THE ADOPTION OF GEOSPATIAL TECHNOLOGIES FOR TEACHING GEOGRAPHY AT LATIN AMERICAN UNIVERSITIES

by

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DEDICATION

I want to dedicate this dissertation to my wife Tatiana Martinez Loria. The success of this project would not be possible without her love, passion, and energy, in every beautiful and difficult moments of the past five years. She is the source of my inspiration, and I am eternally grateful to her for being along my side all these years.

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LIST OF ABBREVIATIONS

Abbreviation

GST – Geospatial Technologies

GIS – Geographic Information Systems

GPS – Global Positioning Systems

TAM – Technology Acceptance Model

UTAUT – Unified Theory of Acceptance and Use of Technology

PE – Perform Expectancy

EE – Effort Expectancy

SI – Social Influence

FC – Facilitating Conditions

SEM – Structural Equation Modeling

CFA – Confirmatory Factor Analysis

GFI – Goodness of Fit Index

RMSEA – Root Mean Square Error of Approximation

NFI – Normed Fit Index

CFI – Comparative Fit Index

AIC – Akaike Information Criterion

BCC – Browne-Cudeck Criterion

ECVI – Expected Cross-Validation

CR – Composite Reliability

AVE – Average Variance Extracted

MSV – Maximum Shared Variance

ABSTRACT

Faculty at geography departments can contribute to student's geographic learning by helping them to develop geospatial technologies (GST) knowledge and skills. However, it is still unknown the extent to which faculty adopt and use GST for teaching purposes. The current research addressed the topic by analyzing the factors that drive faculty at Latin American Universities to adopt and use five GST: desktop GIS, web-based GIS, remote sensing, GPS, and digital globes.

The study used Unified Theory of Acceptance and Use of Technology (UTAUT) as the theoretical framework for understanding the factors that explain the faculty level of adoption and use of a GST. From this perspective, faculty decision is based on the internalization of internal and external factors that influence the adoption and use of a technology. The theory assumes that the intention to use a technology is driven by the performance expectations, effort expectations and social influence. The use of a GST is predicted by the facilitating conditions and the intentions to use the technology in the classroom. In addition, it is possible to analyze the effect that certain moderating variables have in the adoption and use of a technology, including intraregional variations.

The research followed a quantitative approach, using a cross-sectional survey design. A spatially stratified random sampling was developed considering subregions, gender, and the field of expertise as variables. The purpose was to generalize results for the whole region, based on data collected from 337 participants through an online survey.

The analysis was performed using the Structural Equation Modeling method for each GST, comprised of the analysis of the measurement model—including a confirmatory factor analysis, reliability, convergent and discriminant validity analysis—followed by the analysis of structural model through using multiple regression analysis, and a multigroup invariance analysis with the purpose of looking at difference on the moderating variables that explain the faculty profile.

The results confirmed that faculty who perceived the pedagogical benefits of using any GST, report an ease of using and learning of these technologies, and tend to have a positive perception of the opinion of people influential to them about the use of the GST for teaching purposes are more likely to have greater intentions to use the GST—except for the social influence effect on desktop GIS—. In addition, faculty who have more intentions to use the technology and report adequate organizational and administrative resources were more likely to have a frequent use of any GST.

It is also important to recognized that there is a distinctive profile of faculty for each GST regarding adoption and use of GST. The field of expertise, age, and professional experience were identified as more relevant variables across paths of the UTAUT model. The outcomes also suggest differences that exists among faculty working in Brazil, other South American countries, and Mexico, Central America, and the Caribbean. The results confirmed the importance of considering the pedagogical, technological, and working environment components when developing professional development programs for faculty in higher education, and the need for considering differences among faculty for increasing the GST use in the classroom, since not all the technologies have the same adoption and use patterns. The research also provides valuable insights for thinking on successful strategies for including new emerging GST in geography departments.

I. INTRODUCTION

Why are geospatial technologies important for preparing future professionals?

Geospatial technologies (GST) comprise a set of different tools that "facilitate visualization, measurement, mapping, wayfinding, or spatial analysis of features both concrete and conceptual on Earth's surface and subsurface" (Metoyer, Bednarz, and Bednarz 2015, 24). They allow the collection, analysis, and visualization of geospatial data that influences how people think about information (Baker et al. 2015; Harte 2017).

The students' mastery of these technologies is a key issue for geography departments in higher education because they offer greater employment opportunities in the current job market. People who possess GST knowledge and skills are valuable in areas such as education, technology, transportation, communication, utilities, and many other fields in the public and private sector (Mirzoev et al. 2015; United States Department of Labor 2016a).

The GST sector has been recognized as one of the fastest-growing industries in the United States, where the number of professionals in this area is continuously increasing (Hong 2016, United States Department of Labor 2016a). It is expected that the GST market will increase at a 35 percent annual rate, while the job market in GST-related positions will grow at a higher rate (19 percent) than other geographers' potential jobs, or the average for all occupations (7%) from 2016 to 2026 (United States Department of Labor, 2016b).

Despite the promising scenario in the United States, in regions like Latin America, the situation is certainly unknown. No organizations have gathered consistent information about the GST market and job opportunities. However, it is known that the information and communication technologies (ICT) sector is facing some challenges for supplying the demand of more professionals. There will be a deficit of 449,000 ICT workers in 2019 to supply the demand of 900,000 ICT jobs that are created every year in the region (CEPAL 2016). This could represent a possibility for workers with GST knowledge and skills to fill some of these positions in different fields.

In the context of growing opportunities for technology-oriented jobs, proper training on GST might be a key element for increasing the geography students' employment in Latin America. Nonetheless, for increasing GST employability, understood as "the personal attributes, understandings and attainments that make individuals more likely to gain and maintain employment, and to progress in workplaces and build careers" (Watton and Truscott 2006 in Arrowsmith et al. 2011) higher education students require the development of geographic knowledge expertise and personal attributes such as critical thinking and problem-solving skills, which are fundamental for mastering GST skills (Arrowsmith et al. 2011).

The selection of which GST skills should be mastered by students is a difficult but important task in higher education. The Geospatial Technology Competency Model proposed by the Southern Mississippi University (Gaudet, Annulis, and Carr 2003), the GIS&T Body of Knowledge of the University Consortium for Geographic Information Science (DiBiase et al. 2006), the Geospatial Technology Competency Model of the US Department of Labor, Employment and Training Administration—DoLETA— (DoLETA 2014), and researchers like Solem, Cheung, and Slemper (2008) have proposed some ideas for defining desirable GST skills that students should acquire, although they do not necessarily represent the same core of ideas (Hong 2016).

Despite the diversity of GST skills that geography departments can implement for preparing future professionals, the ultimate goal of increasing student's employability and their reputation on society (Piróg 2014, Şeremet and Chalkley 2016) makes very relevant to incorporate such skills in the curriculum, and more significantly, as part of the teaching and learning process in higher education.

