having received professional development. For those who responded that they had received professional development, the majority of respondents (36%) reported greater than 25 hours, or more than 3 days. A small proportion of respondents (14%) reported 4 or fewer hours of professional development received.

Table 8

Professional Development Received by Participants

PD Received	All Respondents		GeoInquiries		No GeoInquiries	
	n	%	*n*	%	*n*	%
PD received?						
No	22	21	13	29	9	15
Yes	82	79	32	71	50	85
Hours of PD received?						
0-4	15	14	10	22	5	8
5-8	17	16	9	20	8	14
9-16	12	12	3	8	9	15
17-24	6	6	2	4	4	7
25 +	37	36	11	24	26	44
Not Specified	17	16	10	22	7	12

It was the intent of this researcher to elicit survey responses from across the United States. The reported teaching location of each respondent is summarized in Table 9. A dot density map of participants is included in Figure 4. Respondents reported teaching in 27 unique states, along with one respondent that did not reside in the United States. Twelve respondents did not report their location. The states with the highest number of respondents were West Virginia (n=21), Virginia (n=15), Texas (n=9), and Minnesota (n=9). As reported earlier in this chapter, one of the methods of survey distribution was sharing the survey with a listserv of West Virginia educators, leading to a larger number of responses from that state.

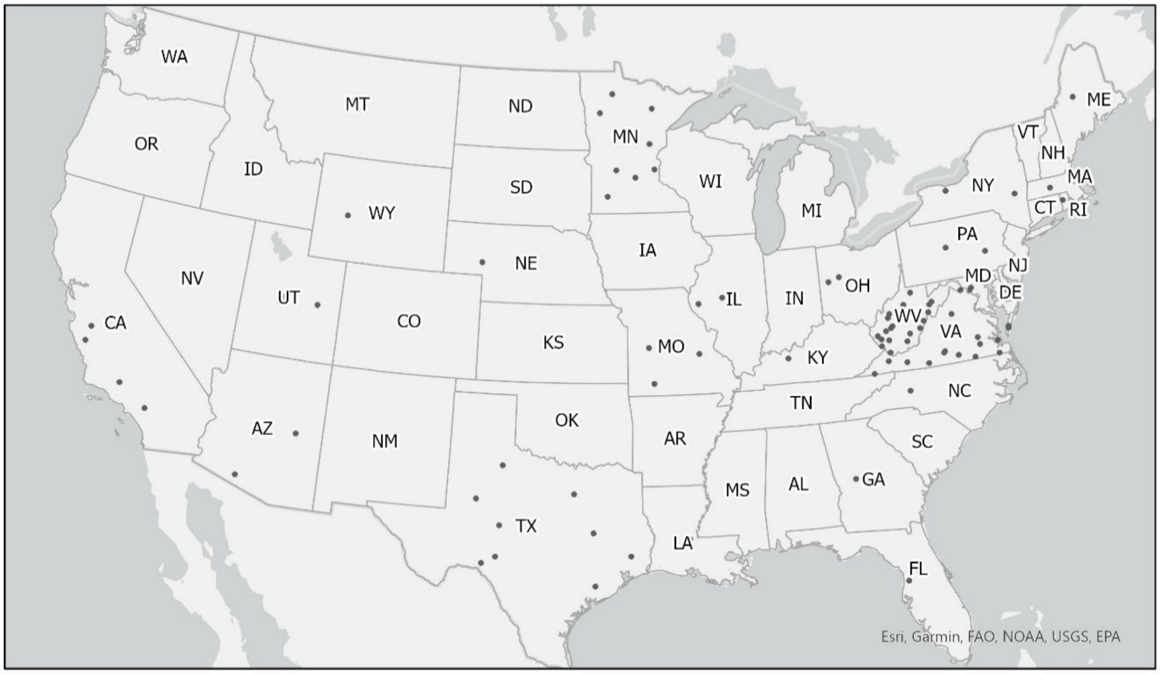
Table 9

Location Characteristics of the Survey Population

Location	All Respondents	GeoInquiries	No GeoInquiries
	n	*n*	*n*
Alaska	1	1	
Arizona	3	1	2
California	4	3	1
Delaware	1		1
Florida	2		2
Georgia	1		1
Illinois	2		2
Kentucky	1	1	
Louisiana	1		1
Maine	1		1
Maryland	2	1	1
Massachusetts	1		1
Minnesota	9	3	6
Missouri	3		3
Montana	1		1
Nebraska	1	1	
New Hampshire	1		1
New York	2		2
North Carolina	1		1
Ohio	2	1	1
Pennsylvania	2		2
Rhode Island	1	1	
Texas	9	3	6
Utah	2	1	1
Virginia	15	6	9
West Virginia	21	15	6
Wyoming	1	1	
Does not reside in US	1	1	
Total	92	40	52
Missing	12	5	7
Total	104	45	59

Figure 4

Dot Density Map of Reported Participant Locations



Note: Each dot in each state represents a survey response, not a specific location.

Research Question 1

Research question one examines the extent that performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC) predict educators' behavioral intention to use GIS/GST technologies in their classrooms. To evaluate this question, descriptive and inferential statistics were used to assess participant responses, as well as the relationship between each of the modified UTAUT constructs, the independent variables, and the dependent variable, behavioral intention (BI).

Descriptive Statistics - UTAUT

Descriptive statistics are a simple way of looking at survey responses individually. Descriptive statistics were calculated in SPSS 28 using options in the basic statistics functions of the software. This section includes the descriptive statistics for the responses to the UTAUT items. As described in Chapter Three, this survey instrument uses a 7-point Likert scale ranging from strongly disagree to strongly agree coded from 1 to 7 for each item of the modified UTAUT model constructs. For each of the modified UTAUT constructs included in this survey, performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), and behavioral intention (BI), this section presents the means, standard deviations, skewness, and kurtosis of each construct. Additionally, in the tables to follow, the frequency of specific responses for each item in each construct are included. A succinct summary of the mean value of these constructs is included in Table 10.

Table 10

Summary Descriptive Statistics of the UTAUT Constructs

Construct	*M*	*SD*	Skewness	Kurtosis
Performance Expectancy	5.64	1.18	-1.15	1.59
Effort Expectancy	5.57	1.17	-1.10	1.60
Social Influence	4.17	1.45	-0.11	-0.36
Facilitating Conditions	4.99	1.47	-0.65	-0.21
Behavioral Intention	5.30	1.62	-0.77	-0.40

Performance Expectancy

Table 11 summarizes the descriptive statistics for the performance expectancy group of items. Performance expectancy is the extent to which a user thinks that the technology will benefit their performance. The mean of all performance expectancy items, on a scale of 1 to 7, is 5.64, indicating that overall educators responded between “somewhat agree” and “agree.” A belief that digital mapping technology will benefit students (6.30) falls in the “agree” to “strongly agree” range, while a belief that digital mapping technology will improve student learning (5.88) and a belief that the technology enables more effective instruction (5.70) fall between "somewhat agree" and "agree." The lowest response, the belief that digital mapping technology will increase professional advancement (4.69), fell between "neither agree nor disagree" and "somewhat agree."

Table 11

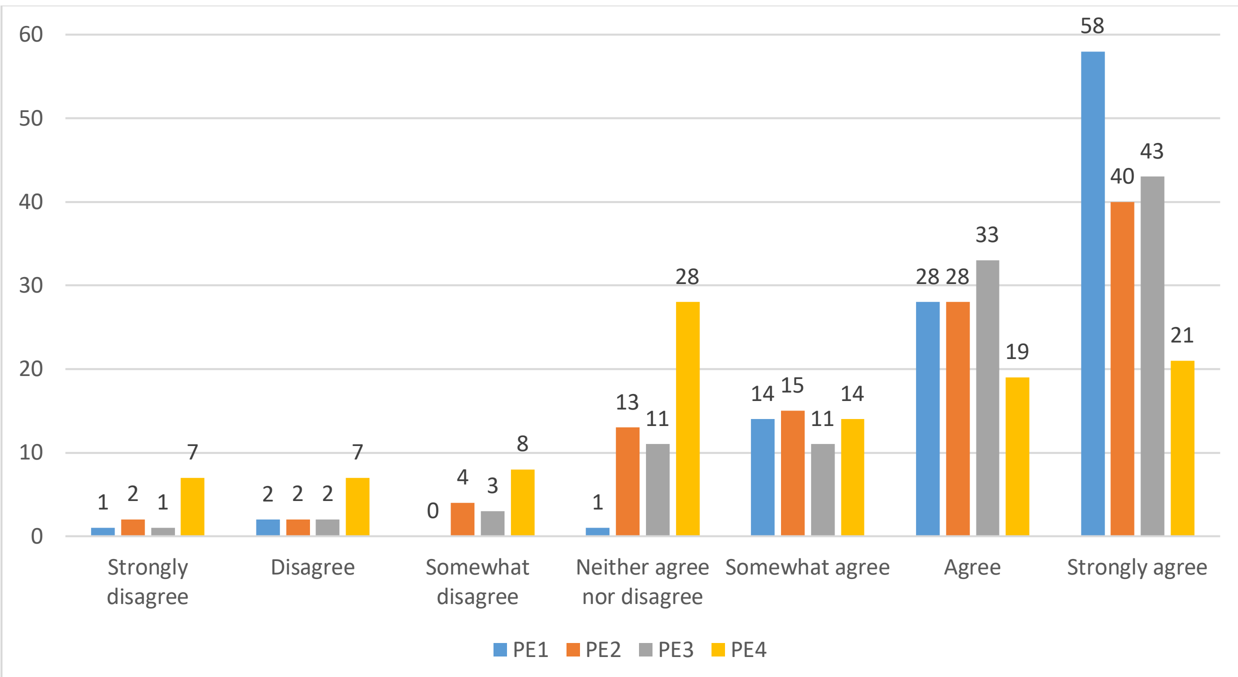
Descriptive Statistics – Performance Expectancy (PE)

Construct	Answer	*f*	%	*M*	*SD*
PE 1 - I believe that digital mapping technology will be beneficial for the students in my classroom.	Strongly disagree	1	1	6.30	1.03
	Disagree	2	2		
	Somewhat disagree	0	0		
	Neither agree nor disagree	1	1		
	Somewhat agree	14	14		
	Agree	28	27		
	Strongly agree	58	56		
PE 2 - Digital mapping technology enables me to deliver instruction more effectively in my classroom.	Strongly disagree	2	2	5.70	1.45
	Disagree	2	2		
	Somewhat disagree	4	4		
	Neither agree nor disagree	13	13		
	Somewhat agree	15	14		
	Agree	28	27		
	Strongly agree	40	39		
PE 3 - Digital mapping technology improves student learning in my classroom.	Strongly disagree	1	1	5.88	1.32
	Disagree	2	2		
	Somewhat disagree	3	3		
	Neither agree nor disagree	11	11		
	Somewhat agree	11	11		
	Agree	33	32		
	Strongly agree	43	41		
PE 4 - Using digital mapping technology in my classroom instruction increases my chance of professional advancement.	Strongly disagree	7	7	4.69	1.79
	Disagree	7	7		
	Somewhat disagree	8	8		
	Neither agree nor disagree	28	27		
	Somewhat agree	14	14		
	Agree	19	18		
	Strongly agree	21	20		

The descriptive statistics for each individual performance expectancy item are included in Table 11. The data indicate that for three out of four of the performance expectancy items, "strongly agree" was the most commonly selected response (PE1-58, PE3-43, and PE2-40). The most commonly selected response for PE4, was "neither agree nor disagree" (28). Figure 5 includes the frequency of the responses to the items related to performance expectancy.

Figure 5

Frequency of Performance Expectancy (PE) Responses



Effort Expectancy

Table 12 summarizes the descriptive statistics for the effort expectancy group of items. Effort expectancy is the amount of effort the user thinks will be required to use the technology. The mean of all effort expectancy items, on a scale of 1 to 7, is 5.57, indicating that the educators surveyed feel positively regarding effort expectancy, with the mean response falling between "somewhat agree" and "agree." The item related to a belief that it would be possible for an educator to increase their skills with digital mapping technology (6.25) falls between "agree" and strongly agree." Two item means fall in the "somewhat agree" to "agree" range – the possibility of learning to operate the digital mapping technology (5.91) and a clear understanding of the technology (5.26). The mean of the item related to the ease of use of digital mapping technology fell in the "neither agree nor disagree" to "somewhat agree" range (4.80).

Table 12

Descriptive Statistics – Effort Expectancy (EE)

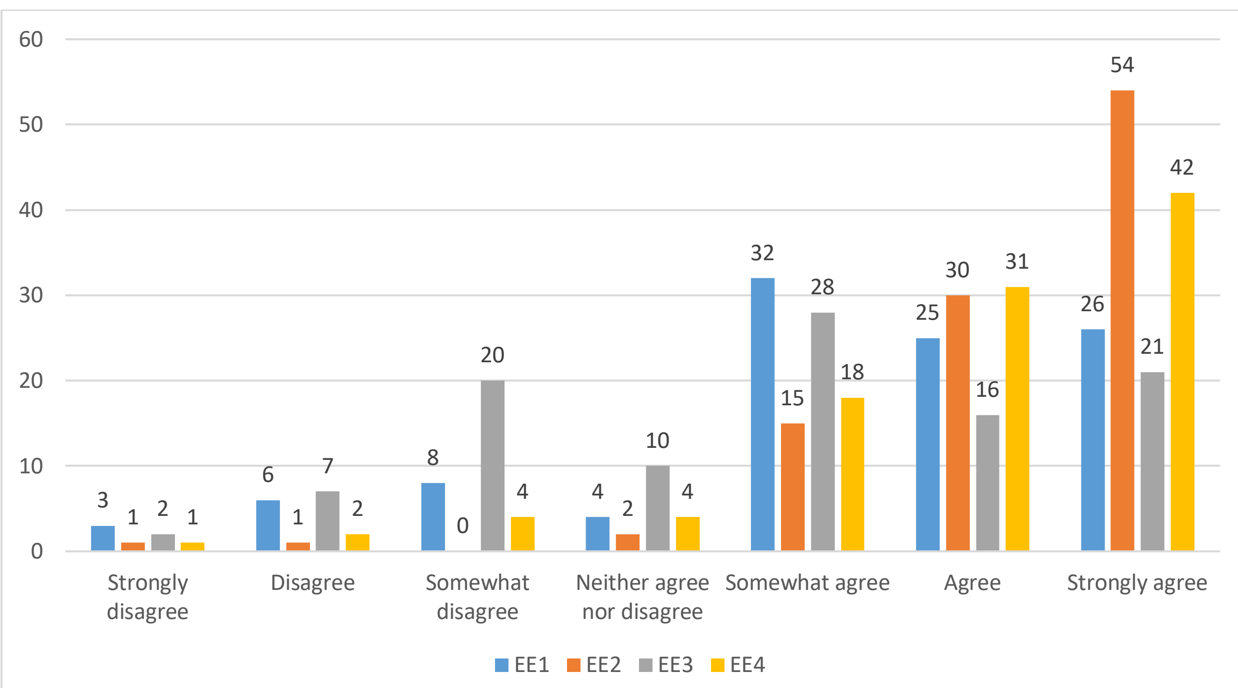
Construct	Answer	*f*	%	*M*	*SD*
EE 1 - I have a clear understanding of digital mapping technology.	Strongly disagree	3	3	5.26	1.59
	Disagree	6	6		
	Somewhat disagree	8	8		
	Neither agree nor disagree	4	4		
	Somewhat agree	32	31		
	Agree	25	24		
	Strongly agree	26	25		
EE 2 - It would be possible for me to become more skillful at using digital mapping technology in my classroom.	Strongly disagree	1	1	6.25	1.05
	Disagree	1	1		
	Somewhat disagree	0	0		
	Neither agree nor disagree	2	2		
	Somewhat agree	15	14		
	Agree	30	29		
	Strongly agree	54	52		
EE 3 - I find digital mapping technology easy to use in my classroom.	Strongly disagree	2	2	4.80	1.65
	Disagree	7	7		
	Somewhat disagree	20	19		
	Neither agree nor disagree	10	10		
	Somewhat agree	28	27		
	Agree	16	15		
	Strongly agree	21	20		

Construct	Answer	*f*	%	*M*	*SD*
EE 4 - Learning to operate digital mapping technology in my classroom is possible for me.	Strongly disagree	1	1	5.91	1.22
	Disagree	2	2		
	Somewhat disagree	4	4		
	Neither agree nor disagree	4	4		
	Somewhat agree	18	17		
	Agree	31	30		
	Strongly agree	42	40		

The descriptive statistics for each individual effort expectancy item are included in Table 12. The data indicate that for two items (EE2-54 and EE4-42), the most commonly selected response is “strongly agree.” The most commonly selected response for the remaining two effort expectancy items is “somewhat agree” (EE1-32 and EE3-28). Figure 6 includes the frequency of the responses to the items related to effort expectancy.

Figure 6

Frequency of Effort Expectancy (EE) Responses



Social Influence

Table 13 summarizes the descriptive statistics for the social influence group of items. Social influence is the extent to which a user thinks that others in their social circle think they should use the new technology. The mean of all social influence items, on a scale of 1 to 7, is 4.17, indicating that the educators surveyed feel somewhat neutral regarding social influence. The mean of three of the four social influence items falls between "neither agree nor disagree" and "somewhat agree." Important people influencing the use of the new technology (4.53), a supportive school community (4.42), and influential people who think educators should use the technology (4.07) fall into this range. The item related to the presence of a principal encouraging the technology usage (3.66) falls into the "somewhat disagree" to "neither agree nor disagree" range.

Table 13

Descriptive Statistics – Social Influence (SI)

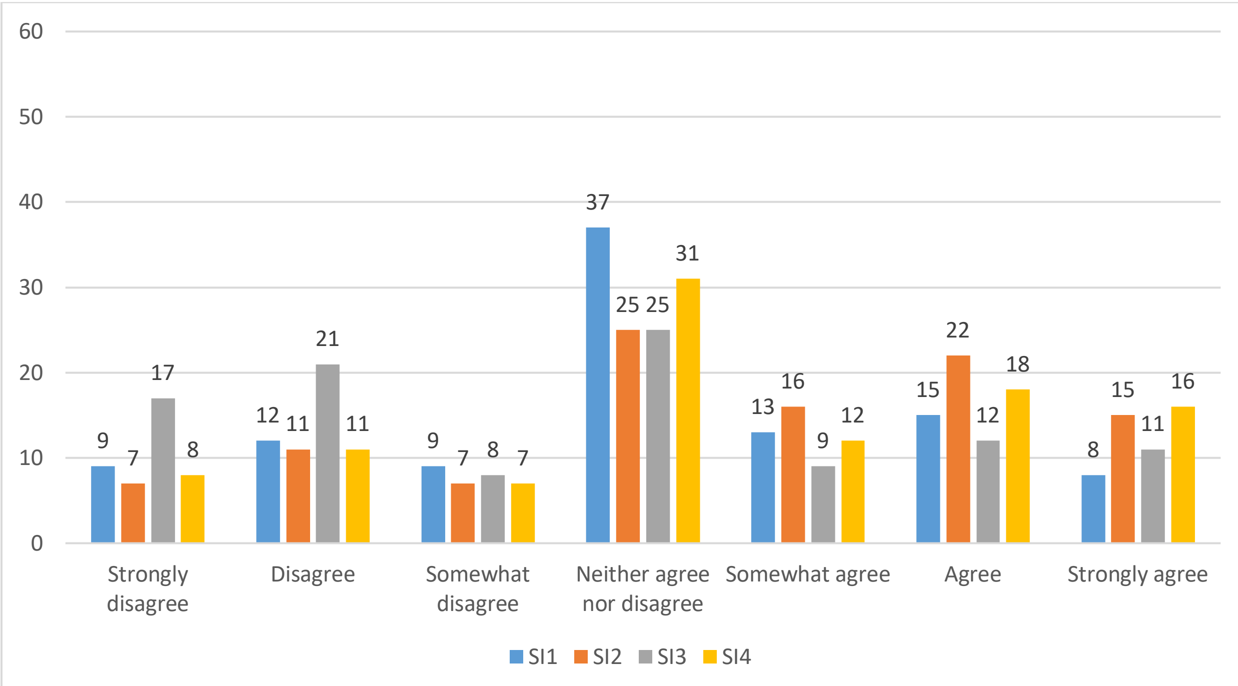
Construct	Answer	*f*	%	*M*	*SD*
SI 1 - People who influence my classroom behavior think that I should use digital mapping technology.	Strongly disagree	9	9	4.07	1.664
	Disagree	12	12		
	Somewhat disagree	9	9		
	Neither agree nor disagree	37	36		
	Somewhat agree	13	13		
	Agree	15	14		
	Strongly agree	8	8		
SI 2 - People who are important to me think that I should use digital mapping technology in my classroom.	Strongly disagree	7	7	4.53	1.781
	Disagree	11	11		
	Somewhat disagree	7	7		
	Neither agree nor disagree	25	24		
	Somewhat agree	16	15		
	Agree	22	21		
	Strongly agree	15	14		

Construct	Answer	*f*	%	*M*	*SD*
SI 3 - The principal of my school has been encouraging in the use of digital mapping technology in my classroom.	Strongly disagree	17	16	3.66	1.953
	Disagree	21	20		
	Somewhat disagree	8	8		
	Neither agree nor disagree	25	24		
	Somewhat agree	9	9		
	Agree	12	12		
	Strongly agree	11	11		
SI 4 - In general, my school community has supported the use of digital mapping technology in my classroom.	Strongly disagree	8	8	4.42	1.807
	Disagree	11	11		
	Somewhat disagree	7	7		
	Neither agree nor disagree	31	30		
	Somewhat agree	12	12		
	Agree	18	17		
	Strongly agree	16	15		

The descriptive statistics for each individual social influence item are included in Table 13. The data indicate that the most commonly selected response for each social influence items is "neither agree not disagree" (SI1- 37, SI4-31, SI2-25, and SI3-25). Figure 7 includes the frequency of responses to the social influence items.