Learning GST is also important for preparing future geography educators, who can become capable of using these technologies for teaching geographic contents, either as part of the preparation of pre-service and in-service teachers of geography or social studies, but more importantly, students in K-12 education. The professionals with GST knowledge and skills should be capable of using new digital ways to interact, analyze and represent different geospatial issues in the classroom, enriching the process of teaching and learning (Kerr 2016), and providing a modern pedagogical approach to geography education.

The relevance of learning GST comes on a time when more and more digital technologies are adding a spatial component (e.gs., the location option of social media, GPS-enabled apps, geotagged photos), and there has been a shift in people's spatial interaction with the world (Downs 2014). In this context, higher education should help students to be prepared to understand the political, social, environmental, and economic implications of the geospatial data in our society, including the potential benefits and risks of using GST.

Scope and purpose of the research

Since GST knowledge and skills are essential components of future geographers and geography teachers, geography programs should develop strategies for including them as part of their curriculum, creating opportunities for learning about or with these technologies. In this way, several researchers have advocated for developing a GST research agenda (Baker et al. 2015) that suggest the analysis of issues such as learning about or with GST, curriculum and student learning, professional development, and geospatial thinking, aiming to improve students' GST education.

The understanding of how people learn by using GST, through the analysis of cognitive, pedagogical, and curricular components is critical for advancing in GST research, which would support the inclusion of these technologies in higher education. However, research frameworks such as those suggested by Baker et al. (2015) do not address if geography programs and their faculty possess the capacity and possibilities for preparing students to use GST for learning geography.

In the Latin American context, researchers suggested the reduction of inequalities between the region and the developed world in terms of technological resources and ICT access (Muñiz-Solari 2009; Buzai and Robinson 2010). However, research is scarce about the context of GST in higher education, and more specifically, the faculty's possibilities for including these technologies as part of their geography courses. Most of the existing research has been focused on secondary education, where several barriers for effective GST implementation have been detected (Milson and Kerski 2012; Kerski, Demirci, and Milson 2013).

The purpose of the following research is to address this issue by analyzing the current faculty's adoption of GST for teaching geography at Latin American universities. The study investigated how scholar's motivations are intersected by technological, societal, professional, and educational factors, which ultimately guide their decision to use these technologies as part of their pedagogical practices.

The identification of Latin American faculty's capacities and limitations for using GST in geography courses provided evidence-based arguments regarding possible changes that could be implemented for increasing and improving GST education. Moreover, the research findings gave some clarity about the factors that could be positively contributing to the successful integration of GST in geography programs of the region.

II. LITERATURE REVIEW

Geospatial technologies: refining the scope of research

Remote Sensing (RS), digital globes, global positioning systems (GPS), and geographic information systems (GIS) represent the four core GST (Baker et al. 2015). Songer (2010) argued that GIS should be sub-divided into desktop-GIS and web-based GIS. In fact, the American Association for the Advancement of Science distinguishes web-based GIS as a fifth core GST (Harte 2017).

The definition of the core GST is not exempt from a debate. The exclusion of emerging technologies (e.g., drones, GPS-enabled apps) that are part of the geographers' profession and the use of certain GST in different geographic contexts, represent some of the challenges for choosing the technologies subject to analysis in this research.

The selection of which GST are the focus of the research relies on two conditions. First, I included the GST that have been subject to study in Latin America during the first two decades of the 21st century, specifically, those that have been addressed by researchers in the context of geography education. There is an extensive list of GST education studies in the region focused on the use and processes of teaching and learning with remote sensing (Siqueira et al. 2010; Lopes and Da Rosa 2011; Werneck 2012; Barboza, Marlenko, and Natenzon 2013; Farias et al. 2013; Silva, Lima, and Dos Santos 2015), GPS (Bezerra 2012), web-based GIS (Donizeti and Pellegrina 2010; Rocha and Diaz 2012; Nunes 2013; Seneme 2013; Cabrera et al. 2014), desktop GIS (Zappettini 2007; Villegas et al. 2011; Leguimazón 2010; Muñiz-Solari and Moreira-Riveros 2012; Pérez and Castro 2012; Esdras and Da Silva 2013; Ferreira et al. 2013; Pombo, Martínez, and Di Franco 2014; Silveira et al. 2014), and digital globes (Gonçalves and Carneiro 2012; Freisleben and Kaercher, 2014).

Second, research about emerging GST in geography education has been scarce in Latin America. Thus, the inclusion of additional GST as part of the research could be inadequate because the collected data might not show an accurate representation of the development of these technologies in educational settings. For these reasons, the current research includes the analysis of five GST: remote sensing, desktop-GIS, web-based GIS, GPS, and digital globes.

The digital divide in education and the implementation of GST

The digital divide is a concept referring to the continuum of high-low digital capabilities and usage, considering differences between nations, regions, businesses, geographic context, groups, and individuals (Pick and Sarkar 2015). It is also expressed in terms of technological access, which according to Van Dijk and Hacker (2003) involves four different types:

- Mental access caused by a lack of interest, anxiety, or unattractiveness of the new technology.
- Material access as the lack of computers and network connections.
- Skill access, as a result of insufficient user-friendliness, inadequate education, or social support.
- Usage access produced by the lack of usage opportunities.

The adoption and use of technologies are multifaceted because different factors and contexts provide dissimilar interpretations of the digital gap. Individual motivations, economic, cultural, and social capital, educational background, and material conditions provide a base for understanding the digital gap continuum and the existence of inequalities in terms of technology usage (Pick and Sackar 2015; Gremigni 2018).

One approach for understanding the digital divide in educational settings is by looking at the level of technological access that a group of students or professionals have of any specific technology. In this research, I argue that there are several factors and variables that mediate in the capacity and possibilities of geography faculty to adopt and use GST for teaching geography in higher education.

The universities should provide the faculty with the opportunities for integrating the GST in students' learning processes in a meaningful way (Juniu 2005). In fact, some authors have advocated that GST learning should be embedded as part of the curriculum of geography programs in higher education because it would improve the student's use of GST and geographic knowledge acquisition (Şeremet and Chalkley 2016; Harte 2017).

Since digital literacy is a key element of socioeconomic mobility and increases the employability of future professionals (Murray and Perez 2014), it is important to place attention on the role that geography faculty have in students' academic preparation. Specifically, it is necessary to investigate their possibilities and capacity for leading the development of students' GST knowledge and skills.

The literature about GST in higher education supports the importance of including the mastery of GST knowledge and skills as part of the students' learning process. Kamruzzaman (2014) showed that students can recognize the relevance of learning land planning through the integration with GIS. Jo, Hong, and Verma's (2016) study pointed out how the use of web-based GIS can enhance students' development of spatial thinking skills. Møller, Madsen and Nielsen's (2013) research has also identified that the instructional methods used by faculty for teaching GST (e.g., video-based methods, map analyzing techniques) influence students' performance and GST learning. Furthermore, Walshe (2017) showed that GIS training is meaningful when aligned to the development of geographic thinking, and the professional benefits are visible to the student.

These studies outlined the benefits of developing GST skills as part of the student's geographic learning in higher education. However, no attention has been given to the analysis of a key factor for reaching those outcomes, which is to what extent geography faculty can adopt and use GST as part of their geography courses. The current research is aiming to analyze this issue in the context of Latin American universities.

Are there any barriers to implement GST in higher education?

The literature suggests the existence of several barriers to the proper implementation of GST in educational settings. However, these studies have accounted only for issues in the context of K-12 education (Kerski, Demirci, and Milson 2013). Research has been scarce addressing or extrapolating possible barriers for GST implementation in higher education. Therefore, it is unknown to what extent faculty have the capacity and possibilities for adopting and using these technologies for teaching geography.

Despite this issue, the K-12 education studies offer some arguments worth considering in this research about barriers for technology implementation. In particular, the research findings propose a framework for understanding the underlying causes that may impede faculty to use GST for teaching geography in higher education. In this way, Kerski, Demirci, and Milson (2013) indicate the existence of three main barriers for using GST in education: technological, societal, and pedagogical.

The technological barrier "*includes not only access to computers that have enough internal and graphics memory, hard disk space, and the proper software to be able to handle spatial analysis, but also include access to the school's computers and support from the school's information technology (IT) staff*" (Kerski, Demirci, and Milson 2013, 239). It represents an overview of the infrastructure and administrative conditions for using a given technology in an educational institution.

Several researchers have pointed out the importance of addressing these technological limitations. Baker (2015) indicated that advancements in open-source and web-based GIS applications have increased the adoption of GST in educational settings. These recent technologies have contributed to overcoming some of the financial, legal, educational, and access limitations that educators and students often face while using GST for learning geography (Borián 2012; del Campo et al. 2012; Johansson 2012; Kim, Kim, and Sang-il 2013; Osachi-Costache, Cocoş, and Cocoş 2017). In addition, Kerski (2003) indicated the importance of information technology (IT) staff support in the effective implementation of GIS.

The analysis of technological barriers in the context of higher education would imply whether geography departments count with the equipment and the resources for allowing faculty to implement GST in their courses. Moreover, it could be expanded to analyze the availability of staff for solving issues about the management and use of these technologies.

The societal barrier refers to the *"lack of awareness of spatial thinking and analysis and their importance in education and society. Coupled with the segmentation of education into discrete subjects, this translates into a lack of a home for GIS in the curriculum"* (Kerski, Demirci, and Milson 2013, 239). Research in K-12 education has shown that GST—especially GIS—has been adapted to a greater extent when their use is compulsory in the curriculum (Milson and Kerski 2012; Milson, Kerski, and Demirci 2012).

Currently, there are no studies addressing this issue in higher education. Thus, research should aim to analyze if GST tend to be used more by faculty for teaching geography when these technologies are a compulsory or optional component of the curriculum. This type of findings could provide key information about the relevance of adding technological components as part of the student's learning process in geography.

The pedagogical barrier involves *"the lack of knowledge and skills about GIS, lack of time to develop GIS lessons, lack of ready-to-use GIS materials, lack of interest in using ICT in their lessons, and lack of guidance to develop pedagogies involving GIS"* (Kerski, Demirci, and Milson 2013, 240). There is an emphasis on the individual's limitations for using GST in the classroom. In the context of higher education, this barrier would imply the analysis of faculty's academic preparation about GST, how to use these technologies for teaching geography, and the availability of instructional materials and resources.

Although there is no explicit research addressing the pedagogical barriers in higher education, some studies showed possible ways in which educators can successfully include GST as part of the geography curriculum (Harte 2017; Walshe 2017;

Şeremet and Chalkley 2016; Jo, Hong and Verma 2016; Şeremet and Chalkley 2015; Kamruzzaman 2014; Møller Madsen and Nielsen 2013). These authors provide alternatives for geography faculty to enhance their teaching strategies and promote curricular changes in higher education.

Furthermore, researchers have suggested that professor's willingness of using GST for teaching tend to increase when they have had training opportunities for using adequate equipment and spatial data (Doering et al. 2014; Hong 2014; Hong and Stonier 2014; Lisenbee, Hallman, and Landry 2015; Höhnle et al. 2016). Moreover, these authors stressed the importance of developing teaching-oriented practices and the mastering of technological skills as a way to increase GST adoption. Although these findings are framed in the context of K-12 education, the researchers indicate the existence of mechanisms for overcoming pedagogical barriers, which could be also analyzed in the context of higher education.

Latin American research on GST barriers in education: contributions and limitations

Latin American research in geography education about the barriers for GST implementation has been also focused on elementary and secondary education, whereas higher education studies have been scarce. In this context, the research findings should be also thought of as part of the framework that would help the present investigation to analyze the context of GST implementation at the university level.

Some researchers have suggested a reduction of the technological barrier in higher education during recent years. Since the beginning of the 21st century, the acquisition of computers and systems has increased to similar levels as developed countries (Buzai and Robinson 2010). Geography education researchers like Macedo, de Oliveira and Barreto (2012) have shown that university environments count with better resources for implementing GST when compared to secondary education.

Buzai and Robinson's (2010) research points out the existence of issues with the faculty's preparation for using geospatial technologies in higher education. In this context, Leguimazón (2010) indicates the lack of interest and preparation as the causes for the low implementation of geospatial technologies in Argentinian universities, even when resources are available. These researchers suggest the influence that technological and pedagogical barriers could have on the faculty's adoption and use of GST for teaching geography. However, more research is needed to analyze these issues at Latin American universities.

The studies about technological barriers in secondary education offer additional elements worth considering for higher education research in Latin America. Several studies have found the usage of open-source GST and free-available spatial data (Macedo, de Oliveira and Barreto 2012; Pinheiro, Berto and de Souza 2012; Rodrigues, Alves and Hunaldo 2012; Farias et al. 2013; Cabrera et al. 2014; Poio 2015) for teaching geography, as a strategy for overcoming the cost and access limitations to licensed products. Future research should aim to what extent the faculty's adoption of open-source GST have contributed to the use of GST for teaching geography in higher education in the region.

The research about pedagogical barriers in Latin American secondary education have stressed the importance of considering issues of resistance, lack of interest

(Werneck 2012; Freire 2013; Barros and Gomes 2015), the digital and age divide between students and educators, and software learning issues (Barros and Carvalho 2012; Farias et al. 2013; Seneme 2013) as factors that could affect the adoption of GST for teaching geography. These findings suggest the importance of considering—in the context of higher education—the analysis of attitudes, motivations, and academic preparation issues of geography faculty for implementing GST in their courses.