Figure 7

Frequency of Social Influence (SI) Responses



Facilitating Conditions

Table 14 summarizes the descriptive statistics for the facilitating conditions group of items. Facilitating conditions are the factors in the user's environment that make the technology simple to employ. The mean of all facilitating conditions items, on a scale of 1 to 7, is 4.99, indicating that overall educators "somewhat agree" with the statements regarding facilitating conditions. Two of the facilitating conditions items have means that fall between "somewhat agree" and "agree." The compatibility of the digital mapping technology with other resources (5.33) and having the knowledge necessary to use the technology (5.16) fall within this range. The remaining two facilitating conditions items have means that fall between "neither agree nor disagree" and "somewhat agree." Having the resources necessary to use digital mapping technology (4.98) and having a specific person or group to assist with digital mapping technology (4.49) fall in this range.

Table 14

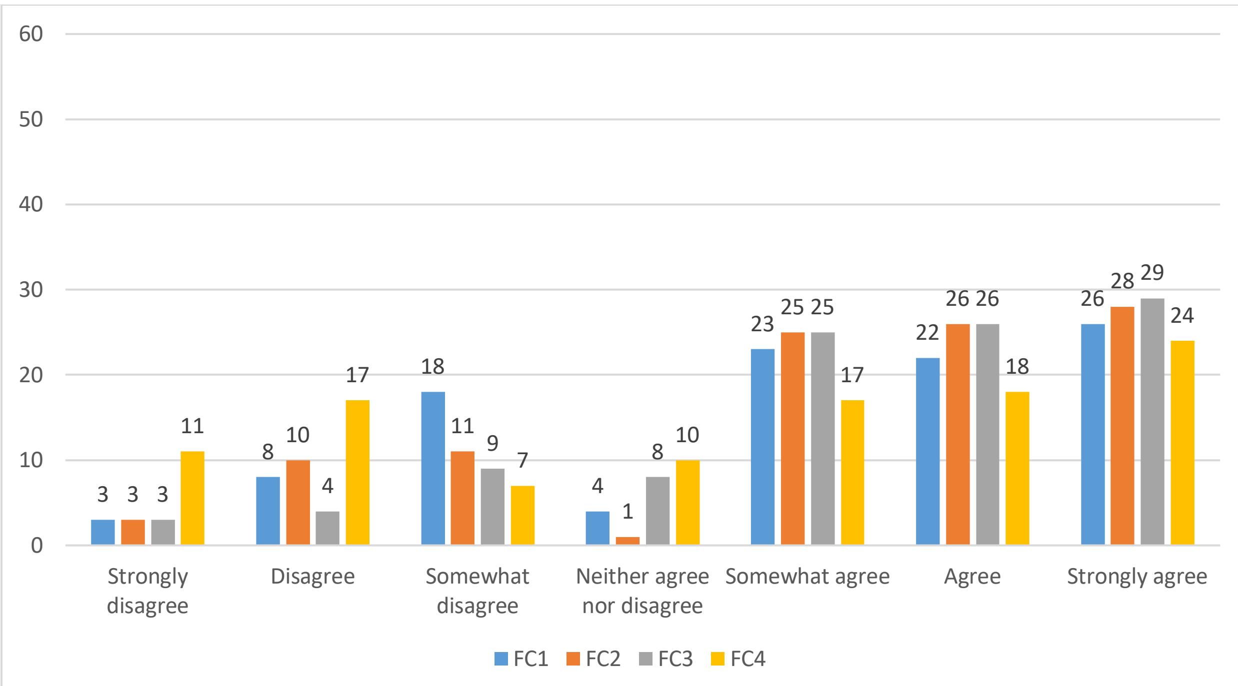
Descriptive Statistics – Facilitating Conditions (FC)

Construct	Answer	*f*	%	*M*	*SD*
FC 1 - I have the resources necessary to use digital mapping technology in my classroom.	Strongly disagree	3	3	4.98	1.77
	Disagree	8	8		
	Somewhat disagree	18	17		
	Neither agree nor disagree	4	4		
	Somewhat agree	23	22		
	Agree	22	21		
	Strongly agree	26	25		
FC 2 - I have the knowledge necessary to use digital mapping technology integration in my classroom.	Strongly disagree	3	3	5.16	1.76
	Disagree	10	10		
	Somewhat disagree	11	11		
	Neither agree nor disagree	1	1		
	Somewhat agree	25	24		
	Agree	26	25		
	Strongly agree	28	27		
FC 3 - Digital mapping technology in my classroom is compatible with other resources I use.	Strongly disagree	3	3	5.33	1.59
	Disagree	4	4		
	Somewhat disagree	9	9		
	Neither agree nor disagree	8	8		
	Somewhat agree	25	24		
	Agree	26	25		
	Strongly agree	29	28		
FC 4 - A specific person (or organization, or group) is available to assist me with digital mapping technology difficulties that may arise in my classroom.	Strongly disagree	11	11	4.49	2.10
	Disagree	17	16		
	Somewhat disagree	7	7		
	Neither agree nor disagree	10	10		
	Somewhat agree	17	16		
	Agree	18	17		
	Strongly agree	24	23		

The descriptive statistics for each facilitating conditions item are included in Table 14. The data indicate that the most commonly selected response for the facilitating conditions items is "strongly agree" (FC3-29, FC2-28, FC1-26, and FC4-24). Figure 8 includes the frequency of responses to the items related to facilitating conditions.

Figure 8

Frequency of Facilitating Conditions (FC) Responses



Behavioral Intention

Table 15 summarizes the descriptive statistics for the behavioral intention group of items. Behavioral intention is the user's intention to use the technology in a given time period. For this investigation, behavioral intention serves as the dependent variable.

The mean of all behavioral intention items, on a scale of 1 to 7, is 5.30, indicating overall educator agreement with the statements regarding behavioral intention. Three of the means of the behavioral intention items fall between “somewhat agree” and “agree.” The recommendation that other educators use digital mapping technology (5.57), the plan to use the technology to a greater degree in the future (5.41), and the prediction that the educator will use the technology in the next 12 months (5.39) fall in this range. One of the means of the behavioral intention items falls between “neither agree nor disagree” and “somewhat agree.” Integrating digital mapping technology into classroom instruction in the last 12 months (4.87) falls in this range.

Table 15

Descriptive Statistics – Behavioral Intention (BI)

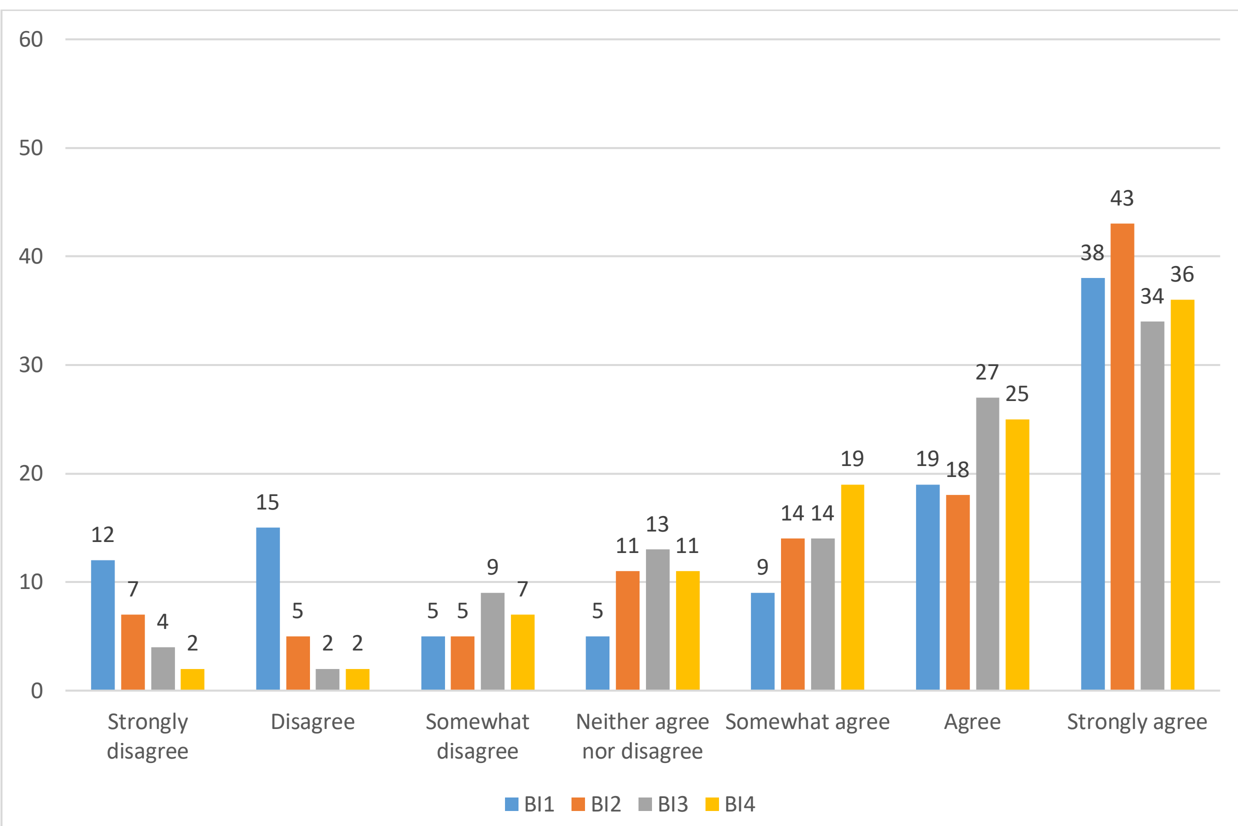
Construct	Answer	*f*	%	*M*	*SD*
BI 1 - I have integrated digital mapping technology in my classroom instruction in the last 12 months.	Strongly disagree	12	12	4.87	2.26
	Disagree	15	14		
	Somewhat disagree	5	5		
	Neither agree nor disagree	5	5		
	Somewhat agree	9	9		
	Agree	19	18		
	Strongly agree	38	37		
BI 2 - I predict I will continue to use digital mapping technology integration in my classroom instruction in the next 12 months.	Strongly disagree	7	7	5.39	1.89
	Disagree	5	5		
	Somewhat disagree	5	5		
	Neither agree nor disagree	11	11		
	Somewhat agree	14	14		
	Agree	18	17		
	Strongly agree	43	41		
BI 3 - I plan to use digital mapping technology to a greater degree in my classroom instruction in the future.	Strongly disagree	4	4	5.41	1.65
	Disagree	2	2		
	Somewhat disagree	9	9		
	Neither agree nor disagree	13	13		
	Somewhat agree	14	14		
	Agree	27	26		
	Strongly agree	34	33		

Construct	Answer	*f*	%	*M*	*SD*
BI 4 - I will recommend other people integrate digital mapping technology in their classroom instruction.	Strongly disagree	2	2	5.57	1.49
	Disagree	2	2		
	Somewhat disagree	7	7		
	Neither agree nor disagree	11	11		
	Somewhat agree	19	18		
	Agree	25	24		
	Strongly agree	36	35		

The descriptive statistics for each individual behavioral intention item are included in Table 15. The data indicate that the most commonly selected response for the facilitating conditions items is "strongly agree" (FC2-43, FC1-38, FC4-36, and FC3-34). Figure 9 includes the frequency of the responses to the items related to behavioral intention.

Figure 9

Frequency of Behavioral Intention (BI) Responses

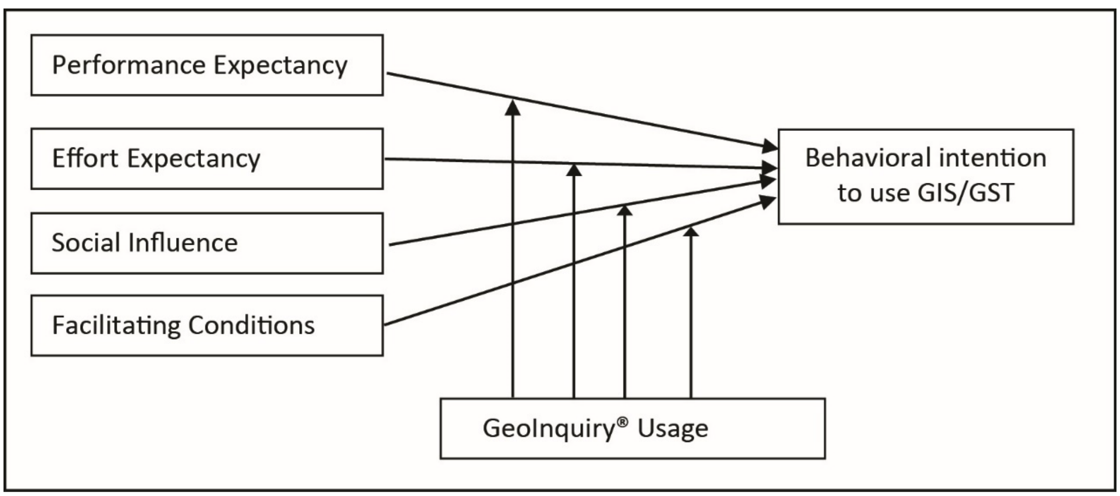


Inferential Statistical Test Results - UTAUT

Inferential statistics were calculated in SPSS using the bivariate correlation and linear regression options in the analysis section of the program, yielding the significance of the effects of and relationships between the modified UTAUT constructs in this study, the independent variables (performance expectancy, effort expectance, social influence, and facilitating conditions) and the dependent (behavioral intention) variable. Figure 10 illustrates the relationship between the four independent variables and the dependent variable, along with a potential moderating variable. The moderation variable will be discussed later in this chapter.

Figure 10

Model of Modified UTAUT Framework



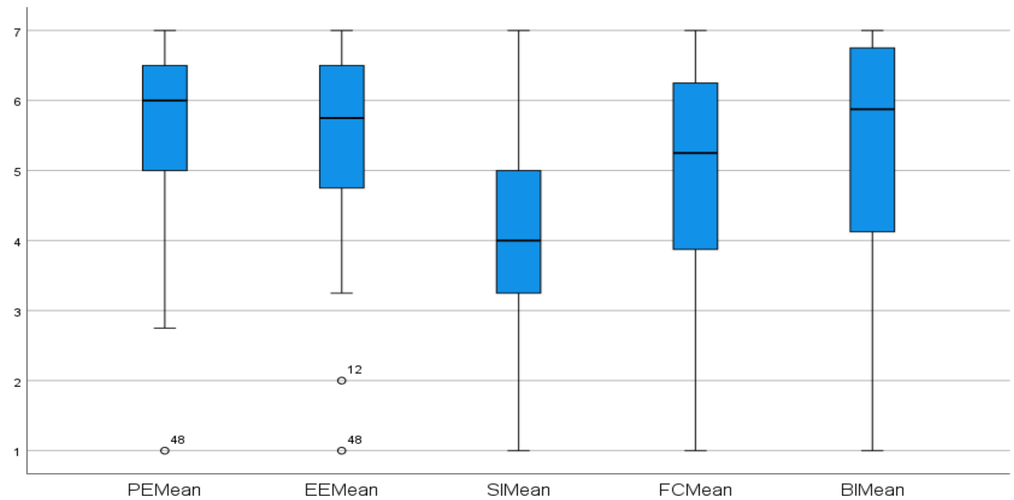
Note: This model was adapted from Venkatesh et al. (2003).

Prior to evaluating the inferential statistics, the data were evaluated to ensure it met the assumptions for regression analysis. As such, the data were plotted using a box plot, as shown in Figure 11. The box plot indicates the inter-quartile range of the mean values of each UTAUT construct within each box, as well as the upper and lower quartiles of the range of values.

Outliers are also indicated on the box plot as labeled points. The box plot indicates three outliers, representing two survey responses, that could influence the regression analysis.

Figure 11

Boxplot of Modified UTAUT Means



To make a decision regarding action to take with the outliers, z scores were calculated to identify the univariate outliers by yielding the number of standard deviations the value is removed from the mean. These z-scores were evaluated and flagged if they were greater than three for any given variable (Beyer, 2021). In record 48 the respondents chose the answer "strongly disagree" for 20 out of 24 answers and "strongly agree" for the remaining answers on the UTAUT constructs. Record twelve has a z-value over three for effort expectancy. Given the small sample size, it was determined that these two records could adversely impact the regression analysis and they were removed from the inferential statistics analysis.

To evaluate the suitability of the items in the constructs for analysis with inferential statistics, using methods similar to Kropf (2018) and Ssekibaamu (2015), a Durbin-Watson test was performed to test independence of observations. The Durbin-Watson statistic should fall between 1.5 and 2.5 (Durbin-Watson Statistic, 2013), which indicates that there is no autocorrelation among the items in the modified UTAUT constructs. The Durbin-Watson score for this regression model is 1.549, as shown in Table 16, indicating the data are appropriate for inferential analysis.

Table 16

Durbin-Watson Test Results for BI And Modified UTAUT Variables

Model	*R*	R^2	*Adj.* R^2	*SD*	Durbin-Watson
1	.738	0.545	0.525	1.04736	1.549

Note. The predictors in this model were FCMean, PEMean, SIMean, and EEMean. The dependent variable was BIMean.

While Cronbach's Alpha was calculated for the entire survey, as reported in Chapter Three, Cronbach's Alpha was also calculated for each set of UTAUT constructs to demonstrate reliability within the constructs, as well as overall. The resulting Cronbach's Alpha data is found in Table 17 and indicates appropriate values for Cronbach's Alpha for each construct.

Table 17

Reliability Analysis for Individual UTAUT Constructs

Scale	*n*	Cronbach's Alpha
Performance Expectancy	4	0.813
Effort Expectancy	4	0.804
Social Influence	4	0.822
Facilitating Conditions	4	0.806
Behavioral Intention	4	0.884

To ensure that the variables did not have highly correlated values (multicollinearity), which would make it difficult to determine which predictor variable led to changes in the dependent variable, the VIF or Variance Inflation Factor, was calculated. All VIF values should fall below five, and the calculated tolerance values should be more than 0.01 for all variables (Hair, 2010). The results of this analysis are shown in Table 18.

Table 18

Partial Table of Coefficients – Tolerance, VIF

		Collinearity Statistics	
Model		Tolerance	VIF
1	PEMean	.443	2.258
	EEMean	.327	3.060
	SIMean	.471	2.124
	FCMean	.345	2.900

Note. The dependent variable for this analysis is BIMean

Research Hypotheses

The research hypotheses that relate to Research Question 1 are:

1. H1: Performance expectancy positively affects educators' behavioral intent to use GIS/GST classroom integration.
2. H2: Effort expectancy positively affects educators' behavioral intent to use GIS/GST classroom integration.
3. H3: Social influence positively affects educators' behavioral intent to use GIS/GST classroom integration.
4. H4: Facilitating conditions positively affect educators' behavioral intent to use GIS/GST classroom integration.

Replicating the methods of multiple researchers (Alghamdi, 2020; Kropf, 2018; Ssekibaamu, 2015), both parametric and non-parametric statistics were used for correlation analysis. Both Pearson r and Spearman *rho* were calculated for each construct and its relationship with behavioral intention. Tests for correlation analysis were chosen based on tests used in other applications of the UTAUT models. While regression for UTAUT has been approached in several ways, a review of Attuquayefio (2019) led the researcher to calculate the Pearson r and Spearman *rho*, in addition to the linear regression.

Correlation analysis was performed using the Pearson r correlation in the SPSS software. This allowed the researcher to determine if there was any linear relationship between each independent variable (performance expectancy, effort expectancy, social influence, and facilitating conditions) and the dependent variable (behavioral intention). Pearson r correlation coefficient values fall between -1 and +1. A perfect positive correlation is indicated by +1, a perfect negative correlation is indicated by -1. No correlation is indicated by a 0 (Cronk, 2016). A Pearson r correlation coefficient was calculated for each independent variable with the dependent variable (behavioral intention).

Correlation analysis was also performed using Spearman's rank-order correlation, or Spearman *rho*. A Spearman *rho* is a non-parametric test that indicates the strength and the direction of the relationship between two variables. Spearman correlation coefficient values fall between -1 and +1. A score close to 0 indicates a weak relationship, while scores close to -1 or +1 indicate a strong relationship. Correlations greater than ±0.7 are strong, between ±0.3 and ±0.7 are moderate, and weak relationships score below ±0.3. A perfect positive correlation is indicated by +1, a perfect negative correlation is indicated by -1. A very weak correlation is indicated by a score close to 0 (Cronk, 2016).

A linear regression was calculated for each hypothesis. Linear regression allows for the prediction of one variable from another. Namely, linear regression allows the researcher to explain the proportion of the variance in the dependent variable that can be explained by change in the independent variable. Linear regression will also yield the significance value, as well as those of R, R^2, and adjusted R^2 (Cronk, 2016).

The results of the Pearson, Spearman *rho*, and linear regression tests are summarized in Table 19.

Table 19

Pearson, Spearman rho, and Linear Regression Results

		Pearson Correlation BI Mean	Spearman Correlation BI Mean	*R*	R^2	*Adj.* R^2	*F*	*Sig*
PEMean	Corr.	.670**	.670**	.670	0.449	0.444	79.9	<.001
	Sig.	<.001	<.001					
	N	100	100					
EEMean	Corr.	.656**	.684**	.656	0.431	0.425	72.6	<.001
	Sig.	<.001	<.001					
	N	98	98					
SIMean	Corr.	.548**	.575**	.548	0.3	0.293	41.6	<.001
	Sig.	<.001	<.001					
	N	99	99					
FCMean	Corr.	.628**	.626**	.628	0.395	0.388	63.9	<.001
	Sig.	<.001	<.001					
	N	100	100					

Performance Expectancy and Behavioral Intention (H1)

Hypothesis one states that performance expectancy positively affects educators' behavioral intent to use GIS/GST classroom integration.