Although several Latin American researchers have advocated for an active role of educators guiding the implementation GST (Lopes and da Rosa 2011; Barros and Carvalho 2012; Freire 2013; Pombo; Martínez and di Franco 2014), it is still unknown to what extent geography faculty are properly trained on GST and pedagogical methods for teaching with these technologies.

Recent research has pointed out problems that exist on the college students' GST preparation in Latin America (Siqueira et al. 2010; Villegas et al. 2011; Barboza, Marlenko, and Natenzon 2013; Farias et al. 2013; Nunes 2013; Barros and Gomes 2015; Silva, Lima and dos Santos 2015). Thus, it could be a possibility that geography faculty are experiencing the effect of pedagogical barriers for including these technologies as part of the learning process in higher education.

Some researchers have proposed the importance of aligning the use of GST with the curriculum, as it would enhance the process of geographic learning (Villegas et al. 2011; Barros and Carvalho 2012; Esdras and Silva 2013; Farias et al. 2013; Figueiredo, Lopes and da Silva 2016; Pombo, Martínez and di Franco 2014). Although these recommendations are framed in the context of the secondary education curriculum, the analysis of faculty's use of GST and the alignment with the geography curriculum offer new perspectives to understand the technology adoption patterns in higher education, especially when the GST have a compulsory or an optional component.

The individual's decision to accept and adopt a technology

The research findings of the barriers to adopting and implementing GST in educational settings offer key arguments for analyzing faculty's adoption of GST for teaching geography in higher education. There are circumstances in which technological, pedagogical, and societal constraints might influence the ultimate decision to implement GST in any course.

However, even when resources are available and an institution takes the decision of implementing a technology, Straub (2009) indicates that the individual's adoption patterns are what really explains the successful implementation of technology. In fact, there could be cases in which a low use of technology occurs in situations when all desirable conditions for their implementation are met (Venkatesh and Davis 2000).

Since geography departments should aim to reduce potential digital divides of future geographers and geography teachers, it is important to understand the faculty's role in providing GST learning because of the freedom they have for selecting the most adequate pedagogical strategies for teaching geography, which may include the use of GST.

The adoption process refers to "the individual's decision whether to integrate innovation into his or her life" (Straub 2009, 629). In the context of this research, the adoption implies the analysis of why university faculty may choose to incorporate a GST to teach geography. Factors such as individual's characteristics (e.gs., age, gender, experience), the specificities of a technological system, and the setting in which the technology is being applied, have been pointed out as key components of adoption (Straub 2009).

The current research follows a theoretical framework in which adopting a technology comprise a set of beliefs and attitudes developed over time (Straub 2009), which includes the analysis of technological, societal, and pedagogical barriers, the individual's personal attributes, and the internalization of those conditions (Davis 1989). In this study, GST student's preparation is conceived as mediated by the faculty who ultimately may decide to use these technologies. Therefore, the importance of knowing to what extent are they prepared for adopting GST for teaching geography remains crucial to explain the process of learning.

The Unified Theory of Acceptance and Use of Technology (UTAUT): a model to explain the faculty's adoption of GST

There are several theoretical frameworks for analyzing the underlying factors that mediate in the individual's decision to adopt and use technology. In this research, I employ a technology acceptance model that contributes to better understanding how the existence of implementation barriers, social and personal attributes, and the internalization of these processes could shape the acceptance and use of GST.

The first proposed model was the theoretical acceptance model (TAM), which provided quantifiable measures to understand an individual's predisposition to adoption

(Straub 2009), accounting for up to 70% of the variance in different modeling processes (Venkatesh et al. 2003). The TAM originally proposed by Davis (1989), suggests that external factors are mediated by the individual's perceived usefulness—the degree to which a person believes that a particular system would enhance his or her job performance—and the perceived ease of use—the degree to which a person believes that using a particular system would be free from effort—, which leads to the acceptance and adoption of a technology.

Even though this model has been implemented by several researchers through time, there have been several critiques, especially because of the limited understanding of the role of personal and external factors in the decision of adopting any technology (Straub 2009; Lay, Chen, and Chi 2013). Thus, further researchers reviewed the model and proposed new extended TAM versions, adding new factors that would explain an individual's technology adoption (Venkatesh and Davis 2000).

Venkatesh et al. (2003) UTAUT is the most comprehensive model because it added more factors accounting for an individual's adoption of technology. The UTAUT integrates different models that seek to explain the adoption of technology: the innovation and diffusion theory (Rogers 1995), the TAM (Davis 1989) and TAM 2 (Venkatesh and Davis 2000), the social cognitive theory (Compeau, Higgins, and Huff 1999), the theory of planned behavior (Ajzen 1991) and its combination with TAM (Taylor and Todd 1995), the theory of reasoned action (Sheppard et al. 1988), the motivational model (Vallerand 1997), and the model of PC utilization (Thompson, Higgins, and Howell 1991).

The UTAUT aims to predict intentions to use and usage of technology through constructs derived from the analysis of the above theoretical frameworks. Based on the statistical analysis and empirical evidence, Venkatesh et al. (2003) proposed four constructs (table 1) that predict the intention and usage behavior: perform expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC).

Table 1. Predicting constructs in UTAUT

Construct	**Definition**
Perform expectancy (PE)	The degree to which an individual believes that using the system will help to attain gains in job performance
Effort expectancy (EE)	The degree of ease associated with the use of the system
Social influence (SI)	The degree to which an individual perceives the importance of others believing the new system should be used
Facilitating conditions (FC)	The degree to which an individual believes that an organizational and technical infrastructure exists to support the use of a system

Each of the constructs is composed of a set of indicators (table 2) that are usually assessed with a Likert-type scale. Furthermore, the authors added the analysis of moderating variables into the model, which contributes to a more comprehensive understanding of the effect of the constructs in the acceptance and use of technology. They state that *"while each of the existing models in the domain is quite successful in predicting technology usage behavior, it is only when one considers the complex range of potential moderating influences that a more complete picture of the dynamic nature of individual perceptions about technology begins to emerge"* (Venkatesh et al. 2003, 470). The empirical evidence of their research suggests that age, gender, experience, and voluntariness of use have a moderating effect on the intention to use a technology, which completes the theoretical model of the UTAUT (figure 1).

Table 2. Questionnaire items that measure the constructs on the UTAUT model.

Construct	Item	Theoretical underpinning
Perform expectancy	I would find the system useful in my job	Perceived usefulness from the theory of acceptance model (Davis 1989)
	Using the system enables me to accomplish tasks more quickly	Relative advantage from the innovation-diffusion theory (Rogers 1995)
	Using the system increases my productivity	Relative advantage from the innovation-diffusion theory (Rogers 1995)
	If I use the system, I will increase my chances of getting a raise	Outcome expectations from the social cognitive theory (Compeau, Higgins, and Hugg 1999)
Effort expectancy	My interaction with the system would be clear and understandable	Perceived ease of use from the theory of acceptance model (Davis 1989)
	It would be easy for me to become skillful at using the system	Perceived ease of use from the theory of acceptance model (Davis 1989)
	I would find the system easy to use	Perceived ease of use from the theory of acceptance model (Davis 1989)
	Learning to operate the system is easy for me	Ease of use from the innovation-diffusion theory (Moore and Benbasat 1991)
Social influence	People who influence my behavior think that I should use the system	Subjective norm from the theory of reasoned action (Davis, Bagozzi, and Warshaw 1989, Fishbein and Azjen 1975), and theory of planned behavior (Ajzen 1991) combined with TAM (Taylor and Todd 1995, Mathieson 1991)
	People who are important to me think that I should use the system	Subjective norm from the theory of reasoned action (Davis, Bagozzi, and Warshaw 1989, Fishbein and Azjen 1975), and theory of planned behavior (Ajzen 1991) combined with TAM (Taylor and Todd 1995, Mathieson 1991)
	The senior management of this business has been helpful in the use of the system	Social factors from the model of PC utilization (Thompson, Higgins, and Howell 1991)
	In general, the organization has supported the use of the system	Social factors from the model of PC utilization (Thompson, Higgins, and Howell 1991)
Facilitating conditions	I have the resources necessary to use the system	Perceived behavioral control from the theory of planned behavior (Ajzen 1991) combined with TAM (Taylor and Todd 1995)
	I have the knowledge necessary to use the system	Perceived behavioral control from the theory of planned behavior (Ajzen 1991) combined with TAM (Taylor and Todd 1995)
	The system is not compatible with other systems I use	Perceived behavioral control from the theory of planned behavior (Ajzen 1991) combined with TAM (Taylor and Todd 1995)
	A specific person (or group) is available for assistance with system difficulties	Facilitating conditions from the model of PC utilization (Thompson, Higgins, and Howell 1991)

Table 2: continued

Intention to use[1]	I intend to use the system in the next <n> months	Venkatesh et al. (2003)
	I predict I would use the system in the <n> months	Venkatesh et al. (2003)
	I plan to use the system in the next <n> months	Venkatesh et al. (2003)

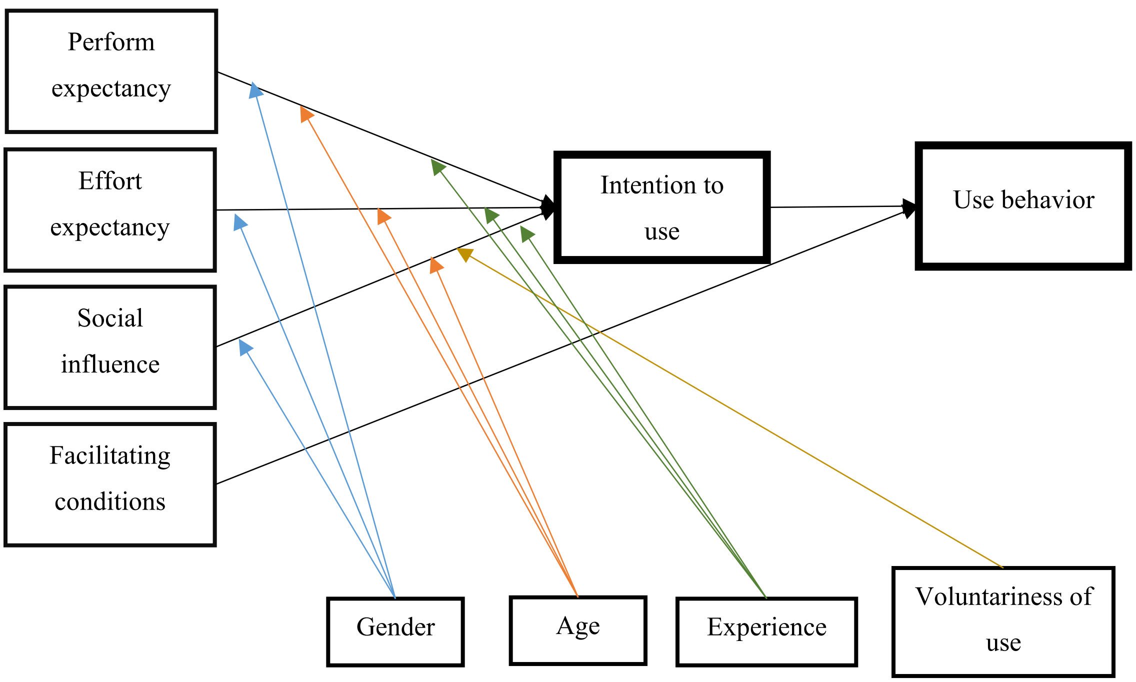

Figure 1. UTAUT model as proposed by Venkatesh et al. (2003)

In this research, the theoretical constructs and moderating variables contribute to explain to what extent technological, pedagogical, societal factors, and personal attributes could represent a barrier in the acceptance and use of GST for teaching geography in higher education. The effect of these elements on the model is conceived as the result of

[1] Referred by Venkatesh et al. (2003) as behavioral intention, express the individual's decision to use a technology, which can be understood through the PE, EE, and SI construct from UTAUT.

the individual's internalization and assimilation of the variables involved in the ultimate decision of adopting and using a GST.

The effect of the constructs and the moderating variables of the UTAUT provide a robust explanation of the individual's acceptance and use of technology. Venkatesh et al. (2003) research show the following interactions:

- PE is a key determinant of behavioral intention to use a technology, whose effect is stronger for men and younger workers.
- EE effect is moderated by age and gender. It is statistically significant for women, older workers, and decreasing with experience.
- The SI has a stronger effect in women, older or less experienced, and when a technology usage is mandatory.
- FC influence usage behavior, which is stronger for older workers with increasing experience.
- The use of technology is driven by the intention that any person might have of using it.

Thus, models such as the UTAUT offer a quantitative perspective explaining to what extent those factors influence the individual's final decision of adopting or implementing the technology.

UTAUT in educational settings: major findings

Several education studies analyzed Venkatesh et al. (2003) arguments about the role of the UTAUT constructs and moderating variables on the acceptance and use of technology. Research on the intention to use technologies in higher education suggests a statistically significant effect of the PE for students and faculty. They believe that the usage of technology would bring benefits in terms of learning or job outcomes. Studies on mobile learning (Thomas, Singh, and Gaffar 2014), online learning (Martín García, García del Dujo, and Muñoz Rodríguez 2014; Mckeown and Anderson 2016), virtual learning environments (Özlem and Özhan 2017), and electronic resources (Pahdi 2018) support Venkatesh et al. (2003) proposition about the effect that PE has on individuals.