A Pearson correlation coefficient was calculated for the relationship between mean performance expectancy (PE) and mean behavioral intention (BI). The results are shown in Table 19. A moderate positive correlation was found (r (98) = .670, p <.001), indicating a statistically significant positive linear relationship between the two variables. A Spearman *rho* correlation coefficient was calculated for the same relationship. The results of this test are included in Table 19. A moderate positive correlation was found (*rho* (98) = .670, p <.001). A significant regression equation was found (F (1,98) = 79.9, $p < .001$) with an R^2 of .449. Performance expectancy explained 45% of the variance in educators' behavioral intention to use digital mapping technology in the future. Educators with an expectation that digital mapping technologies will benefit their classroom instruction are more likely to have an intent to use digital mapping technology in their classrooms in the future. Hypothesis one is supported.

Effort Expectancy and Behavioral Intention (H2)

Hypothesis 2 states that effort expectancy positively affects educators' behavioral intent to use GIS/GST classroom integration.

A Pearson correlation coefficient was calculated for the relationship between mean effort expectancy (EE) and mean behavioral intention (BI). The results are shown in Table 19. A moderate positive correlation was found (r (96) = .656, p <.001), indicating a statistically significant positive linear relationship between the two variables. A Spearman *rho* correlation coefficient was calculated for the same relationship. The results of this test are included in Table 19. A moderate positive correlation was found (*rho* (96) = .684, p <.001). A significant regression equation was found (F (1,96) = 72.6, $p < .001$) with an R^2 of .431. Effort expectancy explained 43% of the variance in educators' behavioral intention to use digital mapping technology in the future. Educators with an expectation that it will be possible and easy for them to integrate digital mapping technologies in their classroom instruction are more likely to have an intent to use digital mapping technology in their classrooms in the future. Hypothesis two is supported.

Social Influence and Behavioral Intention (H3)

Hypothesis 3 states that social influence positively affects educators' behavioral intent to use GIS/GST classroom integration.

A Pearson correlation coefficient was calculated for the relationship between mean social influence (SI) and mean behavioral intention (BI). The results are shown in Table 19. A moderate positive correlation was found (r (97) = .548, p <.001), indicating a statistically significant positive linear relationship between the two variables. A Spearman *rho* correlation coefficient was calculated for the same relationship. The results of this test are included in Table 19. A moderate positive correlation was found (*rho* (97) = .575, p <.001). A significant regression equation was found (F (1,97) = 41.6, p < .001) with an R^2 of .3. Social influence explained 30% of the variance in educators' behavioral intention to use digital mapping technology in the future. Educators with individuals around them who believe they should use digital mapping technologies in their classroom instruction are more likely to have an intent to use digital mapping technology in their classrooms in the future. Hypothesis three is supported.

Facilitating Conditions and Behavioral Intention (H4)

Hypothesis 4 states that facilitating conditions positively affect educators' behavioral intent to use GIS/GST classroom integration.

A Pearson correlation coefficient was calculated for the relationship between mean facilitating conditions (FC) and mean behavioral intention (BI). The results are shown in Table 19. A moderate positive correlation was found (r (98) = .628, p <.001), indicating a statistically significant positive linear relationship between the two variables. A Spearman *rho* correlation coefficient was calculated for the same relationship. The results of this test are included in Table 19. A moderate positive correlation was found (*rho* (98) = .626, p <.001). A significant regression equation was found (F (1,98) = 63.9, $p < .001$) with an R^2 of .395. Facilitating conditions explained 40% of the variance in educators' behavioral intention to use digital mapping technology in the future. Educators with support for the use of digital mapping technologies in their classroom instruction are more likely to have an intent to use digital mapping technology in their classrooms in the future. Hypothesis four is supported.

Research Question 1 Summary

Research question one examined the extent that performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC) predict educators' behavioral intention to use GIS/GST technologies in their classrooms. The descriptive statistics section of this chapter demonstrated that respondents had a generally positive response to the modified UTAUT statements regarding integrating digital mapping technologies into classroom instruction. The inferential statistics section of this chapter demonstrates that there is a statistically significant relationship between each of the independent variables and the dependent variable, though the strength of these relationships is each classified as moderate. A summary of the hypotheses for research question 1 can be found in Table 20.

Table 20

Research Question 1 Hypothesis Summary

Hypothesis	Finding
H1: Performance expectancy positively affects educators' behavioral intent to use GIS/GST classroom integration.	Supported
H2: Effort expectancy positively affects educators' behavioral intent to use GIS/GST classroom integration.	Supported
H3: Social influence positively affects educators' behavioral intent to use GIS/GST classroom integration.	Supported
H4: Facilitating conditions positively affect educators' behavioral intent to use GIS/GST classroom integration.	Supported

Research Question 2

Research question two examines whether GeoInquiry usage moderates the relationships among performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), and educators' behavioral intention (BI) to use GIS/GST in their classrooms. To evaluate this question, descriptive and inferential statistics were used to assess participant responses, as well as the relationship between each of the modified UTAUT constructs, the independent variables, the dependent variable, behavioral intention (BI), and the moderator, GeoInquiry usage.

Descriptive Statistics – GeoInquiry Usage

This section includes descriptive statistics for the GeoInquiry Usage items. Descriptive outputs were obtained in SPSS by using options in the statistics functions. As described in Chapter Three, this section of the survey instrument includes a single Yes / No response regarding GeoInquiry usage and items with answers that include ranges of values related to GeoInquiry usage. The frequency of specific responses for each item are included in Table 21.

The first question in this section of the survey related to whether educators had used GeoInquiries in their classroom instruction. Of those that responded to this question (*n*=100), 58% had used GeoInquiries in their instruction, and 42% had not, as reported in Table 21.

The data related to the number of GeoInquiries an educator has used is also reported in Table 21. These data are summarized in Figure 12. Of the 58 educators who reported using GeoInquiries, 13% had only ever used 1 GeoInquiry (*n*=7); 23% had used 2 (*n*=13); 16% had used 3 (*n*=9); 5% had used 4 (*n*=3); 4% had used 5 (*n*=2); and 39% had used 6 or more different GeoInquiries in classroom instruction (*n*=22).

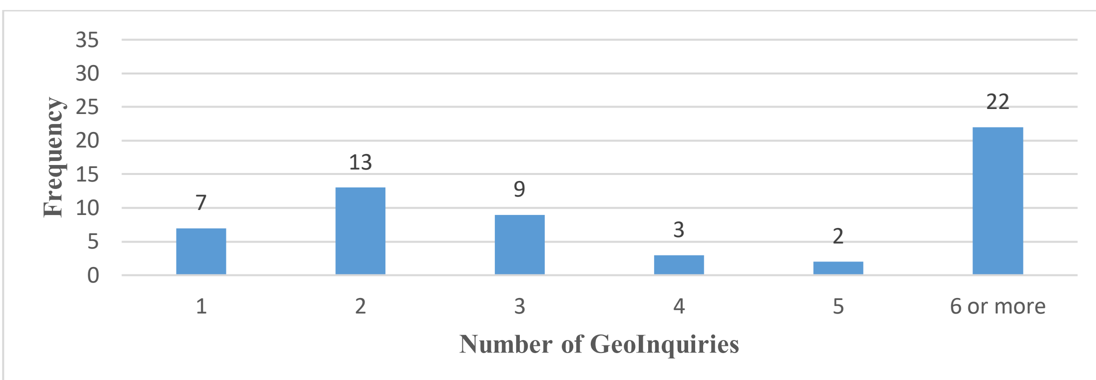
Table 21

Descriptive Statistics – GeoInquiry Usage

Item	Answer	*f*	%
Have you used GeoInquiries in your instruction?			
	No	42	42
	Yes	58	58
How many individual, or different, GeoInquiries have you used?			
	1	7	13
	2	13	23
	3	9	16
	4	3	5
	5	2	4
	6 or more	22	39

Figure 12

Frequency of Individual GeoInquiries Reported Used



The data related to the total number of times that an educator used GeoInquiries in the 2021-2022 school year is reported in Table 22. These data are summarized in Figure 13. Forty-six percent of educators used a GeoInquiry between 1 and 5 times (*n*=25). An additional 15% used a GeoInquiry between 6 and 10 times (*n*=8); 11% between 11 and 15 times (*n*=6); 15%

between 16 and 20 times (*n*=8); and 13% reported using a GeoInquiry more than 20 times in a school year (*n*=7).

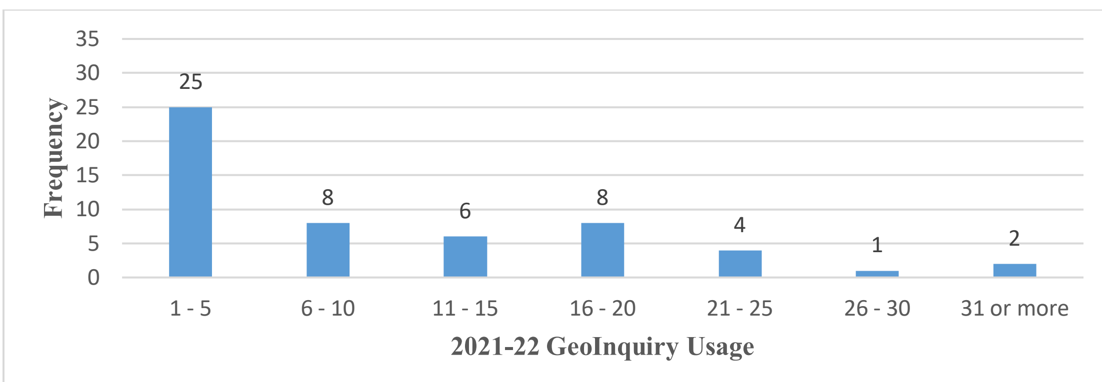
Table 22

Descriptive Statistics – GeoInquiry Usage

Item	Answer	*f*	%
How many times did you use GeoInquiries in the last school year 2021-2022?			
	1 - 5	25	46
	6 - 10	8	15
	11 - 15	6	11
	16 - 20	8	15
	21 - 25	4	7
	26 - 30	1	2
	31 or more	2	4

Figure 13

Frequency of GeoInquiry Usage in 2021-2022



The data related to the number of years that an educator has used GeoInquiries is reported in Table 23. These data are summarized in Figure 14. These data indicate that the distribution of those who have used GeoInquiries is spread out over the last eight years. The greatest number of respondents (*n*=10) had only used GeoInquiries in the last year. Nine educators had used

GeoInquiries for three or four years and eight educators had used GeoInquiries for two or eight years. Six educators had used the resource for five years and five educators for six years.

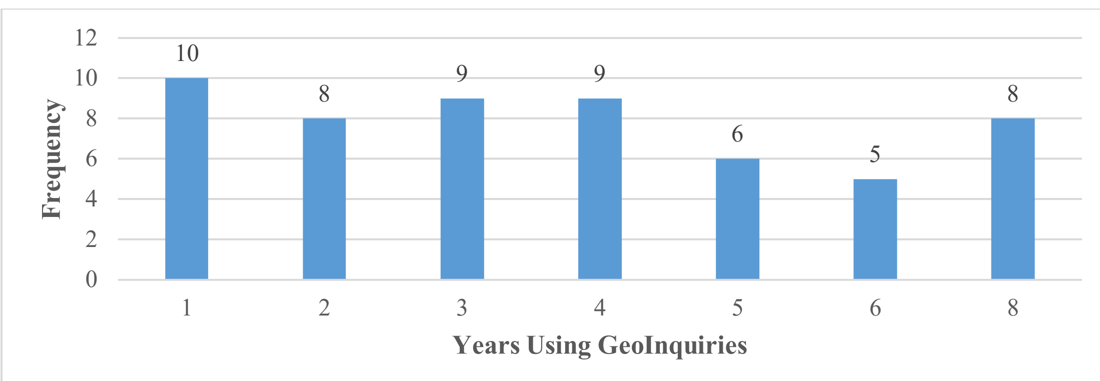
Table 23

Descriptive Statistics – GeoInquiry Usage

Item	Answer	*f*	%
For how many years have you used GeoInquiries in your classroom instruction?			
	1	10	18
	2	8	15
	3	9	16
	4	9	16
	5	6	11
	6	5	9
	8	8	15

Figure 14

Frequency of Years Using GeoInquiries



The data related to the average number of times an educator uses GeoInquiries during the year is reported in Table 24. These data are summarized in Figure 15. These data indicate that the majority of educators reported only using GeoInquiries between 1 and 5 times per year (n=33, 60%). Few educators reported using GeoInquiries more than twenty times per year.

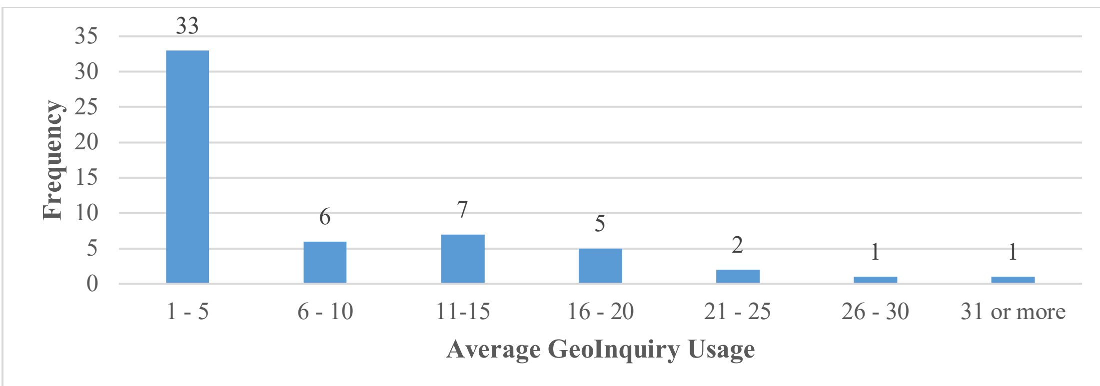
Table 24

Descriptive Statistics – GeoInquiry Usage

Item	Answer	*f*	%
On average, how many times do you use a GeoInquiry each year?			
	1 - 5	33	60
	6 - 10	6	11
	11-15	7	12
	16 - 20	5	9
	21 - 25	2	4
	26 - 30	1	2
	31 or more	1	2

Figure 15

Average GeoInquiry Usage



Moderation Analysis

Moderation Analysis was performed for each of the modified UTAUT constructs as each relates to the behavioral intention construct using two methods, (1) an independent samples t-test and (2) the PROCESS Macro (Hayes, 2022). Moderation analysis allows a researcher to explain variability of models for different circumstances. A moderator is a variable that is used to examine the strength of a relationship between an independent and a dependent variable. Baron and Kenny (1986) define a moderator as “a qualitative (e.g., sex, race, class) or quantitative (e.g., level of reward) variable that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable” (p.1174). A moderator hypothesis is supported if the interaction between the independent and the dependent variables is significantly different than the same interaction without the moderator (Baron & Kenny, 1986). The results for these two methods are in the sections to follow.

Independent Samples T-Test

An independent samples t-test was used to test for significant differences in the mean scale values for each of the modified UTAUT independent variables (performance expectancy, effort expectance, social influence, and facilitating conditions) and the dependent (behavioral intention) variable. The two groups tested in the independent samples t-test were those who reported that they had used GeoInquiries and those who did not report using GeoInquiries. T-test group statistics are reported in Table 25 and Figure 16. Table 26 includes the results of the t-test for equality of means.

Table 25

Mean of Yes/No GeoInquiry Usage Response for Modified UTAUT Constructs

Have you used GeoInquiries in your instruction?		*N*	*M*	*SD*	*Std. Error M*
PEMean	No	42	5.53	0.96	0.15
	Yes	58	5.81	1.10	0.15
EEMean	No	41	5.26	1.10	0.17
	Yes	57	5.92	0.90	0.12
SIMean	No	41	3.88	1.32	0.21
	Yes	58	4.34	1.52	0.20
FCMean	No	42	4.57	1.54	0.24
	Yes	58	5.40	1.21	0.16
BIMean	No	42	4.74	1.62	0.25
	Yes	57	5.85	1.32	0.17

Figure 16

Mean of Yes/No GeoInquiry Usage Response for Modified UTAUT Constructs

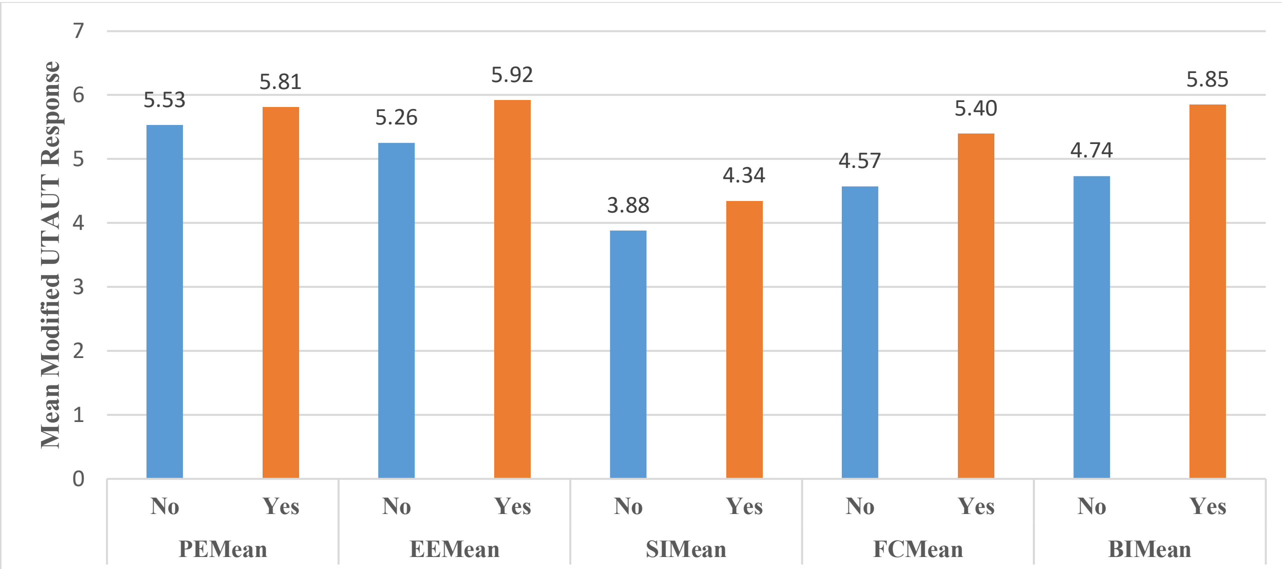


Table 26

T-test for Equality of Means

	Levene's Test for Equality of Variances				Significance			95% Confidence Interval of the Difference	
	F	*Sig.*	*t*	*df*	Two-Sided p	Mean Diff.	Std. Error Diff.	Lower	Upper
PEMean	0.597	0.44	-1.32	98	0.189	-0.28	0.21	-0.70	0.14
EEMean	3.084	0.08	-3.29	96	**0.001**	-0.66	0.20	-1.07	-0.26
SIMean	1.016	0.32	-1.59	97	0.115	-0.47	0.29	-1.05	0.12
FCMean	3.13	0.08	-3.01	98	**0.003**	-0.83	0.27	-1.37	-0.28
BIMean	5.147	0.03	-3.76	97	**<0.001**	-1.11	0.30	-1.70	-0.53

Note. Equal variances assumed for all calculations, $p<0.05$. Significant values bolded.

While the difference in means between groups is produced by the t-test and demonstrates a higher mean for all constructs for the group of educators who had used GeoInquiries, the results of the independent samples t-test are used to determine the significance of the differences in the mean scale values as reported in Table 26 and shown in Figure 16. The t-test yielded significant differences in the means of the two groups for effort expectancy (EE, p=0.001), facilitating conditions (FC, p=0.003), and the dependent variable, behavioral intention (BI, p<0.001). Significant differences were not found for performance expectancy (PE) or social influence (SI).

Performance Expectancy as Moderated by GeoInquiry Usage Only

An independent samples t-test comparing the mean scores of the GeoInquiry group and the No GeoInquiry group was performed for the mean performance expectancy (PE) construct. No significant difference was found (t (98) = -1.32, p >.05). The mean of the No GeoInquiry group (M = 5.53, sd = .96) was not significantly different from the mean of the GeoInquiry Group (M = 5.81, sd = 1.10).

Effort Expectancy as Moderated by GeoInquiry Usage Only

An independent samples t-test comparing the mean scores of the GeoInquiry group and the No GeoInquiry group found a significant difference between the means of the effort expectancy (EE) construct (t (96) = -3.29, p <.05). The mean of the No GeoInquiry group (M= 5.26, sd = 1.10) was significantly different from the mean of the GeoInquiry Group (M = 5.92, sd = 0.90).

Social Influence as Moderated by GeoInquiry Usage Only

An independent samples t-test comparing the mean scores of the GeoInquiry group and the No GeoInquiry group was performed for the mean social influence (SI) construct. No significant difference was found (t (97) = -1.59, p >.05). The mean of the No GeoInquiry group (M= 3.88, sd = 1.32) was not significantly different from the mean of the GeoInquiry Group (M = 4.34, sd = 1.52).

Facilitating Conditions as Moderated by GeoInquiry Usage Only

An independent samples t-test comparing the mean scores of the GeoInquiry group and the No GeoInquiry group found a significant difference between the means of the facilitating conditions (FC) construct (t (98) = -3.01, p <.05). The mean of the No GeoInquiry group (M= 4.57, sd = 1.54) was significantly different from the mean of the GeoInquiry Group (M = 5.40, sd = 1.21).

Behavioral Intention as Moderated by GeoInquiry Usage Only

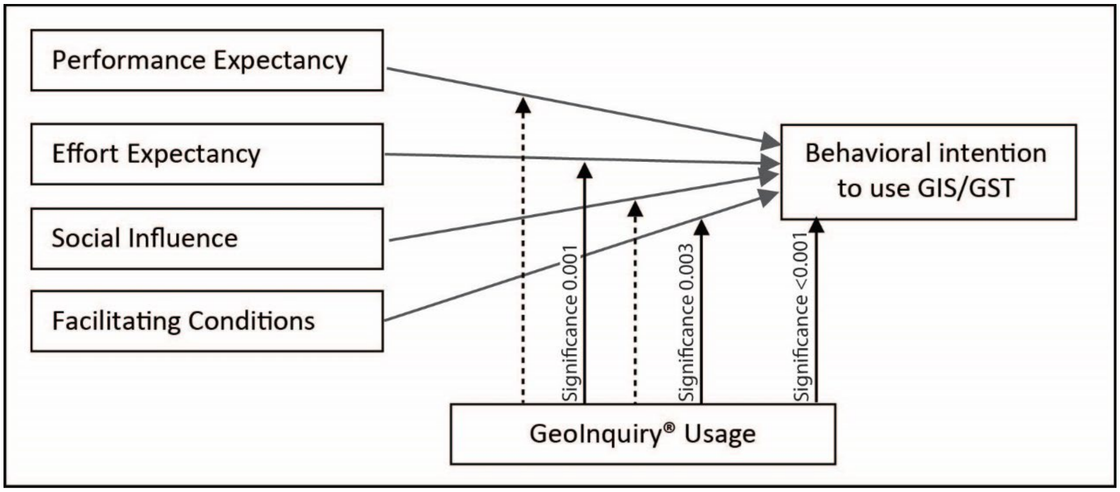
An independent samples t-test comparing the mean scores of the GeoInquiry group and the No GeoInquiry group found a significant difference between the means of the behavioral intention (BI) construct (t (97) = -3.76, p <.05). The mean of the No GeoInquiry group (M= 4.74, sd = 1.62) was significantly different from the mean of the GeoInquiry Group (M = 5.85, sd = 1.32).

Significant Modified UTAUT Constructs

As shown in Figure 17, the difference in the means between the group that used GeoInquiries and the group that did not use GeoInquiries was significant for effort expectancy (p=0.001), facilitating conditions (p=0.003), and behavioral intention (p<0.001). Effort expectancy and facilitating conditions, as dependent variables, impact behavioral intention. The difference in the means of the other two constructs, performance expectancy and social influence, while not significant, still impact the behavioral intention construct.

Figure 17

Significant Results from T-Test for Equality of Means

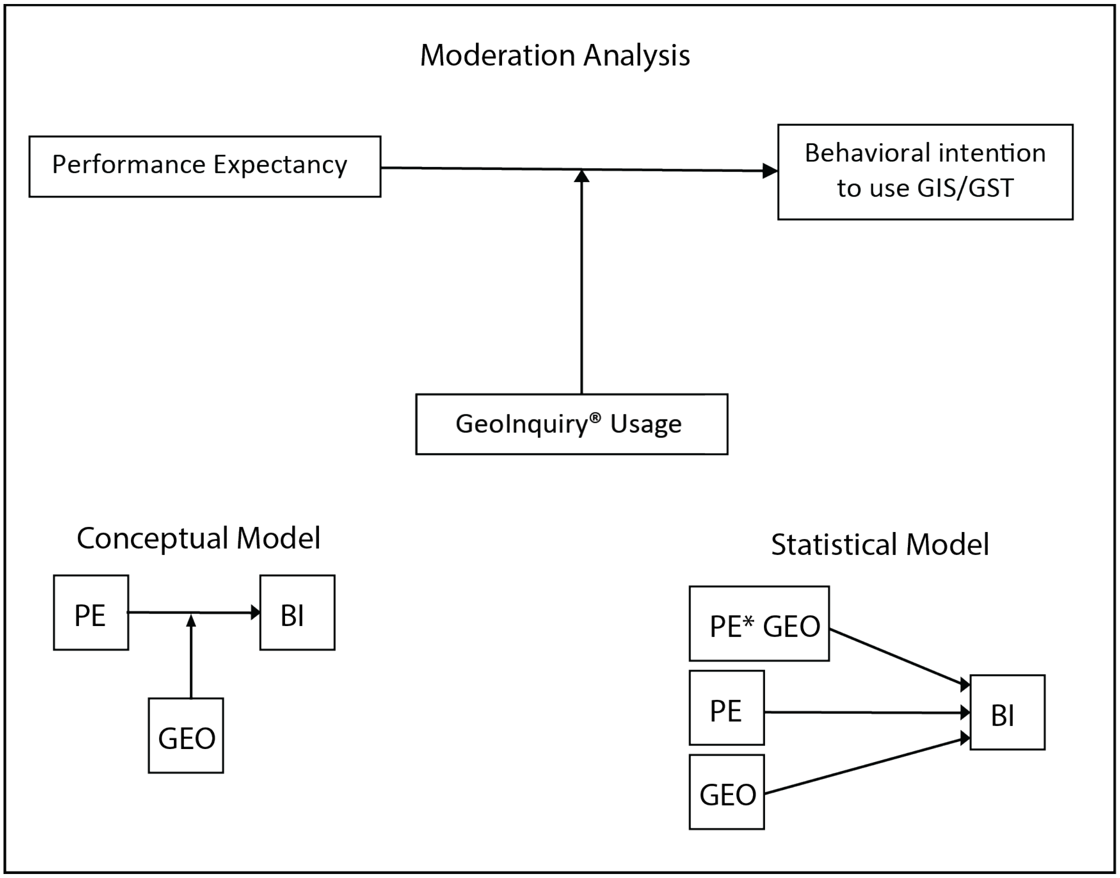


PROCESS Macro Moderation Analysis

Moderation analysis explains the variability of models in different circumstances. As previously described, a moderator is used to examine the strength of a relationship between the independent and the dependent variable. Figure 18 **illustrates the moderation analysis** completed using the PROCESS macro (Hayes, 2022) for the example of performance expectancy. As described above, the moderation analysis will explore how GeoInquiry usage alters the relationship between performance expectancy and behavioral intention. This is further simplified in the **conceptional model** shown in Figure 18. When the PROCESS macro is used to perform a regression analysis, the expression of the conceptual model occurs through the **statistical model**, as illustrated. A regression is calculated between the product of the moderator and the independent variable and the dependent variable, which is compared to a regression calculated for the independent variable and the dependent variable, as well as the moderator and the dependent variable. These values are compared to determine the impact of the moderator.

Figure 18

Example of Conceptual and Statistical Moderation Analysis Used in PROCESS



In order to run the PROCESS macro, several calculations were made. MeanGeo was calculated as the mean of each participant's responses to the four questions related to how many GeoInquiries were used, how often GeoInquiries were used, and for how many years GeoInquiries had been used. A mean for each construct (PEmean, EEmean, SImean, and FCmean) was calculated as the mean of each participant's responses to each of the items in that construct. The PROCESS macro was run in SPSS for each of the independent variables and their interaction (product) with the dependent variable as moderated by GeoInquiry usage. The results of the PROCESS macro are summarized in Table 27. Table 27 includes the coefficients of the regression performed by the PROCESS macro, the standard error, the t value, and the significance. Additionally, this table includes the change in R^2 and the *F* statistic from the regression from the addition of the moderator.

Table 27

Moderation Effect of GeoInquiry Usage Between UTAUT Constructs and BI

Variable	*coeff*	*se*	*t*	***p***	***R²-chng***	*F*
PEMean	0.92	0.10	8.74	0.0000		
MeanGeo	0.20	0.04	4.42	0.0000		
PEMean * MeanGeo	-0.13	0.04	-1.36	**0.1783**	**0.009**	1.84
EEMean	0.86	0.12	7.25	0.0000		
MeanGeo	0.12	0.05	2.42	0.0176		
EEMean * MeanGeo	-0.02	0.04	-0.42	**0.6779**	**0.001**	0.17
SIMean	0.54	0.09	6.26	0.0000		
MeanGeo	0.20	0.05	4.07	0.0001		
SIMean * Mean Geo	-0.05	0.03	-1.49	**0.1398**	**0.014**	2.22
FCMean	0.60	0.09	6.74	0.0000		
MeanGeo	0.16	0.05	3.22	0.0018		
FCMean * MeanGeo	-0.02	0.04	-0.53	**0.5995**	**0.002**	0.28

Independent Variable Effects on BI as Moderated by GeoInquiry Usage

The output of the PROCESS macro demonstrates that none of the product interaction terms (PEMean * MeanGeo, EEMean * MeanGeo, SIMean * Mean Geo, FCMean * MeanGeo) yielded a statistically significant change in the MeanBI (behavioral intention). The significance values were 0.1783, 0.6779, 0.1398, and 0.5995, respectively. The results indicate that the change in R^2 was minimal when the moderator was included in the regression, 0.9% of the change in BI could be attributed to the moderation of the GeoInquiry usage on PE. These values were 0.1% for effort expectancy; 1.4% for social influence, and 0.2% for facilitating conditions.

Research Question 2 Summary

Research question two sought to understand the moderating effect of the use of GeoInquiries on the factors that influence educator use of digital mapping technologies in their classrooms. As the plan for the moderation analysis was developed, it became clear to the researcher that the hypothesis of the moderating effect of GeoInquiry usage on behavioral intention was two-fold. While an independent samples t-test indicated a statistically significant difference in the means of three of the modified UTAUT constructs between the groups that used GeoInquiries and those that did not, the regression analysis through the PROCESS macro, which utilized a mean value for GeoInquiry usage that included responses to a number of questions about the degree of GeoInquiry usage, did not yield a statistically significant difference in the means of any of the constructs. Thus, while these data do indicate that having used GeoInquiries does impact behavioral intention, the PROCESS macro results do not indicate a statistically significant change related to the degree of GeoInquiry usage. Hypothesis 5 is not supported, as shown in Table 28, as both methods of moderation analysis did not confirm the hypothesis.

Table 28

Research Question 2 Hypothesis Summary

Hypothesis	Finding
H5: GeoInquiry usage has a moderating effect on the behavioral intent of educators to use GIS/GST classroom integration.	Not Supported

The variation in the results of the two methods described for Research Question Two does necessitate clarification. While the hypothesis found in Table 28 was not fully supported, it is necessary to clarify two separate aspects of the hypothesis. A test was performed to evaluate the difference between those who had used GeoInquiries and those who did not. As demonstrated in Table 26, this test yields significant results for two out of the four modified UTAUT constructs, indicating that an educator who uses GeoInquiries is correlated to higher responses related to behavioral intention. The second method evaluated the degree of GeoInquiry usage as measured by the calculation of meanGeo, and the moderating effect of the degree of GeoInquiry usage on each of the UTAUT constructs relationship with behavioral intention. This method, using the PROCESS macro, demonstrated that the degree of GeoInquiry usage does not moderate the effect of the modified UTAUT constructs on behavioral intention. The two findings clarifying the results of these tests are presented below:

- The use of GeoInquiries by an educator has a positive moderating effect on the behavioral intent of the educator to use GIS/GST in classroom instruction.
- The degree of GeoInquiry usage does not have a moderating effect on the behavioral intent of the educator to use GIS/GST in classroom instruction.

Conclusion

Chapter 4 presented the data analysis and results of the study designed to answer the two research questions related to the relationship between the modified UTAUT variables, behavioral intention and GeoInquiry usage as a moderating variable. Presented in this chapter were descriptions of the demographics of the participant group, as well as the descriptive statistics of the responses to the modified UTAUT variables. Detailed explanations were provided for both the descriptive statistics and the inferential statistics used to evaluate these variables. Lastly, this chapter included descriptive statistics of the responses to the GeoInquiry items, as well as detailed explanations of the moderation analysis performed using these data. All four hypotheses related to Research Question 1 were supported. The hypothesis related to Research Question 2 was not supported, but two conclusions were presented to further explain this result. Chapter 5 presents a detailed summary and discussion of the findings related to this data analysis.

Chapter 5: Summary and Discussion

By investigating and quantifying the behavioral intent of educators to integrate GIS/GST technologies into classroom instruction, this study was able to explore the moderating effects of a specific curricular resource, the GeoInquiry, on an educator's behavioral intent to integrate other GIS/GST technologies into classroom instruction. This study modified the UTAUT model (Venkatesh et al., 2003) of technology acceptance to precisely measure GIS/GST integration as moderated by educator usage of GeoInquiries. The UTAUT model provided the framework to quantitatively evaluate the impact of the UTAUT constructs on educator behavioral intention.

Purpose

The purpose of this research was to determine the power of the frequent and repeated implementation of a specific GIS/GST curricular support, the GeoInquiry (Esri, n.d.), in building educator confidence in GIS/GST technology and educator intention to use GIS/GST technology to a greater degree. Specifically, this study explored participant integration of GIS/GST technology into their classrooms and the moderation of that implementation by the frequent and repeated usage of the GeoInquiry. This study attempted to determine if the use of the GeoInquiry developed enough confidence in the value of GIS/GST technology to move the educator from one phase of implementation, or level of behavioral intention, to another stage of implementation, or level of behavioral intention as measured by the technology integration framework.

Quantitative data in the form of a survey adapted from the modified UTAUT instrument was gathered to answer questions related to each UTAUT construct (performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), and behavioral intention (BI)) and questions related to GeoInquiry usage. The format of the UTAUT model and instrument allowed for the calculation of the statistical relationship between each construct and the moderating effect, if any, of GeoInquiry use.

Population/Sample

As described in chapter 4, the survey questionnaire was distributed through Qualtrics between September 2022 and December 2022 using three main methods of distribution. The survey was distributed through two posts in the Esri community (K12instruction, by the researcher) and the Education Blog (by Esri staff). The survey was disseminated through email communication to an Esri listserv, a K12 GIS listserv in WV, and through personal emails by the researcher. In December 2022, the survey was distributed by ESRI through their "Esri News for K-12 Schools" newsletter. A copy of this newsletter is included in Appendix K. A total of 152 educators began the survey and 104 educators completed the survey. Of the 104 completed surveys, 102 were able to be used in the inferential analysis.

Most of the respondents to the survey taught in a high school (63%) or middle school (23%). Science (29%) and social studies (27%) were the most common subjects taught. Most of the respondents had taught for more than 15 years (63%), and the majority of those responding had a master's degree (75%). Twenty-seven states were represented by the respondents with multiple responses coming from West Virginia (n=21), Virginia (n=15), Texas (n=9), and Minnesota (n=9). Related to GeoInquiry usage, 58% of respondents had used GeoInquiries in their instruction, and 42% had not used GeoInquiries in their instruction.

Methods

Following data collection, data were prepared and screened to ensure that complete responses were evaluated. Descriptive statistics were calculated for the participant demographic information. Both descriptive and inferential statistics (Pearson r, Spearman *rho*, and linear regression) were calculated for each of the modified UTAUT constructs to answer Research Question 1. Both descriptive and inferential statistics (independent samples t-test and PROCESS macro moderation analysis) were calculated for the responses related to GeoInquiry usage, as well as the moderating effects of the GeoInquiry usage on each of the modified UTAUT constructs to answer Research Question 2.

Summary and Discussion

Research Question 1: Behavioral Intention to use GIS/GST

Research Question 1 asks, "To what extent do performance expectancy, effort expectancy, social influence, and facilitating conditions predict educators' behavioral intention to use GIS/GST in their classrooms?" The dependent study variable in this research study is the core construct of the UTAUT models, i.e., the measured level of educator's behavioral intention to use GIS/GST classroom integration. The independent study variables are the modified predictor variables of the UTAUT instrument, performance expectancy, effort expectancy, social influence, and facilitating conditions.

Educators "strongly agree" or "agree" that digital mapping technology is beneficial to their students (PE1) in that it allows them to deliver instruction more effectively (PE2) and improves student learning (PE3). Performance expectancy explains 45% of educator's variance in behavioral intention. While educators are neutral in their response to the ease of incorporating digital mapping technology in their classroom (EE3), they do indicate having a clear understanding of the technology (EE1), and that they believe they can become more skillful (EE2) at using and learning (EE4) the technology, with this construct explaining 43% of the variance in behavioral intention. Research into educator belief indicates that a pedagogical and values-based mindset influences educator instructional design, which aligns with the results related to the performance expectancy items (Ertmer & Ottenbreit-Leftwich, 2013). Ertmer et al. (2012) discussed that educators make changes in technology integration when the purposes of the technology align to their belief that the technology will deliver content, enrich their curriculum, or transform their teaching. When teachers make changes to the implementation of technology in their classrooms, it is due to the evidence of student outcomes, and teachers see how a change affects what students can do (Backfisch et al., 2021; Bonner et al., 2020). When teachers adopt new technologies, it is dependent on the educator's self-efficacy, in addition to the technology's instructional value (Ertmer & Ottenbreit-Leftwich, 2010).

The social influence construct reveals an area where educators report more disagreement with the survey items (neither agree nor disagree). Thus, social influence only influences 30% of behavioral intention. While educators are, on average, neutral (neither agree nor disagree) with their evaluation of whether they have someone who influences them (SI1), someone who is important to them who influences them (SI2), or a community that influences them (SI4) to use digital mapping technology, educators agree that they do not have a principal (SI3) that has been encouraging their use of digital mapping technology in the classroom. This reported lack of encouragement to use the technology follows the research of Collins (2018) and Collins and Mitchell (2019) who describe the importance of follow up coaching which encourages the continued use of the technology. Eria (2019) noted a connection between the number of social network connections to other GIS users having an impact on behavioral intention. Moore et al. (2016) noted the importance of professional development that is continuous and over time as necessary to develop community, empowerment, relevance, comfort, and competence in using digital mapping technologies in the classroom. Most educators are not connected to a GIS education community to the degree that the community changes or impacts their classroom practice.

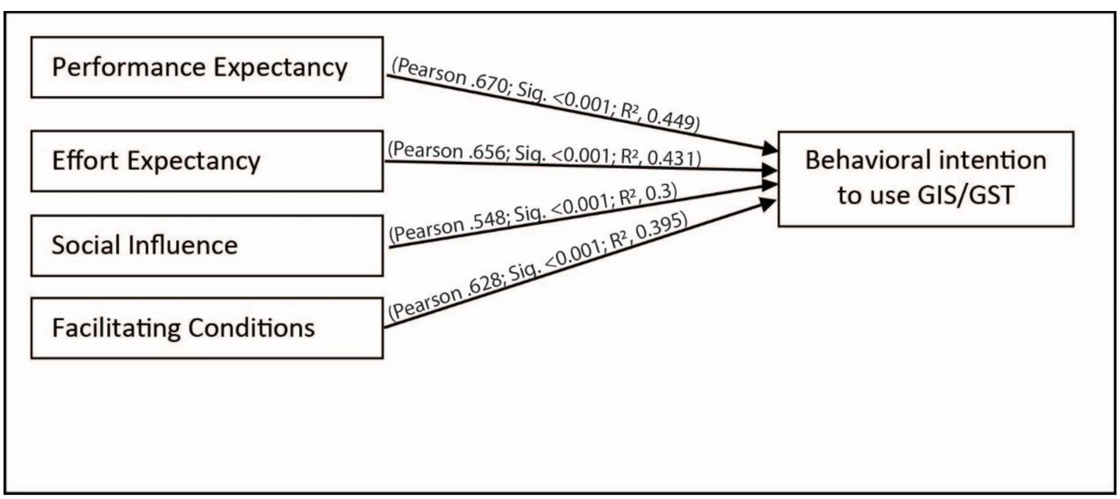
Educators responded positively (somewhat agree to strongly agree) to the items related to facilitating conditions, which explained 40% of the variance in behavioral intention. Educators, overall, responded that they had the necessary resources (FC1) and knowledge (FC2) to use digital mapping technology and that this technology was compatible with other resources they already used (FC3) in the classroom. Educator belief that they can use digital mapping technology effectively in their classrooms is high. However, within the facilitating conditions construct is an item that relates to an individual or person available to the educator to provide support (FC4) with digital mapping technology. For this item, educators responded neutrally, some educators had this help, and some did not. Similar to the social influence construct, this item within facilitating conditions speaks to the necessity of follow up and continuous support and professional development for classroom technologies over time (Moore et al., 2016).

Each of the above constructs are the independent variables in this study that relate to the dependent variable, behavioral intention, which speaks to whether an educator will use this technology in a given time period. Regarding usage, most respondents have used the technology in the last 12 months (BI1), with a greater majority predicting they will (BI2) and are planning to (BI3) use digital mapping technology in the next 12 months and beyond. Most telling is that the majority of educators will recommend peers use digital mapping technology (BI4) in their classrooms. Behavioral intention is strongly tied to the research surrounding educator change. Educator change, like behavior, is uniquely personal to individual educators (Backfisch et al., 2021; Levin & Wadmany, 2007). Behavioral intention is the result of the level of confidence an educator develops while using a technology in the classroom (Howard & Gigliotti, 2016) and how that confidence is turned into action and intent (Tondeur et al., 2017).

Research Question 1 examines how each of the independent variables related to the dependent variable. The descriptive statistics describe generally positive responses related to each of the modified UTAUT constructs. Inferential statistics were used to determine if there is a significant relationship between these generally positive responses and the respondent behavioral intention. The Pearson r, Spearman *rho*, and linear regression tests are summarized in Chapter 4, Table 19. Figure 19 demonstrates a moderate statistically significant relationship between each of the constructs and behavioral intention. An increase in any one of these constructs – performance expectancy, effort expectance, social influence, and facilitating conditions – will result in an increase in the behavioral intention construct.

Figure 19

Summary of Pearson Tests and Linear Regression Analysis



The inferential statistics indicate the strongest relationships between performance expectancy and effort expectancy, followed by facilitating conditions, and social influence. The inferential statistics indicate that the four hypotheses related to Research Question 1 were supported, therefore the following statement can be made- performance expectancy, effort expectance, social influence, and facilitating conditions each positively affect educators' behavioral intent to use GIS/GST classroom instruction.