The effect of SI on the adoption is still debatable. Some researchers identify a significant effect on the acceptance of mobile learning (Thomas, Singh, and Gaffar 2014) and virtual learning environments (Özlem and Özhan 2017), and ICT (Attuquayefio and Hillar 2014), whereas others have detected to a lesser extent an effect in online learning (Martín García, García del Dujo, and Muñoz Rodríguez 2014; Mckeown and Anderson 2016). More research is needed for understanding the discrepancies among studies.

A similar pattern is shown by the effect of EE on behavioral intention to use technology in educational settings. Divergences exist about the effect of EE on the acceptance of educational technologies. Some studies found significant effects towards adoption (Attuquayefio and Hillar 2014; Özlem and Özhan 2017; Padhi 2018), while others differ (Martín García, García del Dujo, and Muñoz Rodríguez 2014; Thomas, Singh, and Gaffar 2014). However, these research findings seem to be consistent with Venkatesh et al. (2003), who stated that the EE effect can be diminished when FC is included as part of the behavioral intention prediction (Martín García, García del Dujo, and Muñoz Rodríguez 2014).

Behavioral intentions and FC have been pointed out by Venkatesh et al. (2003) as key determinants of usage behavior. However, a strong direct effect of FC and not behavioral intention might be in some cases the determinant of usage behavior (Attuquayefio and Hillar 2014). Other scholars suggest that the educational context in which technology is being applied can change the effect of behavioral intention as part of the individual's technology acceptance (Özlem and Özhan 2017). In this way, the literature indicates a dissimilar interpretation of the constructs' effect on educational technologies.

Research in education has found the effects of moderating variables in the behavioral intention to use technologies. Besides age and gender, other proposed moderating variables such as the professional category or field of expertise (Martín García, García del Dujo, and Muñoz Rodríguez 2014) as well as the students' year-level (Mckeown and Anderson 2016) are proposed to have a significant effect on the PE construct. On the other hand, educational research has not proposed an effect of the moderating variables in the EE, despite that Venkatesh et al. (2003) suggest the relevant role of age, gender, and experience.

The effect of age and gender on FC and SI have been reported by several authors in some educational studies (Martín García, García del Dujo, and Muñoz Rodríguez 2014), whereas the effect of the voluntariness of use has been less studied. Faculty's professional categories have also shown a significant effect on SI and intentional behavior to use the technology (Martín García, García del Dujo, and Muñoz Rodríguez 2014), especially among associate faculty or young doctoral assistants.

Lay, Chen, and Chi (2013) demonstrated that the education level and schooling type influence the acceptance of GIS for teaching geography. In this case, the higher the educational level the greater the acceptance of GIS; a similar outcome shows for those working in public education. Although their findings are placed in the context of higher education, and the study focused on using the TAM rather than the UTAUT, the findings provide useful insights for understanding the role that academic preparation and the context in which educators work might have on the acceptance and adoption of technologies.

These UTAUT studies in educational settings provide three key aspects to consider in this research. First, the geographic context seems to play a role in the definition of which factors are statistically significant and explain the intention to use technology. Second, the differences in intentional behavior are also related to the different nature of technology under analysis. It is possible that a group of people can exhibit different levels of acceptance and adoption. Third, the inclusion of additional moderating variables into the standard model can also contribute to explain their effect on the behavioral intention to use technologies.

III. RESEARCH HYPOTHESES

The aim of the research is to analyze the geography faculty's acceptance and use of GST—desktop GIS, web-based GIS, remote sensing, GPS, and digital globes—for teaching geography at Latin American universities. For this purpose, the research use the Venkatesh et al. (2003) UTAUT theoretical constructs (PE, EE, SI, and FC), to obtain a quantitative measure of how different social, economic, pedagogical, administrative factors, personal attributes, and moderating variables influence the faculty's adoption of the GST as part of their geography courses. Thus, the research hypotheses that guided the analysis are:

1. PE, EE, and SI explain the faculty's intentions to use GST for teaching geography in Latin American universities

The constructs PE, EE, and SI have a statistically significant effect on the Latin American faculty's intentions to use each of the selected GST— desktop GIS, web-based GIS, remote sensing, GPS, and digital globes— for teaching geography. This means that they will be more willing to adopt any of these technologies when they consider that:

- The GST will help them to teach geography in a better way.
- The GST is relatively easy to master and use.
- People who are influential to them in the geography department believe that the use of GST is important.

2. The FC and the intention of using GST explain the faculty's use of these GST for teaching geography.

The FC and the intention to use a GST—each of the five included in this research—have a statistically significant effect on the actual use of these technologies for teaching geography in higher education. This means that the faculty's use of GST geography courses is more frequent when the geography department has adequate organizational and administrative resources to use these technologies, and there is a faculty's intention to use any or more than one GST.

3. The moderating variables have an effect in PE, EE, SI, FC, and intention to use paths regarding the faculty's adoption and use patterns of GST for teaching geography

Each variable (age, gender, decision to use, professional experience, academic degree, the field of expertise, GST research, worktime, type of software used, and , professional category) moderate the effect of PE, EE, and SI on the intention to use GST. In addition, the variables also moderate the effect of FC and intention to use on the faculty's use of any GST for teaching geography. However, the characteristics of such an effect have yet to be determined by the data analysis.

4. There are no intraregional variations on the effect PE, EE, SI, FC, intention to use, and the moderating variables in geography faculty's adoption and use of GST

Since there are no prior studies on this issue, this research looks for differences that might exist among different Latin American subregions. There are no statistically significant differences in the UTAUT results for any subregion under analysis. Therefore, the outcomes obtained for Latin America as a region should be similar for each of the subregions.

IV. RESEARCH DESIGN

The research followed a quantitative post-positivist approach by using a cross-sectional survey design (Creswell 2014; Nardi 2016). The aim was to analyze the geography faculty's acceptance and use of GST for teaching geography in Latin American universities.

The nature of the research required to reach a large number of faculty located in several Latin American countries. Nardi (2016) and Tanner (2018) suggest that a survey design constitutes an efficient, economical, and accessible way to gather information from participants in different locations, based on the definition of a representative sample of the total population. Thus, this approach was adequate for contacting and collecting data from the participants located in different countries of the region.

Population of study

The unit of analysis is any geography faculty that was part of a geography department at a Latin American university from April to July 2018. The participants were selected from Mexico, Honduras, Nicaragua, Costa Rica, Panama, Dominican Republic, Puerto Rico, Jamaica, Trinidad & Tobago, Colombia, Venezuela, Ecuador, Peru, Bolivia, Brazil, Chile, Uruguay, and Argentina. These countries[2] were included as part of the study because they have at least one university with a geography department.