Research Question 2: Moderating Effects of GeoInquiry Usage

Research Question 2 asks, “Does GeoInquiry usage moderate the relationships among performance expectancy, effort expectancy, social influence, facilitating conditions, and educators’ behavioral intention to use GIS/GST in their classrooms?” A moderator is a variable that affects the direction or strength of the relationship between two variables (Baron & Kenny, 1986). This question is looking for evidence of a difference in the relationship between each of the independent variables in this study (performance expectancy, effort expectancy, social influence, and facilitating conditions) and the dependent variable, behavioral intention. This research question was investigated through several methods. The descriptive statistics for those questions related to GeoInquiries were evaluated to inform the moderation analysis. The moderation analysis was performed through an independent samples t-test and the PROCESS macro (Hayes, 2022).

Fifty-eight percent of the respondents to the survey had used GeoInquiries in their classroom instruction. The majority of those (64%) had used more than one GeoInquiry, though many had only used them between 1 and 5 times in the last year and similarly in the years prior. Of those who had used GeoInquiries, nearly equal proportions began using the resource throughout the last 8 years.

The results of the independent samples t-test show that for every construct, the mean response on the Likert scale (1 – 7) was higher for the group that had used GeoInquiries than the group that had not. The mean differences were the least for performance expectancy and the highest for behavioral intention (performance expectancy - 0.28; effort expectancy - 0.66; social influence - 0.47, facilitating conditions - 0.83; and behavioral intention - 1.11). This indicates that there is some correlation between using GeoInquiries and the responses to the modified UTAUT items. However, the independent samples t-test also tests for the significance of the difference in the means for each of the constructs. The independent samples t-test yielded significant differences in the means of the two groups for effort expectancy (EE), facilitating conditions (FC), and the dependent variable, behavioral intention (BI). Significant differences were not found for performance expectancy (PE) or social influence (SI). These results are summarized in Figure 17.

The results of the independent samples t-test indicate that GeoInquiry use supports educators with the aspects of classroom integration related to how easy or difficult a technology is to employ in instruction and how the resources available to the educator support the technology in classroom instruction. As these two areas are then supported, it leads to a statistically significant increase in the behavioral intention of the educator to use digital mapping technologies in the classroom, as well as to recommend that other educators do the same. The independent samples t-test yielded results indicating the change in the mean of the performance expectancy construct was not statistically significant. This is not surprising as this construct deals not with using digital mapping technology in the classroom as much as whether educators believe the technology to be of value to student learning. Similarly, as the social influence construct deals with the relationship between the support for the educator, peer educators, and the community, a curricular resource would have less impact on this construct.

While the t-test allowed for the comparison of two groups of educators, the PROCESS macro, through regression analysis, evaluated moderation through the model of Baron and

Kenny (1986), which evaluates the independent variable and the moderator variable individually, and then evaluates their product to assess the moderating effect. Using a mean value for GeoInquiry usage calculated from the responses to the GeoInquiry questions, the PROCESS macro results, as reported in Chapter 4, yield no statistically significant moderating effect for any of the modified UTAUT constructs. The hypothesis related to research question 2 (GeoInquiry usage has a moderating effect on the behavioral intent of educators to use GIS/GST classroom integration.) is not supported by both methods of moderation analysis.

Like the results of Li and Zhao (2021), Holzman et al. (2020), and Hu et al. (2020), the UTAUT constructs, when modified for specific technologies yield specific outcomes that differ technology by technology. Additionally, in some cases the moderating effects of the identified moderator are significant (Li & Zhao, 2021), but in other cases the moderating effects are not significant (Hu et al., 2020). While the two tests of the moderating effect of GeoInquiry usage do not yield similar results, the study does indicate that it is possible to test this moderating effect and that there is a correlation between GeoInquiry usage and behavioral intention to use digital mapping technologies. This correlation is more closely tied to whether an educator uses GeoInquiries, and less closely tied to how often or for how long they have used GeoInquiries in instruction.

Conclusions and Discussions

The application of the UTAUT framework to digital mapping technology in the classroom demonstrated the significance of the many aspects that are involved with the choices that educators make regarding instructional activities in their classrooms, specifically the supplemental instructional activities not required by the school or district, i.e., those considered supplemental or implemented at the discretion of the educator. The results of this study demonstrate that UTAUT effectively models factors that influence behavioral intention. As discussed in Chapter 2, many technology integration models deal with levels and methods of technology integration (Harmes, Welsh, & Winkelman, 2016; Koehler & Mishra, 2005; Koehler & Mishra, 2009; Mishra & Koehler, 2006; Puentedura, 2003; Roblyer & Doering, 2013; Voithofer et al., 2019), while some behavioral models such as UTAUT (Venkatesh et al., 2003) deal more with facets of educator belief and educator change (Burton-Jones & Hubona, 2005; Chen & Jang, 2014; Davis, 1989; Hall, 2013; Rogers, 2003; Venkatesh et al., 2012; Wozney et al., 2006). UTAUT is an effective model for investigating the predictors of the choices educators make in the classroom.

Survey respondents had a generally positive response to the modified UTAUT statements regarding integrating digital mapping technologies into classroom instruction. The inferential statistics demonstrate a moderate statistically significant relationship between each of the independent variables and the dependent variable. The moderate nature of the relationship indicates that there are additional factors, not measured by UTAUT, that impact an educator's behavioral intention to use digital mapping technologies.

Within UTAUT constructs, however, specific items held more influence over construct results. Performance expectancy received the highest results of any of the constructs and has a statistically significant effect on the educator's behavioral intention, explaining 45% of the variance in educators' behavioral intention to use digital mapping technology in the future. Performance expectancy contains items related to the benefits to student learning in the classroom. These results indicate that educators are most likely to use a technology that will assist them in delivering content to their students, and technology that educators believe will benefit their students. When teachers do make changes to their practice and belief, it is because of student outcomes (Bonner at al., 2020; Ertmer et al., 2012). The innovative technology must increase student engagement or cognition to a degree that a teacher is motivated to change for the purpose of student learning (Backfisch et al., 2021).

While performance expectancy is closely tied to outcomes for students, effort expectancy is most closely tied to educator self-efficacy and technology ease of use. This construct received positive response and demonstrated a moderate statistical significance to behavioral intention and explained 43% of the behavioral intention results. Effort expectancy, an educator's own self confidence in using the technology is tied closely to the research concepts of Cuban (1986) who concluded that unless technologies are easily implemented into classroom instruction, technology use will be limited. The work of Rogers (2003) and Davis (1989) classified the degree of technology classroom implementation, tied to teacher use. Within GIS/GST research, Curtis' research (2019), which developed from Rogers' (2003) Diffusion of Innovations, classified educators into groups according to their own readiness to incorporate GIS/GST. Effort expectancy most closely parallels the technology integration models that center around educator readiness, self-efficacy, and technology comfort.

Research in GIS/GST touches on the importance of community and social interaction related to GIS/GST integration. Hong and Melville (2018) indicate that extended time is needed with educators to increase integration, and Moore et al. (2016) speak to the need for follow up with coaching activities to ensure educator success. The social influence construct had the lowest mean response and only explained 30% of the variance in educators' behavioral intention to use digital mapping technology in the future. The social influence items centered around the people in the lives of the educator integrating GIS/GST. Given the low scores, it is safe to say that educators often integrate GIS/GST in isolation and not within a community. While there may be someone or some group that supports the educators in some capacity, that is not a given. Interestingly, the item that scored the lowest across all constructs is the item related to the principal in the school encouraging the use of digital mapping technology. The results indicate that educators who use digital mapping technology, use it because they believe that it will benefit their students learning outcomes, and because they believe that they can use it. Educators are not using the technology because their peers in the classroom are using it and influencing their use. It is important to note, though, that the highest scoring behavioral intention item is related to educators recommending to others that they use the technology. Educators using GIS/GST are doing so in isolation but are also acting as evangelists for the technology.

Facilitating conditions are those that allow a technology to be implemented with ease. These items referred to resources, knowledge and compatibility with other classroom technologies, in addition to a person or group to provide support for the technology. While this construct received only a slightly positive response, the construct's influence on behavioral intention was statistically significant and it did explain 40% of behavioral intention. Given that much of the technologies in use today related to digital mapping technologies and GIS/GST integration are online resources, the need for specialized equipment is minimal to integrate these technologies into classroom instruction. Still, these items did not receive the highest responses, indicating that educators still believe they need something else to incorporate these technologies. It is important to note that the item that scored the lowest within this construct was an item that ties closely to social influence, "FC 4 - A specific person (or organization, or group) is available to assist me with digital mapping technology difficulties that may arise in my classroom." This item ties back to the need for community and ongoing coaching (Moore et al., 2016).

While the moderation analysis did not yield a statistically significant relationship for the moderating effect of GeoInquiry usage, the descriptive statistics did indicate that those who had used GeoInquiries did give higher responses on all constructs. This indicates a correlation between the usage and behavioral intention, likely indicating that GeoInquiries are used as one resource in a suite of other resources related to digital mapping technology integration. GeoInquiries are available for most content areas (Baker, 2015), and are numerous for science and social studies (which 46% of respondents taught). It is of value to note here that the research of Perrotta (2017) indicates that it takes educators 5-6 years to effect change in their own practice. One of the factors in the moderating effect of GeoInquiry usage could be the relatively short (about eight years) amount of time the resources have been available. Additionally, while GeoInquiries are designed for lecture replacement, they can be and likely are being used in a number of different capacities in classrooms, though their usage does not indicate a significant change in behavioral intention.

Ancillary Findings

The demographic information collected in the survey yielded interesting results. If one were to use the reported participant demographic data to create a picture of an educator that uses GIS/GST technology in their classroom, you would have a high school (63%) science (29%) or social studies (27%) teacher who had been teaching for more than 15 years (62%) with a master's degree (75%). These results align with Baker and Kerski (2014), who worked with science educators using GIS/GST and who the authors characterized as "lonely trailblazers." These results are consistent with the result of the social influence construct in that educators using this technology are often using it in isolation, but they are able to do so due to preparation, comfort in the classroom, and experience in providing students with experiences beyond those in a curriculum provided by their school or district.

The item related to principal support may indicate that administrators are not aware of the usage of GIS/GST as a supplemental instructional resource. While educators note the instructional value of the GIS/GST, they may not be sharing these classroom successes with their administrators, or due to the fact that the technology is not used daily, the technology is not coming across an administrator's radar.

Implications

The findings of this study will contribute information to the body of research related to GIS/GST in K-12 classrooms, as well as to the general body of research related to technology integration and technology integration models. Those that develop and deliver professional development in GIS/GST technology integration, provide supports for educators using GIS/GST, and develop instructional resources for GIS/GST may find these results inform their work and research, and should consider the following implications:

1. While this research notes that experienced educators are using GIS/GST technology in their instruction, there is a clear lack of less experienced educators using the technology. This likely indicates a lack of professional development as noted by Osborne et al. (2020). Similar to Kerr (2016), this research implies that efforts to reach less experienced educators while they are still developing effective classroom practices would increase GIS/GST usage overall and given the agreement among educators of the value of GIS/GST to student learning, would increase overall student learning.

2. While educators agree on the value of GIS/GST to increase student learning, it is imperative to make the connections to measurable outcomes related to student learning. Measurable data related to student learning will influence both administrators and communities alike to the value of GIS/GST in classroom instruction, thus increasing usage more broadly. This echoes Baker et al.'s (2009) recommendation regarding assessment strategies.
3. Given that effort expectancy is a moderately strong predictor of behavioral intention, it is important to ensure that professional development related to GIS/GST and instructional supports for GIS/GST include numerous opportunities for educator success, thereby increasing an educator's self-efficacy and intent to use the technology. Successes should be tied specifically to classroom tasks and student activities, so that successes are quickly applied to classroom practice.
4. While social influence predicts behavioral intention, it also demonstrates a great opportunity for growth within the K-12 educational community. Those who provide professional development and develop instructional resources for GIS/GST have the opportunity to create opportunities for ongoing support and teacher social engagement around GIS/GST. Modern communication tools allow teachers to share questions and ideas quickly and allow for those committed to supporting educators to engage. Providing educators who complete professional learning, or who use an instructional resource, with a "take-away" to share with a peer educator or an administrator could provide an avenue for the growth of GIS/GST integration, as well as deepen the social relationships around GIS/GST.

5. While the conditions necessary for the integration of modern GIS/GST into classroom instruction are minimal, the data related to facilitating conditions does not indicate that educators are aware of their own ability and capacity to utilize the technology. Scaffolded supports and simplified activities to integrate the technology in standards-aligned and meaningful capacities may increase usage of the technologies.
6. Absence of administrator support as a facilitating condition is clearly noted in this study. Those who provide professional development and develop instructional resources should consider including information that can be shared with administrators as to the value of the technology for student learning and student engagement, thus facilitating the conversation between educator and administrator.
7. While this research did not indicate a statistically significant relationship between the degree of GeoInquiry usage and behavioral intention, the data do indicate a relationship between those who use GeoInquiries and behavioral intention, indicating that GeoInquiries are likely part of a suite of digital mapping technology resources used throughout the year. As an example of an introductory resource to lead educators into GIS/GST integration, the opportunity still exists to develop additional resources similar to the GeoInquiry that can support student learning and educator capacity alike.

Recommendations for Further Research

This study demonstrates that the implementation of GIS/GST, or any novel technology into the classroom, requires a multi-faceted approach that should be a guide for all those working in the field of GIS/GST education research. This study also demonstrated that not all the "facets" related to GIS/GST implementation are known, identified, or fully developed. Research is needed to understand the power of GIS/GST to increase student achievement and student engagement with educators confident in their abilities. Recommendations for further research are provided.

1. Replicate this study in several years when the post-COVID reaction has lessened, assuming that it will lessen, and when educators are not in such a "reactive" state. This may increase the number of survey respondents and would allow for a much broader survey sample.
2. Replication of this study with a modification to PE 4, "Using digital mapping technology in my classroom instruction increases my chance of professional advancement," would allow the construct to be more closely aligned to student outcomes and not aligned to a professional outcome for educators. The item was developed to align to the UTAUT items (Venkatesh et al., 2003), but may better serve the GIS/GST community if modified.
3. Replication of this study with a modification to FC 4, "A specific person (or organization, or group) is available to assist me with digital mapping technology difficulties that may arise in my classroom." The responses to FC 4 are more in alignment with those in the social influence construct. The modification of FC 4 to more closely relate to classroom needs, or the inclusion of the relationship with a school administrator could more closely align both facilitating conditions and social influence on the research related to educator belief and educator change, as well as to other technology integration models.

4. Structured interviews with those who use GeoInquiries would allow for a greater characterization of their methods of utilization in instruction and may allow for the modification of items related to GeoInquiry usage if the survey were repeated, and/or could inform those developing supplemental instructional resources.
5. While not a primary focus of this research, a longitudinal implementation of this study could allow for research into actual use in addition to behavioral intention. Though items were included related to GeoInquiry usage in the last year, and on average, participants were not asked how often other GIS/GST, or digital mapping technologies, were used in their classrooms.
6. This research demonstrated a need for social supports for those integrating GIS/GST technologies into their classroom instruction. Research into best practices related to developing supportive networks for GIS/GST integration is needed.
7. This research focused on the moderating effect of a single supplemental instructional resource. It is the opinion of this researcher that there are many factors that moderate, statistically, behavioral intention to use GIS/GST and further research is needed to both identify those factors and research their moderating effects.
8. This research demonstrated strong responses related to specific content areas and educator experience. Further research into behavioral intention and these demographic qualities could reveal additional important results.
9. This research identified a narrow characterization of those educators using GIS/GST. Research is needed into best practices related to incorporating GIS/GST into pre-service and beginning educator preparation programs to both deepen educator capacity, but also develop student learning and student engagement.

Final Thoughts

This research involved using the UTAUT technology integration model, which has been broadly implemented in numerous applications, with a highly unique population of educators, many of which can be characterized as “lonely trailblazers” (Baker and Kerski, 2014). While the data collected from these “lonely trailblazers” will become part of the body of research related to GIS/GST technology integration, of greater value is these “lonely trailblazers” themselves. Any work done by organizations, universities, and associations to support and elevate these educators can only increase the integration of this powerful tool and at the same time increase the influence of these experienced educators.

> Technology will never replace great teachers, but technology in the hands of great teachers is transformational.
>
> – George Couros (2014)

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Appendix A: IRB Approval

MARSHALL UNIVERSITY®
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Office of Research Integrity
Institutional Review Board
One John Marshall Drive
Huntington, WV 25755

FWA 00002704

IRB1 #00002205
IRB2 #00003206

September 23, 2022

Lisa Heaton, Ph.D.
College of Education and Professional Development, MUCG

RE: IRBNet ID# 1916796-1
At: Marshall University Institutional Review Board #2 (Social/Behavioral)

Dear Dr. Heaton:

Protocol Title:	[1916796-1] Teacher Acceptance of GIS Technologies Following Frequent and Repeated Usage of Instructional Resources	
Site Location:	MUGC	
Submission Type:	New Project	APPROVED
Review Type:	Exempt Review	

In accordance with 45CFR46.104(d)(2), the above study was granted Exempted approval today by the Marshall University Institutional Review Board #2 (Social/Behavioral) Designee. No further submission (or closure) is required for an Exempt study **unless** there is an amendment to the study. All amendments must be submitted and approved by the IRB Chair/Designee.

This study is for student Erika Klose.

If you have any questions, please contact the Marshall University Institutional Review Board #2 (Social/ Behavioral) Coordinator Lindsey Taylor at (304) 696-6322 or l.taylor@marshall.edu. Please include your study title and reference number in all correspondence with this office.

Sincerely,

Bruce F. Day, ThD, CIP
Director, Office of Research Integrity

Appendix B: UTAUT Permission

From: creis2@vt.edu
To: Klose, Erika
Subject: Permission to use UTAUT
Sun 5/8/2022 7:29 PM

Dear Erika Klose,

My name is Carolina Reis, and I am contacting you on behalf of Prof. Dr. Venkatesh regarding your request. Thank you for your interest.

All permissions and access to papers are typically handled through the website: http://vvenkatesh.com. However, the system is currently undergoing an update. Therefore, I am sending the permission email below on behalf of Dr. Venkatesh:

Thank you for your interest. Your permission to use content from the paper is granted. Please cite the work appropriately. Note that this permission does not exempt you from seeking the necessary permission from the copyright owner (typically, the publisher of the journal) for any reproduction of any materials contained in this paper.

Sincerely,
Viswanath Venkatesh
Eminent Scholar and Verizon Chair of Business Information Technology
Email: vvenkatesh@vvenkatesh.us
Website: http://vvenkatesh.com

You may also find Prof. Dr. Venkatesh's book to be of use: http://www.vvenkatesh.com/book/!

Thank you,
Carolina Reis

Appendix C: Survey Instrument

GeoInquiry Usage

Start of Block: Consent

Q22 You are invited to participate in a research project entitled *Quantitative Study of The Acceptance of Geospatial Technologies in the K-12 Classroom Using the Unified Theory of Acceptance and Use of Technology (UTAUT)*, designed to analyze the integration of geospatial mapping technologies in the classroom. The study is being conducted by Dr. Lisa Heaton and Erika Klose from Marshall University and has been approved by the Marshall University Institutional Review Board (IRB). This research is being conducted as part of the dissertation requirements for Erika Klose.

This survey is comprised of a 21-question survey. It is anticipated this survey will take 10-15 minutes to complete. Your replies will be anonymous. There are no known risks involved with this study. Participation is entirely voluntary, and there will be no penalty or loss of benefits if you choose not to participate in this research study or withdraw. If you decide not to participate, you can leave the survey site. You may choose not to answer any question by simply leaving it blank. Once you complete the survey, you can delete your browsing history for added security. Completing the online survey indicates your consent for use of the answers you supply. If you have any questions about the study, you may contact Dr. Lisa Heaton at (304) 746-2026 or Erika Klose at (304) 412-5512.

If you have any questions concerning your rights as a research participant, you may contact the Marshall University Office of Research Integrity at (304) 696-4303.

By completing this survey, you are also confirming that you are 18 years of age or older.

In appreciation of the attention you have given to this study, you can enter your name into a drawing for 1 of 10 prizes. The prize includes one $10 Amazon gift card. Your odds of winning one of the prizes is based on the number of individuals participating in the study. We expect that approximately 200 individuals will take part in the study. Information collected to draw for the prizes will not be linked to the study data. This identifying information will be stored in a separate survey, then destroyed after the prizes have been provided. If you would like to participate in the drawing for the gift cards, you will be prompted to enter your email in a separate survey link at the end of this survey. Please print this page for your records.

Your completion of this survey indicates your consent. Please respond to all the questions as accurately as possible. Thank you in advance for your participation in this research study.

End of Block: Consent

Start of Block: Demographics

Q1 Grade level you currently teach:

- ▢ K-2 (1)
- ▢ 3-5 (2)
- ▢ 6-8 (3)
- ▢ 9-12 (4)

Q2 Years of teaching experience:

- ○ 0 - 4 (1)
- ○ 5 - 9 (2)
- ○ 10 - 14 (3)
- ○ 15 - 19 (4)
- ○ 20+ (5)

Q3 Level of Education

- ○ Bachelors (1)
- ○ Masters (2)
- ○ Specialist (3)
- ○ Doctorate (4)
- ○ Other (5)

Q4 The area(s) you teach:

- ▢ Elementary (1)
- ▢ Math (2)
- ▢ Science (3)
- ▢ Social Studies (4)
- ▢ English (5)
- ▢ CTE (6)
- ▢ Technology (7)
- ▢ Computer Science (8)
- ▢ Other (9)

Page Break

state In which state do you currently teach?