There are no official statistics or information compiled by any institution or organization regarding the quantity and profile of faculty working in Latin American

[2] Despite that Cuba has a geography representation, there were administrative and technical issues that did not allow to reach the geography faculty in this country.

geography departments. Therefore, I conducted research identifying the faculty's name and profile from each country to define the total population. For faculty and lecturers to be included as part of the population, they had to comply with the following criteria:

- Be part of a geography department, excluding from this research graduate assistants and emeritus faculty that might be working in the department.
- Must have been assigned at least one geography course during the academic year 2018 and still teaching in 2019.
- Should have a minimum of personal online information available. Participants were selected only if their names, gender, email accounts, and the geographic field of expertise was available.
- Must work on a field of expertise associated with geography. Non-geography faculty were excluded from the research.

The use of these filters is needed for establishing the statistical sampling that guided the research. The faculty who did not meet these criteria were not counted as part of the total population because of the lack of data for conducting the statistical sampling of the study. In this way, it is possible to say that the faculty included as part of the population possess at least a minimum set of information that guarantees they are part of the geography programs at Latin American universities.

Gathering the participant's data involved a five-month search which started by using a reliable list of geography departments in Latin America. The "2016-2017 AAG Guide to Geography Programs in the Americas" contains a comprehensive—but no definitive—list of the region's geography departments and their official websites. Then, the list was complemented by including the geography department's information that exists in national geographers' associations from Brazil, Argentina, Chile, and Colombia. The final expansion of this list comprised an extensive online search for geography departments in each Latin American country.

Once the department's information was collected, I conducted a review of each professor's profile available online. Even though most of the data was accessible, there was missing information in some cases. In those circumstances, I reached the department's chair and administrative staff to complete the required information. If the requested information was not available at all, the faculty was finally excluded from the dataset.

The final product of this search is a database containing the list of Latin American geography faculty, which includes basic information such as their name, gender, country, university, email, and field of expertise. The latter category required an additional filter because of the diverse nature of sub-discipline in geography in which faculty often develop their academic careers. I categorized their field of expertise into three core areas: human geography, physical geography, and GST. The assignment of a category involved a careful review of their curriculum vitae, research, and teaching experience.

The search concluded with a total of 2,659 geography faculty from 156 different geography departments in 17 Latin American countries (Table 3). Appendix 1 expands on this issue by showing the name of each university and the number of geography faculty by country.

Table 3. Number of universities by country included as part of the research

Country	Number of Universities
Brazil	95
Chile	18
Argentina	11
Mexico	9
Colombia	6
Peru	3
Costa Rica	2
Venezuela	2
Bolivia	1
Dominican Republic	1
Ecuador	2
Honduras	1
Jamaica	1
Nicaragua	1
Puerto Rico	1
Trinidad & Tobago	1
Uruguay	1
Total	156

The results showed a contrasting distribution of faculty in the region (table 4), as most of the countries count with few geography scholars, except Brazil that holds most of them in Latin America. The population is composed of 58.2 percent of male and 41.8 percent female faculty. The distribution of scholars according to their field of expertise indicates that 60.5 percent are working in human geography, whereas 27.5 percent are in physical geography, and only 2 percent focuses mostly on GST.

Table 4. Number of geography faculty by gender working at Latin American universities

Country	Number of geography faculty			
	Female	**Male**	**Total**	**Relative percentage**
Brazil	730	1056	1786	67.2
Mexico	83	133	216	8.1
Argentina	136	62	198	7.4
Chile	42	120	162	6.1
Peru	26	55	81	3.1
Colombia	23	38	61	2.3
Venezuela	14	27	41	1.5
Costa Rica	12	25	37	1.4
Honduras	8	6	14	0.5
Uruguay	7	6	13	0.5
Bolivia	1	11	12	0.5
Ecuador	5	6	11	0.4
Nicaragua	5	2	7	0.3
Dominican Republic	1	5	6	0.2
Trinidad & Tobago	1	5	6	0.2
Puerto Rico	1	3	4	0.2
Jamaica	1	3	4	0.2
Total	1096	1563	2659	--

The research context

Latin America is a region with historical, cultural, educational and economic conditions that have been developed differently among countries throughout history (Muñiz-Solari 2009). The situation is no different in higher education, where the number of universities and the availability of human and financial resources varies from country to country.

Nonetheless, it is possible to say that the universities share similar organization regarding the development of undergraduate and graduate programs in the geography departments. Appendix 2 shows details of the geography programs in each university that was included as part of the research's database. In general terms, the departments offer a four-year bachelor program in geography or a fifth-year option for obtaining a “licentiate”. In the case of Brazil, the licentiate degree refers to the preparation for becoming a geography teacher in secondary education.

These programs follow national regulations as well as their own university norms with the purpose of assuring quality standards in students’ preparation. The programs have a structure as any other in higher education around the world, with a list of core and elective courses that students should take for obtaining their degree.

A total of 151 out of 156 universities offer a bachelor and licentiate degree. Approximately 50 percent of the Latin American universities have a geography graduate program, from which 69 of them offer a master’s degree and 47 a doctoral degree. Moreover, 39 universities (24.5 percent) offer both graduate programs, where 25 (18.7 percent) only have a master’s program and six (3.87 percent) offer exclusively a doctoral degree, whereas five universities have geography graduate programs exclusively. This information indicates the existence of a consolidated presence of geography in the Latin America’s higher education system.

The sampling design

There are many geographic, economic and time-related constraints for developing the research by including the total population. Instead, a stratified random sampling was used for gathering the data and making inferences about the faculty’s acceptance and adoption of GST for teaching geography at Latin American universities. Since the population database showed a heterogeneity in the faculty’s profile, the stratified random sampling process allowed considering these differences for obtaining the most accurate data possible (Burt, Barber, Rigby 2009; Creswell 2014).

The sample size required for making inferences about the Latin American geography faculty is composed of 337 participants, considering a total population of 2,659 scholars, a confidence interval of 95 percent and a margin of error of +/- 5. The stratified random sampling used the variables gender, and field of expertise to identify the 337 potential participants because the purpose is to represent the highest level of diversity of faculty members, based on the information available from the faculty's profile.

In addition, the stratified random sampling included a selection of participants, using a division of Latin America into three subregions, since one of the research objectives is to analyze intraregional variations of faculty's acceptance and use of GST for teaching geography. These subregions are "Subregion 1", which includes Brazil, left alone because it has the greater number of geography departments; "Subregion 2", which includes the other South American countries (Colombia, Venezuela, Ecuador, Peru, Bolivia, Chile, Uruguay, and Argentina); and "subregion 3" comprised of Mexico, Central American countries (Costa Rica, Honduras, and Nicaragua), and the Caribbean (the Dominican Republic, Jamaica, Trinidad & Tobago, and Puerto Rico).