▼ Alabama (1) ... I do not reside in the United States (53)

Q8 Please read the following:
Digital mapping technology integration includes classroom activities for students such as online student map creation, student data collection with a GPS or GPS-enabled device, student access to online map data, student analysis of online map data, and student StoryMap creation.

Q10 Have you received any professional development related to digital mapping technology integration?

- No (1)
- Yes (2)

Q11 If you answered yes to the previous question, how many hours of professional development did you receive?

- 0 - 4 (1)
- 5 - 8 (2)
- 9 - 16 (3)
- 17 - 24 (4)
- 25 + (5)

End of Block: Demographics

Start of Block: UTAUT

Q18 Please read the following:

For the purposes of this survey, *digital mapping technology classroom integration* includes student-centered activities like student web-map creation, student data collection with a GPS or GPS-enabled device, student access to online map data, student analysis of online map data, and student StoryMap creation.

For the purposes of this survey, *digital mapping technology classroom integration* does not include direct instruction (lecture) with digital mapping products, such as GeoInquiries.

The following sections will use a seven-point Likert scale ("1 = strongly disagree" and "7 = strongly agree") for each statement in the section. Please indicate your level of agreement with each statement.

Q17 Section 1

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I believe that digital mapping technology will be beneficial for the students in my classroom. (1)	○	○	○	○	○	○	○
Digital mapping technology enables me to accomplish instruction more effectively in my classroom. (2)	○	○	○	○	○	○	○
Digital mapping technology increases my productivity in my classroom. (3)	○	○	○	○	○	○	○
Using digital mapping technology in my classroom instruction increases my chance of professional advancement. (4)	○	○	○	○	○	○	○

Q19 Section 2

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
My interaction with digital mapping technology is clear and understandable. (1)	○	○	○	○	○	○	○
It would be possible for me to become skillful at using digital mapping technology in my classroom. (2)	○	○	○	○	○	○	○
I find digital mapping technology easy to use in my classroom. (3)	○	○	○	○	○	○	○
Learning to operate digital mapping technology in my classroom is possible for me. (4)	○	○	○	○	○	○	○

Q20 Section 3

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
People who influence my behavior think that I should use digital mapping technology in my classroom. (1)	o	o	o	o	o	o	o
People who are important to me think that I should use digital mapping technology in my classroom. (2)	o	o	o	o	o	o	o
The principal of my school has been encouraging in the use of digital mapping technology in my classroom. (3)	o	o	o	o	o	o	o
In general, my school community has supported the use of digital mapping technology in my classroom. (4)	o	o	o	o	o	o	o

Q21 Section 4

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I have the resources necessary to use digital mapping technology in my classroom. (1)	○	○	○	○	○	○	○
I have the knowledge necessary to use digital mapping technology integration in my classroom. (2)	○	○	○	○	○	○	○
Digital mapping technology in my classroom is compatible with other resources I use. (3)	○	○	○	○	○	○	○
A specific person (or organization, or group) is available to assist me with digital mapping technology difficulties that may arise in my classroom. (4)	○	○	○	○	○	○	○

Q22 Section 5

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I have integrated digital mapping technology in my classroom instruction in the last 12 months. (1)	○	○	○	○	○	○	○
I predict I will continue to use digital mapping technology integration in my classroom instruction in the next 12 months. (2)	○	○	○	○	○	○	○
I plan to use digital mapping technology to a greater degree in my classroom instruction in the future. (3)	○	○	○	○	○	○	○
I will recommend other people integrate digital mapping technology in their classroom instruction. (4)	○	○	○	○	○	○	○

End of Block: UTAUT

Start of Block: GeoInquiries

Q12 DIRECTIONS: Please read the following paragraph and respond to the following statements.

GeoInquiries® are map-based activities designed to allow an educator to use web-based mapping tools to teach specific content using direct instruction. GeoInquiries are accessible here: https://esri.com/geoinquiries (clicking the link will open the page in a new tab and will not interrupt your survey). In the statements below, you will be asked about how many times you have used GeoInquiries in your instruction.

Q13 Have you used GeoInquiries in your instruction?

○ No (1)

○ Yes (2)

Skip To: End of Block If Have you used GeoInquiries in your instruction? = No

Q14 In the questions below a GeoInquiry refers to 1 single lesson in a collection, such as "Cracked Plates" in the Earth Science collection, or "Poe and the Red Death" in the American Literature collection. For example, if you used these two lessons, your answer below would be 2.

How many individual, or different, GeoInquiries have you used?

○ 1 (1)

○ 2 (2)

○ 3 (3)

○ 4 (4)

○ 5 (5)

○ 6 or more (6)

Q15 In the question below the total number of times that GeoInquiries were used indicates the number of times the educator did the activity. For example, an educator may teach Earth Science and teach 5 sections a day. If the educator uses “Cracked Plates” and “A River Runs Through It” during the instructional year, which is 2 GeoInquiries, the total number of times that GeoInquiries have been used would be: “2 GeoInquiries” times “5 class periods” equals “10 times the GeoInquiries were used”.

How many times did you use GeoInquiries in the last school year 2021-2022?

○ 1 - 5 (1)

○ 6 - 10 (2)

○ 11 - 15 (3)

○ 16 - 20 (4)

○ 21 - 25 (5)

○ 26 - 30 (6)

○ 31 or more (7)

Q20 For how many years have you used GeoInquiries in your classroom instruction?

○ 1 (1)

○ 2 (2)

○ 3 (3)

○ 4 (4)

○ 5 (5)

○ 6 (6)

○ 7 (7)

○ 8 (8)

Q21 On average, how many times do you use a GeoInquiry each year?

- 1 - 5 (1)
- 6 - 10 (4)
- 11-15 (5)
- 16 - 20 (6)
- 21 - 25 (7)
- 26 - 30 (8)
- 31 or more (2)

End of Block: GeoInquiries

Appendix D: Anonymous Consent Email

To: [Email, Post in ESRI Geo Net Educator Forum]

Subject: Educator Acceptance of Digital Mapping Technologies

You are invited to participate in a research project entitled *Quantitative Study of The Acceptance of Digital Mapping Technologies in the K-12 Classroom Using the Unified Theory of Acceptance and Use of Technology (UTAUT),* designed to analyze the integration of digital mapping technologies in the classroom. The study is being conducted by Dr. Lisa Heaton and Erika Klose from Marshall University and has been approved by the Marshall University Institutional Review Board (IRB). This research is being conducted as part of the dissertation requirements for Erika Klose.

This survey is comprised of a 21-question survey. It is anticipated this survey will take 10-15 minutes to complete. Your replies will be anonymous. There are no known risks involved with this study. Participation is entirely voluntary, and there will be no penalty or loss of benefits if you choose not to participate in this research study or withdraw. If you decide not to participate, you can leave the survey site. You may choose not to answer any question by simply leaving it blank. Once you complete the survey, you can delete your browsing history for added security. Completing the online survey indicates your consent for use of the answers you supply. If you have any questions about the study, you may contact Dr. Lisa Heaton at 304-746-2026 or Erika Klose at 304-412-5512.

If you have any questions concerning your rights as a research participant, you may contact the Marshall University Office of Research Integrity at (304) 696-4303.

By completing this survey, you are also confirming that you are **18** years of age or older.

In appreciation of the attention you have given to this study, you can enter your name into a drawing for 1 of 10 prizes. The prize includes one $10 Amazon gift card. Your odds of winning one of the prizes is based on the number of individuals participating in the study. We expect that approximately 200 individuals will take part in the study. Information collected to draw for the prizes will not be linked to the study data. This identifying information will be stored in a separate survey, then destroyed after the prizes have been provided. If you would like to participate in the drawing for the gift cards, you will be prompted to enter your email in a separate survey link at the end of this survey.

Please print this page for your records.

If you choose to participate in the study, you will find the survey at https://marshall.az1.qualtrics.com/jfe/form/SV_3w3fx1x5P7tTIB8

If the link above does not work, please copy and paste it into your browser.

Please respond to all the questions as accurately as possible. Thank you in advance for your participation in this research study.

If you know any educators whose experience with digital mapping technologies makes them a candidate to complete this survey, please feel free to forward this communication.

Sincerely,
Erika Klose

Appendix E: Panel of Experts

Esri Education Staff

Chris Bunin, K-16 Geography Instructor, National Geographic Society Explorer, Virginia Geographic Alliance Co-Coordinator

Michael Camponovo, GIS Outreach Coordinator and GIST Director at University of Tennessee, Knoxville

Shana Crosson, U-Spatial at the University of Minnesota

Barbaree Ash Duke, Editor-in-Chief at Directions Magazine

Ashley Melville, Social Studies Specialist, Georgia

Roger Palmer, Product Manager, PASCO Scientific

Questions Asked Regarding Survey:

1. As a GIS education expert, would you be willing to spend a few minutes in the next few days reviewing my draft survey questions and providing recommendations?
2. Specifically, is there any other demographic information that you think I should ask? The demographic information is only included to better understand and describe the survey population. It will not be used in the direct statistical analysis of the data. The survey will be distributed nationally.
3. Do you think my definition of GIS/GST technology integration is complete? Do you think anything needs added or removed?
4. I have modified the UTAUT instrument to refer to GIS/GST technology integration. The original UTAUT instrument can be found on page 36 of the attached paper. Do you believe that the items I have written are worded appropriately?

5. Do you believe my questions regarding the number of times educators used GeoInquiries are appropriate? Do you think that asking “over the past year” and the “last four years” is appropriate? If you think of GeoInquiries as a way to move GIS integration forward, do you believe four years of usage is sufficient?
6. Is there anything else I am missing?

Appendix F: GeoInquiry Examples

The following pages include examples of these GeoInquiries accessed from

https://www.esri.com/en-us/industries/k-12-education/geoinquiries

Example	Collection	Title	Link
1	American Literature	Poe & the Red Death	https://www.esri.com/content/dam/esrisites/en-us/media/fliers/geoinquiries/american-lit/3-poe-and-the-red-death.pdf
2	Earth Science	Cracked plates	https://www.esri.com/content/dam/esrisites/en-us/media/pdf/geoinquiries/earth-science/6-plateboundaries-earthscience-geoinquiry.pdf
3	Early Elementary	Climate	https://www.esri.com/content/dam/esrisites/en-us/media/pdf/geoinquiries/elementary/9-climate-elementary4-geoinquiry.pdf

AMERICAN LITERATURE

Poe & the Red Death

from the Esri GeoInquiries™ collection for American Literature

Target audience – American literature learners | **Time required – 15 minutes**

Activity	Discover the impact of tuberculosis on 1800s America and modern society.
Standards	**CCSS: ELA-LITERACY.RL.11-12.3.** Analyze the impact of the author's choices regarding how to develop and relate elements of a story or drama (for example, where a story is set, how the action is ordered, and how the characters are introduced and developed). **CCSS: ELA-LITERACY.RL.11-12.9.** Demonstrate knowledge of eighteenth-, nineteenth-, and early twentieth-century foundational works of American literature, including how two or more texts from the same period treat similar themes or topics.
Learning Outcomes	• Students will analyze the impact of tuberculosis on Edgar Allan Poe. • Students will analyze the impact of tuberculosis on modern society.

Map URL: http://esriurl.com/litGeoInquiry3

Ask

Where was the red death?

→ Read aloud, "Poe didn't have tuberculosis (TB); however, the disease claimed his mother when he was almost 3 in 1811 in Richmond, Virginia. His foster mother died in 1829. The disease struck again in 1842, killing his wife."
→ Click the link above to launch the map.
→ Read aloud, "Two percent of the population was dying of the disease in New England."
→ Click the darkest red counties.
? In 1800, which counties had the most deaths from TB? *[Philadelphia, Hampshire, and more]*
? How many people were dying in those counties? *[More than 1,000 per county]*
→ With the Details button depressed, click the button, Content.
→ Click the checkbox to the left of the layer name, Tuberculosis Deaths in 1800.

Acquire

How does this disease affect different regions and people?

→ Click New York and New Orleans to view the chart. *(Note: The small arrow in upper right corner of the popup. Click through thearrow until the orange chart is displayed.)*
? What patterns of the disease do you see related to black and white people? *[More black people were dying of TB.]*
? What patterns do you see over time? *[It decreased over time, but there were fewer deaths in New Orleans.]*
→ Click the checkbox to the left of the layer name, New York and New Orleans....

Explore

Where is TB in the U.S. today?

→ Click the checkbox to the left of the layer name, TB Incidence In The US 2015.
? What states are above the average three per 100,000 people? *[Alaska, Hawaii, California, Texas, New York, New Jersey, and Georgia]*
? Of those states, what state has the highest case rate? *[Alaska]*
? Why Alaska? *[The disease can be latent for many years. Experts believe many may have been infected in the 1940s or 1950s and it becomes activated and then spreads further.]*

more ▶

Analyze

How does TB affect other countries?

- → Turn on the layer, New TB Cases In The World 2009.
- → Click the button, Bookmarks. Select World.
- → Examine the new cases in 2009 around the world.
- ? What countries have the most cases? *[Russia, Oman, and more]*
- → Turn off the layer, New TB Cases in the World, 2009.
- → Turn on the layer, New TB Cases in the World, 2015.
- ? What has changed around the world? *[More new cases – Australia, Peru, Kazakhstan, and more]*

Act

What can we do to treat or eradicate the disease?

- – Now that you have an idea about where people have TB, you will examine successful treatment.
- → Turn off all layers.
- → Turn on the layer, Success Rate Of Treatment Worldwide.
- ? Where has treatment been successful? *[USA, Russia, Oman, and Kuwait]*
- ? Where has treatment not been successful? *[Jamaica, Belize, and Finland]*
- ? Why might it not be successfully treated? *[Some people have strains of the disease that are more resistant to tradition antibiotic treatments.]*

SET FILTER PARAMETERS

- The Filter is only available for certain map layers.
- In the Contents pane, point to a layer and click the Filter button beneath the layer name.
- Set the Filter parameters.

TURN A MAP LAYER ON AND OFF

- Make sure that the Details pane is selected, and click Show Contents Of Map.
- To show individual map layers, select the check boxes next to the layer names.
- Hint: If a map layer name is light gray, zoom in or out on the map until the layer name is black. The layer can now be turned on.

Next Steps

DID YOU KNOW? ArcGIS Online is a mapping platform freely available to U.S. public, private, and home schools as a part of the White House ConnectED Initiative. A school subscription provides additional security, privacy, and content features. Learn more about ArcGIS Online and how to get a school subscription at http://connected.esri.com.

THEN TRY THIS...

- Explore other statistics in the data tables by symbolizing other factors.
- Filter the data tables.

TEXT REFERENCES

This GIS map has been cross-referenced to material in the following short story.

- *"The Masque of the Red Death," Edgar Allan Poe*

Cracked plates

from the Esri GeoInquiries™ collection for Earth Science

EARTH

Target audience – Earth Science learners | **Time required – 15 minutes**

Activity	Investigate dynamics in the earth's crust that explain multiple phenomena.
Science Standards	NGSS:MS-ESS2-1 – Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
Learning Outcomes	• Students will explain the pattern of earthquakes globally to gain insight about the driving forces that cause them. • Students will differentiate ways that large plates of the crust interact when they meet.

Map URL: http://esriurl.com/earthgeoinquiry6

Engage

Can earthquakes occur anywhere on the earth?

→ Click the URL above to launch the map.
? Where have you heard of earthquakes occurring? *[Answers will vary.]*
? Is there a pattern to the quakes that students have heard about? *[Many will think of "The Ring of Fire."]*
→ With the Details button underlined, click the button, Show Contents of Map (Content).
→ Turn on the layer, Global Quakes Of Large Magnitude 5.8 Or Greater.
? What patterns are visible where quakes occurs? *[A common misconception is that quakes occur just around continents or oceans. Help students recognize that quakes define plates around both sections of continents and oceans together. There are exceptions, of course (for example, the Pacific).]*
? What is happening to the area within a ring of earthquakes? *[This area moves as one piece, so no collisions are happening inside a single piece of crust called a plate.]*

Explore

How many different ways can you crash your car?

→ Turn on the layer, Relative Motion At Plate Boundaries.
– Note that you will not see anything until you perform the next step.
→ Press the button, Bookmarks.
→ Select each bookmark and describe the plate movement at the bookmark. *[South America would have a direct collision, California would have a side swipe, and Mid Atlantic would be torn apart.]*

Explain

What are these types of plates called?

– Earthquakes occur where large pieces of the earth's crust run into, pull away from, or slide against other pieces of independent crust.
→ Turn on the layer, Plate Boundaries.
→ Click the layer name, Plate Boundaries, to see its legend.
→ Choose each bookmark in turn (South America, California, and Mid Atlantic Ridge).
? What are plates that collide head-on called? *[Convergent.]* What are boundaries called where plates are stretched apart? *[Divergent.]*
? What are boundaries called where plates are in a side-swipe collision? *[Transform.]*
→ Turn off the layer, Global Quakes Of Large Magnitude 5.8 Or Greater.

more ▶

Elaborate

How are earthquakes distributed differently at each plate boundary type?

- → Turn on the layer, South American Quakes. Pan the map to South America.
- → Hover over the layer name, South American Quakes.
- → Click the button, Change Style.
- → Change the attribute (#1) from Show Location Only to Depth_km.
- – The new symbology draws dots larger according to how deep quakes occur. Click Done to apply these changes.
- ? Do these earthquakes occur only at the boundary between plates? *[No, they spread out - in one direction.]*
- ? Suggest a hypothesis for what is happening to these colliding earthquakes. *[Because quakes happen where plates touch and only on the continent side, South America must be on top of the Pacific crust.]*
- ? Ask students to construct a three row table where earthquakes occur compared to plate boundary types. *[Suggested answers in table below.]*

	Quakes compared to boundary	Pattern of depths of quake
Convergent	*Only one side*	*Gets deeper under continent*
Divergent	*Close boundary*	*More shallow but random*
Transform	*Both sides of boundary*	*Mixed depths but random*

Evaluate

Which type of boundary separates the Caribbean and the Gulf of Mexico?

- → Turn on the layer, Caribbean Quakes.
- ? Determine which type of plate boundary occurs here based on your table. *[This is a transform boundary.]*

MEASURE

- Click the button, Measure.
- Click the Distance button. Choose unit of measurement.
- Click once on the map to start the measurement; click again to change direction. Double click to stop.

BOOKMARK

- Click the button, Bookmarks.
- Choose a bookmark.
- The map move to the locatoin and scale set in the book-mark.

Next Steps

DID YOU KNOW? ArcGIS Online is a mapping platform freely available to public, private, and home schools. A school subscription provides additional security, privacy, and content features. Learn more about ArcGIS Online and how to get a school subscription at http://www.esri.com/schools.

THEN TRY THIS...

- Explore the 2015 Nepal earthquakes with the story map at http://esriurl.com/Geo519.
- Log in to the school's ArcGIS Online organizational subscription. Use Analysis tools to identify patterns in either depth or time.

TEXT REFERENCES

This GIS map has been cross-referenced to material in the plate tectonics sections of chapters from middle-school texts.

- *Earth Science by Glencoe McGraw Hill – Chapter 5*
- *Earth Science by McDougal Littell – Chapter 1*
- *Earth Science by Prentice Hall – Chapter 7*
- *Earth Science by Tarbuck and Lutgens – Chapter 7*

4

ELEMENTARY

Climate

from the Esri GeoInquiries™ collection for Upper Elementary

Target audience – Upper elementary **Time required – 15 minutes**

Activity	Investigate the patterns between climate and the physiography of the U.S.
Standards	**NGSS:4-ESS2-1.** Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. **NGSS:4-ESS2-2.** Analyze and interpret data from maps to describe patterns of the earth's features.
Learning Outcomes	• Students will identify temperature patterns in summer and winter across the U.S. • Students will relate temperature patterns to patterns of yearly precipitation across the U.S. to describe climate. • Students will investigate patterns that exist between climate and elevation across the U.S.

Map URL: http://esriurl.com/fourgeoinquiry9

Engage

What is weather?

→ Click the map URL link above to launch the map, or type it into your Internet browser.
→ Click the Show Contents Of Map button.
? What is weather? *[Short-term conditions in the atmosphere.]*
? What is the weather like in January where we are? *[Students should say that temperatures are colder in January than at other times of the year.]*
? What is the weather like here in June? *[Students should say that temperatures are warmer in June than at other times of the year.]*
? Is the weather the same in other parts of the country as it is here? *[Depending on students' experiences, answers may vary. Students should say that weather is not the same in other parts of the country.]*

Explore

What climate patterns do you see?

? What are two long-term atmospheric factors that make up climate? *[Temperature and precipitation]*
? What average temperature patterns do you see on the map? *[Northern areas of the U.S. are colder, and southern areas of the U.S. are warmer.]*
? Where are average temperatures the warmest? *[Across southern Florida and Hawaii]*
? Where are they the coldest? *[Across Alaska, the northern plains (North Dakota, South Dakota, Montana, Minnesota, and Wisconsin), and the Rocky Mountain region (Idaho, Wyoming, and Colorado).]*
→ Turn off the January Temperatures layer and turn on the July Temperatures layer.
? Do the same patterns exist in July as they do in January? *[Approximately, except the warmest weather is in southern Arizona.]*
→ Turn off the June Temperatures layer and turn on the Average Yearly Precipitation layer.
? Are there patterns that you see in precipitation? *[Yes, it is wet across the Pacific Northwest (Northern California, Oregon, and Washington) and all areas east of the Mississippi River.]*

more ▶

Explain

Can we classify climate areas?

? Were the patterns of average temperatures in both January and July similar? *[Yes, they were similar—colder in the north, warmer in the south.]*

? Were the patterns of precipitation the same as the patterns of temperatures? *[No.]*

→ Classify areas of the U.S. as warm or cold and wet or dry. *[Students should identify northern areas as cold, southern areas as warm, northwestern and eastern areas as wet, and the central U.S. as dry.]*

→ Turn off the Precipitation layer, and turn on the Climate Regions layer.

→ Examine how close students were to correctly identifying the regions.

Elaborate

How does climate relate to elevation?

? Do you see any patterns of regional climate and how they relate to elevation? *[Higher elevations seem to be colder and drier, while lower elevations are dependent on latitude.]*

? Do areas of higher elevation have warmer or colder climates? *[Colder climates]*

? Do areas of higher elevation have wet or dry climates? *[Dry climates]*

TURN A MAP LAYER ON OR OFF

- Make sure that the Details pane is selected.
- Click Show Contents Of Map.
- Click the check boxes next to the layer names.
- Hint: If a map layer name is light gray, zoom in or out on the map until the layer name is black. The layer can now be turned on.

IDENTIFY A MAP FEATURE

- Click a feature on the map, and a pop-up window will open with information.
- Links and images in the pop-up are often clickable.
- An arrow icon in the upper-right of the window indicates that multiple features have been selected.
- Click the arrow button to scroll through the features.

Next Steps

DID YOU KNOW? ArcGIS Online is a mapping platform freely available to public, private, and home schools. A school subscription provides additional security, privacy, and content features. Learn more about ArcGIS Online and how to get a school subscription at http://www.esri.com/schools..

THEN TRY THIS...

- Compute the difference between temperatures in January and June in an area of interest. Do this by estimating the temperature in July and subtracting the temperature in January.
- Explore the Stanford Story map, *Mapping the Impacts of Global Change*, at http://mappingglobalchange.org.

TEXT REFERENCES

This GIS map has been cross-referenced to material in sections of chapters from these texts

- *Science: A Closer Look by Macmillan/McGraw-Hill — Chapter 7*
- *Science by Houghton Mifflin — Chapter 10*
- *Science by Harcourt — Chapter 2*

Appendix G: SPSS Code Book

Variable	Position	Label	Measurement Level	Role
StartDate	1	Start Date	Scale	Input
EndDate	2	End Date	Scale	Input
Status	3	Response Type	Scale	Input
IPAddress	4	IP Address	Nominal	Input
Progress	5	Progress	Scale	Input
Duration in seconds_	6	Duration (in seconds)	Scale	Input
Finished	7	Finished	Scale	Input
RecordedDate	8	Recorded Date	Scale	Input
ResponseId	9	Response ID	Nominal	Input
LocationLatitude	10	Location Latitude	Nominal	Input
LocationLongitude	11	Location Longitude	Nominal	Input
DistributionChannel	12	Distribution Channel	Nominal	Input
UserLanguage	13	User Language	Nominal	Input
Q1	14	<none>	Nominal	Input
Q1_1	15	Grade level you currently teach: K-2	Scale	Input
Q1_2	16	Grade level you currently teach: 3-5	Scale	Input
Q1_3	17	Grade level you currently teach: 6-8	Scale	Input
Q1_4	18	Grade level you currently teach: 9-12	Scale	Input
Q2	19	Years of teaching experience:	Scale	Input
Q3	20	Level of Education	Scale	Input
Q4_1	21	The area(s) you teach: Elementary	Scale	Input
Q4_2	22	The area(s) you teach: Math	Scale	Input
Q4_3	23	The area(s) you teach: Science	Scale	Input
Q4_4	24	The area(s) you teach: Social Studies	Scale	Input
Q4_5	25	The area(s) you teach: English	Scale	Input
Q4_6	26	The area(s) you teach: CTE	Scale	Input
Q4_7	27	The area(s) you teach: Technology	Scale	Input
Q4_8	28	The area(s) you teach: Computer Science	Scale	Input
Q4_9	29	The area(s) you teach: Other	Scale	Input
state	30	50 States, D.C., and Puerto Rico	Scale	Input
Q10	31	Have you received any professional development related to digital mapping technology integration?	Scale	Input

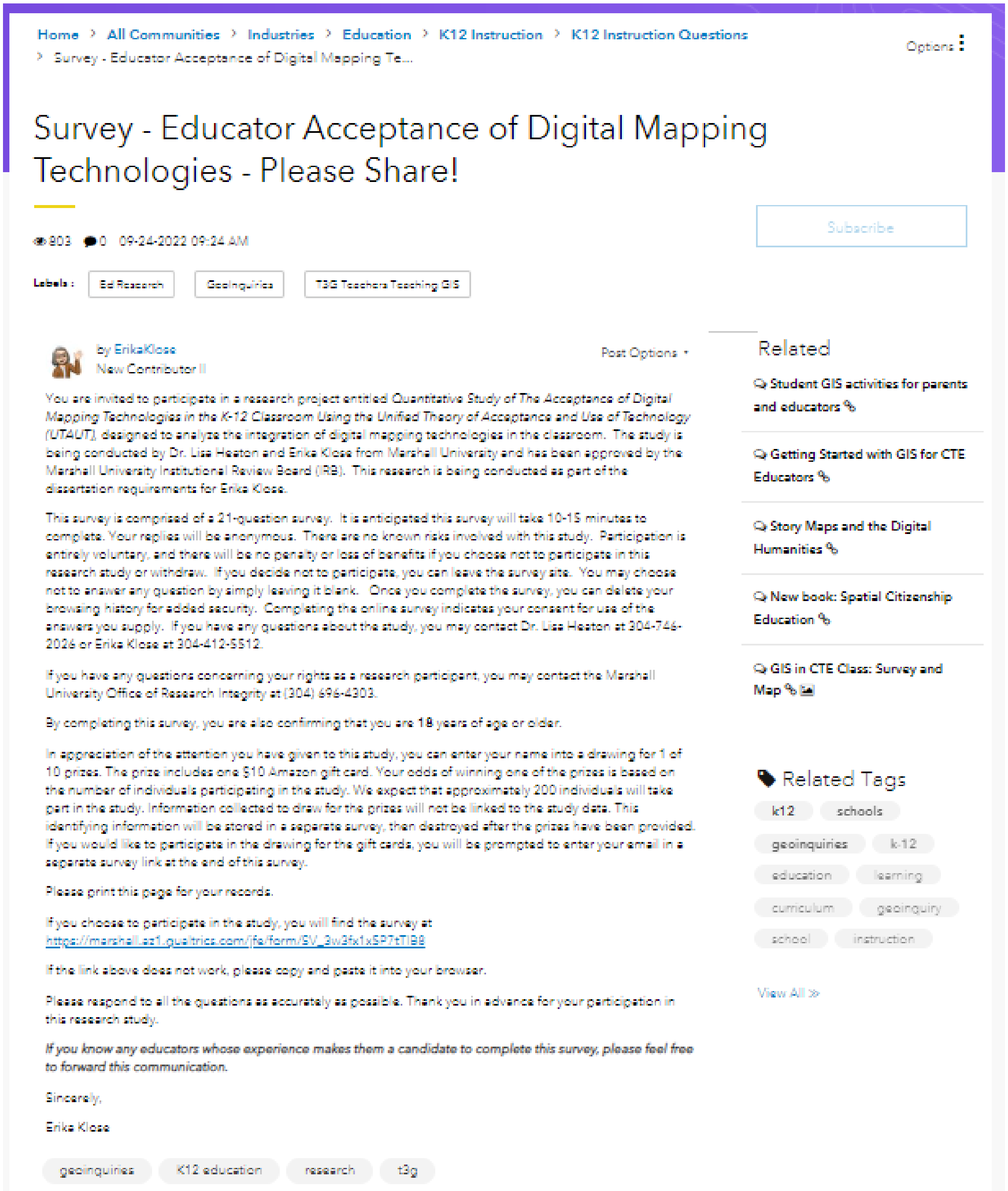
Q11	32	If you answered yes to the previous question, how many hours of professional development did you receive?	Scale	Input
Q17_1	33	Section 1 - I believe that digital mapping technology will be beneficial for the students in my classroom.	Scale	Input
Q17_2	34	Section 1 - Digital mapping technology enables me to deliver instruction more effectively in my classroom.	Scale	Input
Q17_3	35	Section 1 - Digital mapping technology improves student learning in my classroom.	Scale	Input
Q17_4	36	Section 1 - Using digital mapping technology in my classroom instruction increases my chance of professional advancement.	Scale	Input
Q19_1	37	Section 2 - I have a clear understanding of digital mapping technology.	Scale	Input
Q19_2	38	Section 2 - It would be possible for me to become more skillful at using digital mapping technology in my classroom.	Scale	Input
Q19_3	39	Section 2 - I find digital mapping technology easy to use in my classroom.	Scale	Input
Q19_4	40	Section 2 - Learning to operate digital mapping technology in my classroom is possible for me.	Scale	Input
Q20_1	41	Section 3 - People who influence my classroom behavior think that I should use digital mapping technology.	Scale	Input
Q20_2	42	Section 3 - People who are important to me think that I should use digital mapping technology in my classroom.	Scale	Input

Q20_3	43	Section 3 - The principal of my school has been encouraging in the use of digital mapping technology in my classroom.	Scale	Input
Q20_4	44	Section 3 - In general, my school community has supported the use of digital mapping technology in my classroom.	Scale	Input
Q21_1	45	Section 4 - I have the resources necessary to use digital mapping technology in my classroom.	Scale	Input
Q21_2	46	Section 4 - I have the knowledge necessary to use digital mapping technology integration in my classroom.	Scale	Input
Q21_3	47	Section 4 - Digital mapping technology in my classroom is compatible with other resources I use.	Scale	Input
Q21_4	48	Section 4 - A specific person (or organization, or group) is available to assist me with digital mapping technology difficulties that may arise in my classroom.	Scale	Input
Q22_1	49	Section 5 - I have integrated digital mapping technology in my classroom instruction in the last 12 months.	Scale	Input
Q22_2	50	Section 5 - I predict I will continue to use digital mapping technology integration in my classroom instruction in the next 12 months.	Scale	Input
Q22_3	51	Section 5 - I plan to use digital mapping technology to a greater degree in my classroom instruction in the future.	Scale	Input
Q22_4	52	Section 5 - I will recommend other people integrate digital mapping technology in their classroom instruction.	Scale	Input

Q13	53	Have you used GeoInquiries in your instruction?	Scale	Input
Q14	54	In the questions below a GeoInquiry refers to 1 single lesson in a collection, such as “Cracked Plates” in the Earth Science collection, or “Poe and the Red Death” in the American Literature collection. For example, if you used these two lessons, yF4020IME20	Scale	Input
Q15	55	In the question below the total number of times that GeoInquiries were used indicates the number of times the educator did the activity. For example, an educator may teach Earth Science and teach 5 sections a day. If the educator uses “Cracked Plates” F4020IME20	Scale	Input
Q20	56	For how many years have you used GeoInquiries in your classroom instruction?	Scale	Input
Q21	57	On average, how many times do you use a GeoInquiry each year?	Scale	Input

Appendix H: Esri Community Post 1

https://community.esri.com/t5/k12-instruction-questions/survey-educator-acceptance-of-digital-mapping/m-p/1215821#M321



Home > All Communities > Industries > Education > K12 Instruction > K12 Instruction Questions > Survey - Educator Acceptance of Digital Mapping Te...

Options

Survey - Educator Acceptance of Digital Mapping Technologies - Please Share!

803 0 09-24-2022 09:24 AM

Subscribe

Labels: Ed Research | GeoInquiries | T3G Teachers Teaching GIS

by ErikaKlose
New Contributor II

Post Options

You are invited to participate in a research project entitled *Quantitative Study of The Acceptance of Digital Mapping Technologies in the K-12 Classroom Using the Unified Theory of Acceptance and Use of Technology (UTAUT)*, designed to analyze the integration of digital mapping technologies in the classroom. The study is being conducted by Dr. Lisa Heaton and Erika Klose from Marshall University and has been approved by the Marshall University Institutional Review Board (IRB). This research is being conducted as part of the dissertation requirements for Erika Klose.

This survey is comprised of a 21-question survey. It is anticipated this survey will take 10-15 minutes to complete. Your replies will be anonymous. There are no known risks involved with this study. Participation is entirely voluntary, and there will be no penalty or loss of benefits if you choose not to participate in this research study or withdraw. If you decide not to participate, you can leave the survey site. You may choose not to answer any question by simply leaving it blank. Once you complete the survey, you can delete your browsing history for added security. Completing the online survey indicates your consent for use of the answers you supply. If you have any questions about the study, you may contact Dr. Lisa Heaton at 304-746-2026 or Erika Klose at 304-412-5512.

If you have any questions concerning your rights as a research participant, you may contact the Marshall University Office of Research Integrity at (304) 696-4303.

By completing this survey, you are also confirming that you are 18 years of age or older.

In appreciation of the attention you have given to this study, you can enter your name into a drawing for 1 of 10 prizes. The prize includes one $10 Amazon gift card. Your odds of winning one of the prizes is based on the number of individuals participating in the study. We expect that approximately 200 individuals will take part in the study. Information collected to draw for the prizes will not be linked to the study data. This identifying information will be stored in a separate survey, then destroyed after the prizes have been provided. If you would like to participate in the drawing for the gift cards, you will be prompted to enter your email in a separate survey link at the end of this survey.

Please print this page for your records.

If you choose to participate in the study, you will find the survey at
https://marshall.az1.qualtrics.com/jfe/form/SV_3w3fx1x5P7tTIB8

If the link above does not work, please copy and paste it into your browser.

Please respond to all the questions as accurately as possible. Thank you in advance for your participation in this research study.

If you know any educators whose experience makes them a candidate to complete this survey, please feel free to forward this communication.

Sincerely,

Erika Klose

geoinquiries | K12 education | research | t3g

Related

- Student GIS activities for parents and educators
- Getting Started with GIS for CTE Educators
- Story Maps and the Digital Humanities
- New book: Spatial Citizenship Education
- GIS in CTE Class: Survey and Map

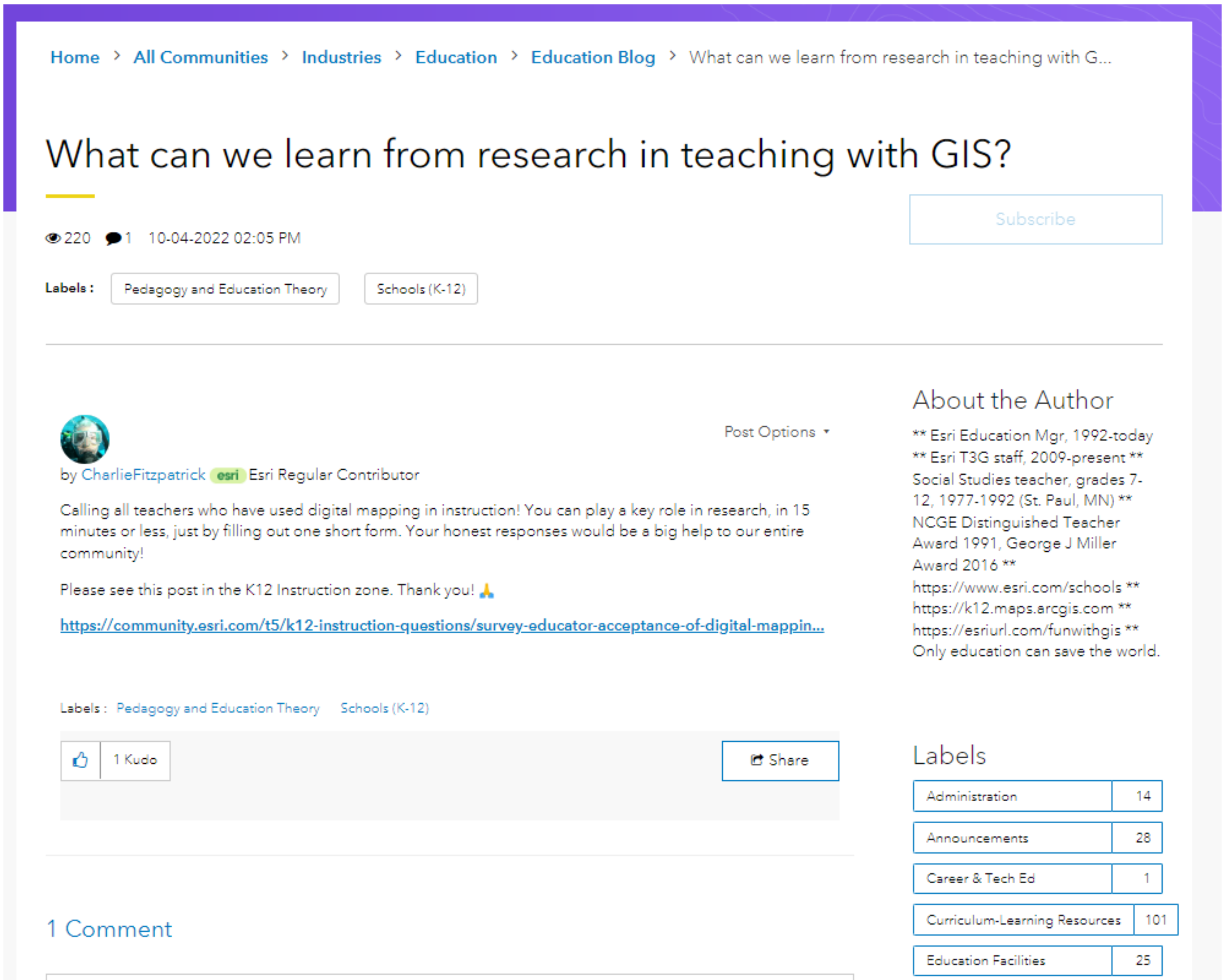
Related Tags

k12 | schools | geoinquiries | k-12 | education | learning | curriculum | geoinquiry | school | instruction

View All »

Appendix I: Esri Community Post 2

https://community.esri.com/t5/education-blog/what-can-we-learn-from-research-in-teaching-with/ba-p/1218824



Home > All Communities > Industries > Education > Education Blog > What can we learn from research in teaching with G...

What can we learn from research in teaching with GIS?

Subscribe

220 1 10-04-2022 02:05 PM

Labels: Pedagogy and Education Theory Schools (K-12)

Post Options

by CharlieFitzpatrick esri Esri Regular Contributor

Calling all teachers who have used digital mapping in instruction! You can play a key role in research, in 15 minutes or less, just by filling out one short form. Your honest responses would be a big help to our entire community!

Please see this post in the K12 Instruction zone. Thank you! 🙏

https://community.esri.com/t5/k12-instruction-questions/survey-educator-acceptance-of-digital-mappin...

Labels: Pedagogy and Education Theory Schools (K-12)

1 Kudo

Share

1 Comment

About the Author

** Esri Education Mgr, 1992-today ** Esri T3G staff, 2009-present ** Social Studies teacher, grades 7-12, 1977-1992 (St. Paul, MN) ** NCGE Distinguished Teacher Award 1991, George J Miller Award 2016 ** https://www.esri.com/schools ** https://k12.maps.arcgis.com ** https://esriurl.com/funwithgis ** Only education can save the world.

Labels

Administration	14
Announcements	28
Career & Tech Ed	1
Curriculum-Learning Resources	101
Education Facilities	25

Appendix J: T3G Email

From: T3G-GROUP <T3G-GROUP@ATLANTIS.ESRI.COM> on behalf of Charlie Fitzpatrick <00000018c300655e-dmarc-request@ATLANTIS.ESRI.COM>
Sent: Tuesday, October 4, 2022 5:12 PM
To: T3G-GROUP@ATLANTIS.ESRI.COM <T3G-GROUP@ATLANTIS.ESRI.COM>
Subject: [T3G-GROUP] Got 15 minutes to help us all?

T3Gers: You can help us all, if you have taught in schools using digital mapping, or know someone who has.
Plea: https://community.esri.com/t5/education-blog/what-can-we-learn-from-research-in-teaching-with/ba-p/1218824
Info: https://community.esri.com/t5/k12-instruction-questions/survey-educator-acceptance-of-digital-mapping/m-p/1215821#M321
15 minutes would really help! So would sharing this with peers who have taught with digital mapping tools.

Charlie Fitzpatrick | K12 Education Manager
Esri | Arlington, VA 22201 | USA
T 909 369 8349 | M 612 309 8897
cfitzpatrick@esri.com | esri.com/schools

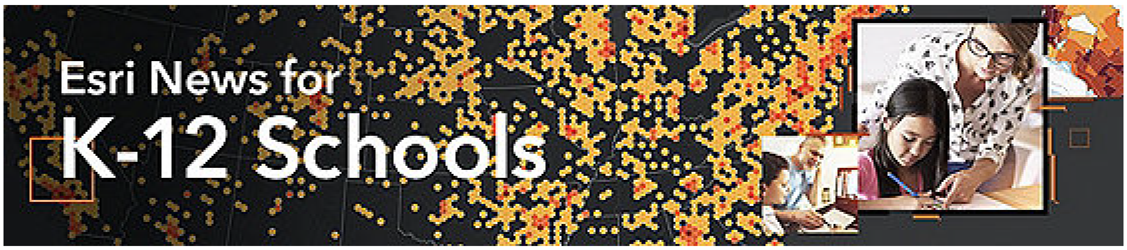
THE SCIENCE OF WHERE ®

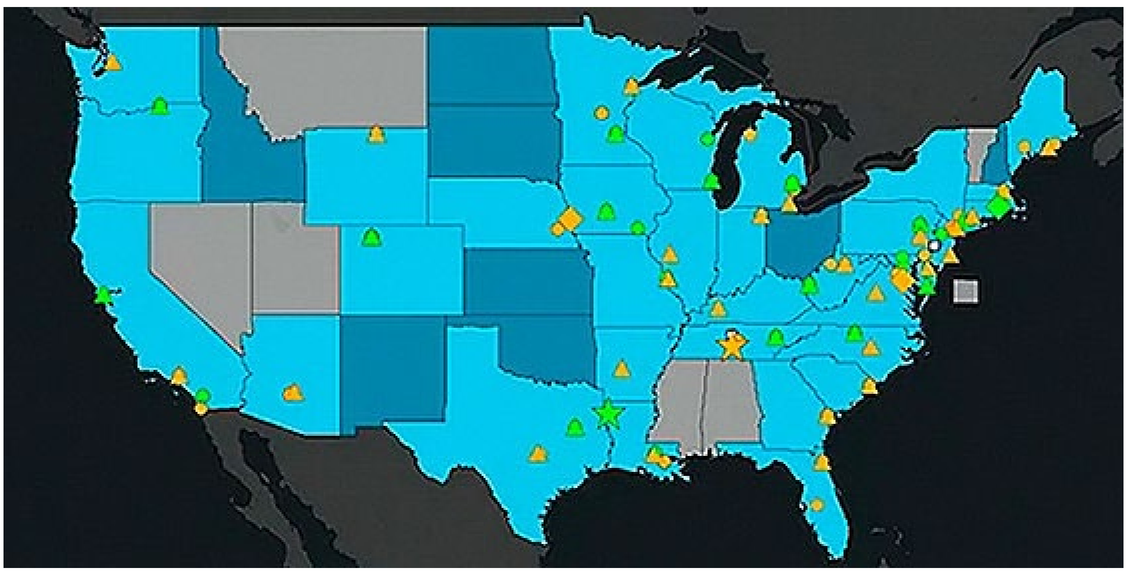
===== Listserv for alums of Esri's T3G Institute (http://esriurl.com/t3g). Contact t3g-institute@esri.com with private issues. =====

Appendix K: Esri K-12 Newsletter

View email in web browser.

esri





2023 ArcGIS Online Competition for US HS+MS Students

Esri challenges US students to conduct and share a research project about something in their home state. Esri's ArcGIS Online Competition is open to high school (HS, gr. 9–12) and middle school (MS, gr. 4–8) students in participating states in the US who can gather, create, analyze, interpret, and present data via ArcGIS StoryMap.

View Competition

Your Help Is Needed

We need 10–15 minutes from K–12 teachers to better understand GIS in the classroom. You are invited to participate in a research project designed to analyze the integration of digital mapping technologies in the classroom.

Take Survey

ArcGIS Puzzles

Puzzles pique our curiosity; feed our need to explore; and, on occasion, have us pulling out our hair. For the GIS teacher or student, GIS puzzles will check all these boxes—and more. Introduced by Charlie Fitzpatrick over 25 years ago, the puzzles below have been moved to ArcGIS Online and updated. The puzzles provide clues and data layers for finding a special location on the planet.

View Puzzles

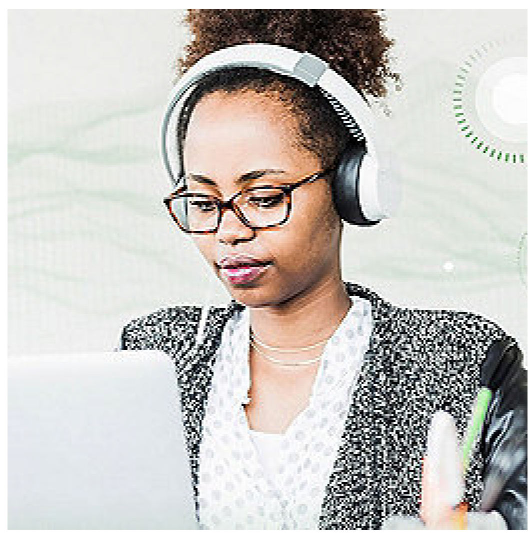
ArcGIS Online Administration: One Critical Task

Administrators of an ArcGIS Online organization account has many responsibilities. They control all permissions and settings in the organization, including invitations, entries, and privileges. So I am astonished when teachers seek assistance because the ONLY administrator of the organization has left the school.

Get Details →

New Web Course: Getting Started with Imagery and Remote Sensing

In October, Esri Academy added three new e-Learning resources in imagery and remote sensing. Most exciting is an introductory web course on the topic, which educators have been requesting for some time. The 3.5-hour course, Getting Started with Imagery and Remote Sensing, requires ArcGIS Pro 2.9 (Standard or Advanced), ArcGIS Image Analyst, and ArcGIS Spatial Analyst software.



Take Course →

From the Community/In Case You Missed It

GeoInquiries
Especially for those educators new to GIS in the classroom, explore over 180 prebuilt instructional activities with maps and data. Most activities don't even require a login and will run on common school-issued devices.

Teacher Video Challenge
Submit and win with your GIS education video. Monthly winners who complete the challenge win $500. Discover the challenge.

Curriculum Vitae

Erika S. Klose
(Contact information available upon request.)

Education / Certification

Ed.D.	Education, Curriculum and Instruction Marshall University, Huntington, WV, 2023
Ed.S.	Education Specialist Marshall University, Huntington, WV, 2022
Educational Leadership	Educational Leadership Certificate WV State University, Institute, WV, 2017
M.A.	Teaching, Marshall University, S. Charleston, WV, 2007
M.S.	Earth and Environmental Sciences, Lehigh University, Bethlehem, PA, 1999
B.A.	Geology, Smith College, Northampton, MA, 1997
Administrative Certificate	Superintendent, PK – Adult, West Virginia Supervisor General Instruction, PK – Adult, West Virginia Principal, PK – Adult, West Virginia
Teacher Certificate	5 - Adult, General Science, West Virginia 9 - Adult, Earth and Space Science, West Virginia National Board Certification, Early Adolescent Science

Current Position

Science, STEAM, Computer Science, GIS Coordinator 2021 –present

West Virginia Department of Education
Coordinates the Science Standards Policy development and implementation
Coordinates transdisciplinary STEAM initiative statewide
Coordinates Technology and Computer Science Policy development and implementation
Coordinates WV Science and Engineering Fair
Develops programming related to GIS for WV educators
Develops professional learning for WV educators

Leadership Experience

Advisory Board, First2 Network, September 2020 - present

Advisory Council, Remake Learning Council, September 2019 - present

WV Public Education Collaborative Board, September 2018 - present

President, West Virginia Science Teachers Association, October 2018 – October 2020
Coordinate with the Board to plan WVSTA Annual Meeting
Provide science leadership to WV Teachers

WVDE ACEPPRB Review Team for Alternative Certification Programs, 2016 – 2018
Participated in review of County applications for Alternative Certification Programs

WVDE State Review Team for Next Generation Science Standards, 2011 – 2018
Participated in the development and implementation of the Next Generation Science Standards for WV
Participated in the development of assessment questions and question review for the Next Generation Science Standards for WV

WVDE Contracted GIS Program Manager, 2010 – 2018
Coordinated the Esri ArcGIS software license for WVDE
Trained teachers (between 30 and 90 per year) in the instructional use of GIS for WVDE
Answered questions on and provide support for the instructional use of GIS throughout the year

Esri Education Community Advisory Board, 2014 – 2015
Advised Esri Education on the implementation of the ConnectEd campaign

President-Elect, West Virginia Science Teachers Association, October 2016 – 2018
Coordinate with the Board to plan WVSTA Annual Meeting
Chair the Election Committee to elect slate of new officers

Professional Development Trainer for Putnam County, 2014 – 2018
Instructed Putnam County Teachers in incorporating technology into classroom instruction

Putnam County Science / STEM Fair Coordinator, 2009 – 2018
Planned and coordinated the Putnam County Science/STEM Fair for the middle and high schools

Winfield Middle School, WEB Program Chair, 2012-2018
Coordinated the Winfield Middle School WEB Program
Trained student leaders to fulfill the duties of WEB leaders

Winfield Middle School, Faculty Senate President, 2012 – 2018
Chaired Faculty Senate Meetings and acted as liaison between Winfield Middle School

faculty and administration
Participated in all Winfield Middle School staff interviews

Winfield Middle School, Science Department Chair, 2008-2018
Coordinated the Winfield Middle School Science teachers
Approved Science Department purchases and created department budget

Education Experience

STEM and Computer Science Coordinator, 2018 –2021
West Virginia Department of Education
Coordinated the completion of the WVDE Comprehensive Approach to STEM,
Coordinated the development of the WVDE Computer Science Plan
Developed a GIS Plan that creates a pathway for K12 GIS instruction
Worked with WV State GIS Planning Council to develop a GIS HS Certification
Developed Professional Learning for WV Teachers

Winfield Middle School, Science Teacher, January 2008 – April 2018
Integrated a variety of instructional and laboratory techniques to create student interest
Maintained positive relationships with faculty, students, and parents with the goal of student success
Evaluated and tracked data on student progress using formative and summative assessments

Marshall University Graduate College, Adjunct Faculty, Spring Semester 2013
Taught Secondary Teaching Methods and the accompanying classroom observations for MUGC graduate students.
Evaluated student progress through formative and summative assessment

WV Learns, Instructor, September 2017 – September 2018
Wrote and currently instructs Computer Science Introduction to GIS

Coaching Experience

Winfield High School, Assistant Boys Tennis Coach, Spring 2018
Winfield High School, Assistant Girls Tennis Coach, Spring 2018
Winfield Middle School, Boys Tennis Coach, Eight seasons, 2010 – 2017
Winfield High School, Boys Tennis Coach, Three seasons, 2016 – 2017

Related Experience

US Geological Survey, Woods Hole, MA, Geologist, 1999-2005
Active participation in science research related to marine geology and marine hazards
Prepared and delivered teacher outreach events, classroom visits, and field trips
Coordinated data compilation for multiple national research projects

Department of Earth and Environmental Sciences, Lehigh University, Bethlehem, PA

Teaching Assistant, 1998 - 1999

Prepared, taught, and evaluated laboratory and field exercises for Seismology, Introduction to Planet Earth, and Hydrogeology courses

Smith College, Northampton, MA, Geology Department Lab Assistant, 1996 - 1997

Instructed students in Adobe Illustrator, AutoCAD, and other graphics applications

Prepared laboratory exercises dealing with coastal processes, coastal issues and physical oceanography

Selected Professional Development

T3G – Teachers Teaching Teachers GIS, Esri, Redlands, CA June 2012

Week-long intensive professional development at Esri in Redlands, CA learning technology and techniques to teach teachers how to teach with the ArcGIS software.

NSTA New Science Teacher Academy Fellow, 2009

Awarded one year of intense online professional development and mentoring through NSTA with a focus on creating an inquiry-centered classroom.

PBS Digital Innovator 2014

Awarded one year of intense online professional development through PBS with a focus on incorporating PBS's collection of high-quality media into classroom instruction, homework, and assessment.

Curriculum Experience

SREB Lead Writer for Middle School STEM Curriculum, 2015 – 2017

Served as one of three lead writers in the development of a set of twelve 30-day PBL modules.

Wrote four modules and coordinated the math and reading language arts writers for each of these four modules.

Professional Affiliations

National Science Teachers Association, 2007 - present
West Virginia Science Teachers Association, 2010 – present
West Virginia Association of Geospatial Professionals, 2011, 2018 - present

Honors and Awards

Esri Special Achievement in GIS (SAG) Award, WVDE, 2019
Milken Educators Award, 2017
Presidential Award for Excellence in Mathematics and Science Teaching, 2017
Arch Coal Golden Apple Award, 2015

Putnam County Middle School Teacher of the Year, 2015
Winfield Middle School, Teacher of the Year, 2012 & 2014
Hour of Code, $10,000 Award, 2013
GLOBE Star, 2012, (www.globe.gov)
Star Award, U.S. Geological Survey, 2002
Kravis Fellowship, Lehigh University, 1997-1998
AAPG Grant-in-Aid, Lehigh University, 1998
Dean's List, Smith College, 1993-1997

Presentations

Klose, E. (2021). Poster: GIS is Now Everywhere: Professionals Needed. In E. Langran & L. Archambault (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 1101-1105). Online, United States: Association for the Advancement of Computing in Education (AACE). Retrieved September 15, 2021 from https://www.learntechlib.org/primary/p/219261/.

Klose, E.S. (2020, July). *State Map Contest Roundtable.* Paper presented at the Esri Education Users Conference Annual Meeting

Klose, E.S. (2019, July). *Removing Barriers to K12 GIS Implementation in WV.* Paper presented at the Esri Education Users Conference Annual Meeting

Klose, E.S. (2018, January). *Reaching K-12 Students through GIS and Geography.* Paper presented at the WVU Geography Colloquium

Klose, E.S. (2017, November). *Teaching content through ESRI Geoinquiries.* Paper presented at the WV Science Teachers Annual Conference

Klose, E.S. (2017, July). *Geoinquiries as a Gateway to Teacher GIS.* Plenary presentation at the Esri Education Users Conference Annual Meeting

Klose, E.S. (2016, November). *Teaching content through GIS.* Paper presented at the WV Science Teachers Annual Conference

Klose, E.S. and Baker, T.R. (2016, March). *Refining Earth Misperceptions with Interactive Online Models*. Paper presented at 2017 Geotech Conference

Baker, T.R, and **Klose**, E.S. (2016, March). *Maps for Environmental Topics*. Paper presented at 2017 Geotech Conference

Miller, M, and **Klose**, E.S. (2016, July). *Is This Forest Healthy and What Does That Mean to Me?* Paper presented at the National Science Teachers Association Annual Conference.

Klose, E.S. (2015, July). *Using GIS to Identify Community Issues.* Paper presented at the Esri Education Users Conference Annual Meeting

Klose, E.S. (2014, July). *Teaching Science Content and the NGSS with Geotechnologies*. Paper presented at the National Science Teachers Association Annual Conference.

Klose, E.S. (2014, July). *Using GIS to implement NGSS.* Paper presented at the Esri Education Users Conference Annual Meeting

Klose, E.S. (2014, July). *ArcGIS for WV Teachers*. Paper presented at WV Statewide Technology Conference

Klose, E.S. (2014, June). *K12 Education Update*. Paper presented at WV Association of Geospatial Professionals Annual Meeting

Klose, E.S. (2013, July). *Enriching Science through Geotechnology*. Paper presented at the Esri Education Users Conference Annual Meeting

Klose, E.S. (2013, July). *ArcGIS – Explore the Possibilities!* Paper presented at Annual WVDE CTE Instructor Summer Conference

Klose, E.S. (2013, February). *Using ArcGIS to Bring the Real World to the Classroom*. Paper presented at the 2013 Ohio Educational Technology Conference.

Klose, E.S. (2013, February). ***"Hands-on" Lab for Using ArcGIS in the Classroom.*** Paper presented at the 2013 Ohio Educational Technology Conference.

Klose, E.S. (2012, July). *Science Standards and Practice*. Paper presented at the Esri Education Users Conference Annual Meeting

Klose, E.S. and Miller, M. (2012, March). *Science + GIS = Real World Problem Solving + Core Knowledge*. Paper presented at the National Science Teachers Association Annual Conference.

Klose, E.S. (2011, July). *ESRI's ArcGIS for WV Teachers*. Paper presented at WV Statewide Technology Conference

Klose, E.S. (2011, July). *PBS Learning Media for WV Teachers*. Paper presented at WV Statewide Technology Conference

*In 2006, my last name changed from Hammar-Klose to Klose.

Hammar-**Klose**, E. S., Thieler, E. R. and Williams, S. J. (2001, October). *Mapping Relative Coastal Vulnerability to Future Sea-Level Rise in the National Seashores,* Paper presented at the Geological Society of America Annual Meeting.

Hammar-**Klose**, E. S., and Thieler, E.R., (2000, December). *Coastal Vulnerability to Sea-Level Rise: Preliminary Results for the U.S. Shoreline*, Paper presented at the American Geophysical Union Annual Meeting.

Hammar-**Klose**, E. and Meltzer, A., (1999, March) *An integrated, high-resolution, geophysical investigation, of a groundwater discharge fen, northeastern Pennsylvania,* Paper presented at the American Geophysical Union Spring Meeting

Hanneman, D.L., Conaway, J., Feiveson, D.T., Hammar-**Klose**, E., Sneeringer, J., (1997, October). *Cenozoic geology of a part of the Silver Bow Creek/Butte area Superfund site, southwestern, Montana;* Paper presented at the Geological Society of America Annual Meeting.

Publications

Klose, E. (2021). Poster: GIS is Now Everywhere: Professionals Needed. In E. Langran & L. Archambault (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 1101-1105). Online, United States: Association for the Advancement of Computing in Education (AACE). Retrieved September 15, 2021 from https://www.learntechlib.org/primary/p/219261/.

Thieler, E.R., Foster, D.S., Mallinson, D.M. Himmelstoss, E.A., McNinch. J.E., List. J.H., Hammar-**Klose**, E.S. (2013) *Quaternary geophysical framework of the northeastern North Carolina coastal system*. USGS Open-File Report 2011-1015

Thieler, E.R., Williams, S.J. and Hammar-**Klose**, E.S. (2007) *National Assessment of Coastal Vulnerability to Sea-Level Rise*, USGS Woods Hole Science Center Report. http://woodshole.er.usgs.gov/project-pages/cvi/

Cross, V., Twichell, D.C., Halley, R.B., Cimebronowicz, K.T., Jarrett, B.D., Hammar-**Klose**, E.S., Hine, A.C., Locker, S.D., and Naar, D.F., (2005). *GIS compilation of data collected from the Pulley Ridge Deep Coral Reef region*. USGS Open-File Report 2005-1089

Pendleton, E.P., Hammar-**Klose**, E.S., Thieler, E.R., and Williams, S.J., (2004). *Coastal vulnerability assessment of Gulf Islands National Seashore (GUIS) to sea-level rise.* USGS Open-File Report 2003-108

Pendleton, E.P., Hammar-**Klose**, E.S., Thieler, E.R., and Williams, S.J., (2004). *Coastal vulnerability assessment of Olympic National Park to sea-level rise.* USGS Open-File Report 2004-1021

Hutchinson, D.R., Childs, J.R., Hammar-**Klose**, E.S., Dadisman, S., Edgar, N.T., Barth, G.A, (2004). *A preliminary assessment of geologic framework and sediment thickness studies relevant to prospective US submission on extended continental shelf*, USGS Open-File Report 2004-1447

Hammar-**Klose**, E.S., Twichell, D.C., and Worley, C.R., (2001). *Archive of sidescan-sonar data and DGPS navigation data collected during USGS cruise SUNCO1010, Pulley Ridge, Gulf of Mexico, 05 September-12 September, 2001*, USGS Open-File Report 2002-155

Pendleton, E.P., Hammar-**Klose**, E.S., Thieler, E.R., and Williams, S.J., (2003). *Coastal vulnerability assessment of Cape Cod National Seashore to sea-level rise.* USGS Open-File Report 2002-233

Capone, M.K., Hammar-**Klose**, E.S., Hill, J.C., Schwab, W.C. (2002), *Archive of sidescan-sonar data and DGPS navigation data collected during USGS cruise DIAN97011 Long Island, NY inner shelf-Fire Island, NY, 5 May-26 May, 1997,* USGS Open-File Report 2002-120

Roberts, C.S., Hammar-**Klose**, E.S., Schwab, W.C., (2002), *Archive of sidescan-sonar data and DGPS navigation data collected during USGS cruise ATSV99044, South Carolina coast, 29 October-14 November, 1999,* USGS Open-File Report 2002-103

Hammar-**Klose**, E.S., Thieler, E.R. (2001), *Coastal vulnerability to sea-level rise: a preliminary database for the U.S. Atlantic, Pacific, and Gulf of Mexico coasts,* USGS Digital Data Series 68

Hammar-**Klose**, E.S., Hill, J.C., Thieler, E.R., Schwab, W.C., (2000). *Archive of Sidescan-Sonar Data and DGPS Navigation Data Collected During USGS Cruise DIAN97032 Long Island, NY Inner Shelf - Fire Island, NY 25 September - 19 October, 1997.* U.S. Geological Survey, Open-File Report 00-440, 7 DVD-ROMs

Hammar-**Klose**, E.S., and Thieler, E.R., (2000). *Coastal Vulnerability to Sea-Level Rise: Preliminary Results for the U.S. Atlantic, Pacific and Gulf of Mexico Coasts*. U.S. Geological Survey, Digital Data Series, DDS-68, 1 CD-ROM.

Thieler, E.R., and Hammar-**Klose**, E.S., (2000). *National Assessment of Coastal Vulnerability to Future Sea-Level Rise: Preliminary Results for the U.S. Gulf of Mexico Coast.* U.S. Geological Survey, Open-File Report 00-179, 1 sheet.

Thieler, E.R., and Hammar-**Klose**, E.S., (2000). *National Assessment of Coastal Vulnerability to Future Sea-Level Rise: Preliminary Results for the U.S. Pacific Coast.* U.S. Geological Survey, Open-File Report 00-178, 1 sheet.

Thieler, E.R., and Hammar-**Klose**, E.S., (1999). *National Assessment of Coastal Vulnerability to Future Sea-Level Rise: Preliminary Results for the U.S. Atlantic Coast.* U.S. Geological Survey, Open-File Report 99-593, 1 sheet.

Hammar-**Klose**, E., 1999 *A 3-d geophysical investigation of a groundwater discharge fen, northeastern Pennsylvania*, Thesis, Lehigh University, Bethlehem, PA, 165 p.

Hammar-**Klose**, E., 1998 *Geophysical imaging of a fen complex, northeastern Pennsylvania;* AAPG Foundation grants-in-aid recipients for 1998; AAPG Bulletin v.82 no. 11 p.2163

Hammar-**Klose**, E., 1997 *A high-resolution seismic reflection study of the Rocker Timber Framing and Treatment Plant site, Rocker, Montana,* B.A. Thesis, Smith College, Northampton, MA, 88 p.

Community Involvement/Service

Woman at the Well Ministries, Milton, WV, 2003-present, Web Manager, Teacher, Treasurer

I maintain a website for a national Christian teaching ministry; develop podcasts, manage social media, teach lessons; create logos and artwork for visual identity purposes; maintain listservs for subscribers; edit and engineer audio programming for broadcast maintain budget, accounts, and contracts; and maintain updated working knowledge of html, xml, databases, web design and internet audio.