Table 5 shows the distribution of the participants according to the proposed criteria. In the case of the subregions, the selection reflected the existing distribution of faculty within the subregion. This means that for "subregion 3", the selection of the participants follows the proportion of faculty working in Mexico, Central America, and the Caribbean countries, respectively. In the case of "subregion 1" no further division is needed. In "subregion 2" the selection also shows the proportion of scholars working in each of the South American countries listed above.

Table 5. Stratified random sampling of participants according to the selected variables.

Variables	Number of participants	
Gender	Male = 196 (58.2%) Female = 141 (41.8%)	
Field of expertise	Human geography = 204 (60.5%) Physical geography = 93 (27.6%) Geospatial technologies = 40 (11.9%)	
Region	Subregion 1 = 229 (68 %)	Brazil = 229
	Subregion 2 = 69 (20.4 %)	Argentina = 21 Chile = 21 Peru = 10 Colombia = 8 Venezuela = 5 Bolivia = 2 Ecuador = 1 Uruguay = 1
	Subregion 3 = 39 (11.6 %)	Mexico = 28 Central America = 8 Caribbean = 3

Data collection

I administered an online survey (see appendix 3) consisting on three sections: a) demographics, b) academic and professional information, c) the Venkatesh et al. (2003) UTAUT questionnaire (table 6), adapted to identify the faculty's intention to use and adoption of GST for teaching geography in higher education. The preparation, application, and collection of data were performed using the software Qualtrics.

Table 6. Adapted items from the UTAUT constructs including the GST

Construct	Item
Perform expectancy	I would find geospatial technologies useful in my job as a faculty
	Using geospatial technologies enables me to accomplish tasks more quickly
	Using geospatial technologies increases my productivity
	If I use geospatial technologies, I will increase my chances of getting a raise
Effort expectancy	My interaction with geospatial technologies would be clear and understandable
	It would be easy for me to become skillful at using geospatial technologies
	I would find geospatial technologies easy to use
	Learning to operate geospatial technologies is easy for me
Social influence	People who influence my behavior think that I should use geospatial technologies
	People who are important to me think that I should use geospatial technologies
	The chair of the department has been helpful in the use of geospatial technologies
	In general, the school or department has supported the use of geospatial technologies
Facilitating conditions	I have the resources necessary to use geospatial technologies
	I have the knowledge necessary to use geospatial technologies
	Geospatial technologies are not compatible with other technologies I use
	A specific person (or group) is available for assistance with geospatial technologies difficulties
Behavioral intention	I intend to use geospatial technologies in the next 3 months of teaching geography
	I predict I would use geospatial technologies in the 6 months of teaching geography
	I plan to use geospatial technologies in the next 12 months of teaching geography
Use behavior	I have to use geospatial technologies in the last academic year while teaching geography.

Each of the selected GST in the research (i.es., desktop GIS, web-based GIS, remote sensing, GPS, and digital globes) have their own set of items incorporated as part of the UTAUT questionnaire. The questions were answered by using a Likert-type scale from one to five, where one represents very unlikely conditions and five very likely conditions. The demographics, personal, and academic information provided the data for analyzing the effect of the moderator variables in each on the UTAUT constructs

(Venkatesh et al. 2003). Therefore, it is important to acknowledge the scope (Table 7) of each of the demographics, personal, and academic information.

Table 7. Characteristics of the moderating variables included in the demographic and personal information sections of the survey

Moderating variable	Question	Answer options
Age	What is your age?	Open answer (continuous value)
Gender	What is your gender?	Male or female
Decision to use	Is it the use of GST for teaching geography mandatory in your program's curriculum?	Yes, it is mandatory for everyone. No, it is completely optional
Professional experience	How many years of experience do you have teaching at the university level?	Open answer (continuous value)
Academic degree	What is your last academic degree obtained?	Bachelor, Licentiate, Master, Doctor
Field of expertise	What is your field of expertise?	GST, human geography, physical geography
GST research	Do you use GST for doing research?	Yes / No
Work time	Do you work full time or part-time in your department?	Full time, and partial time
Type of software used	In your opinion, would you say that your department use more GST licensed products or free-open source products	Licensed or free-open source,
Professional category	What is your professional category as a university faculty?	Tenure, Associate, Adjunct, Assistant, lecturer or another (subsequent classification)

I reached the faculty by using two complementary mechanisms that aimed to increase completion and participation in the online survey. First, I sent an electronic request through their academic emails on five separate occasions. The email list was compiled and verified while searching for each faculty's profile.

A second method consisted of reaching the geography department chairs through regular mail and email, requesting their support in the development of the survey to be responded by the participants. The purpose was to increase the research's acceptance and validity among the faculty.

The online survey was presented in Spanish and Portuguese; official languages of the countries included in the research. In addition, the invitation to participate was also sent in both languages, with the purpose of reaching all the faculty in the Region.

The survey was reviewed by a group of five Latin American geography faculty, who provided their insights regarding the structure and grammar of the sentences. In addition, a pilot testing with ten participants allowed the identification and correction of issues related to the time spent in the survey, the distribution of the sections, and the sentences and questions wording. After making changes based on the feedback, the survey was ready to be sent to the participants.

Data analysis

The outcomes of the data collection phase were analyzed through several procedures. First, there was a brief discussion on some issues that arose from the implementation of the survey and description of the results of the moderating variables data, which is necessary for further analysis.

The second phase involved a statistical analysis for each of the five GST, divided into several chapters. The research employed a structural equation modeling (SEM) for each technology, performed with the SPSS AMOS 26 software. SEM is understood as follows:

"(SEM) allows complex modeling of correlated multivariate data in order to sieve out interrelationships among observed and latent variables. SEM constitutes a flexible and

comprehensive methodology for representing, estimating, and testing a theoretical model with the objective of explaining as much of their variance as possible" (Indranarain 2017, 1)

The structural equation modeling is comprised of two models. The measurement model corresponds to *"the degree to which the indicator variables capture the essence of the latent factor... We call it a measurement model because the indicator of each factor are measured variables used to give us some access to or indication of the intangible, unmeasured latent factor" (Meyers, Gamst, and Guarino 2013, 974)*. The structural model *"looks at the causal relationships between the variables of interest in the theory. These are typically not the indicator variables for the factors but usually are the latent variables and measured variables theoretically associated with the phenomenon addressed by the model" (Meyers, Gamst, and Guarino 2013, 974-975)*.

The measurement model for each technology was assessed through confirmatory factor analysis (CFA), testing the viability of the hypothesized factor structure. This part is key for further statistical analysis because the evaluation of the model allowed identifying whether the UTAUT model is capable of explaining the phenomena under study. Table 8 showed the indexes that were used to assess the construct validity of the factor model. The procedure was applied for each technology dataset.

Table 8. CFA indexes and cut-off values

Index	Definition	Cut-off value
$\chi2$ / df	Chi-squared divided by the degrees of freedom (Hooper, Coughlan, and Mullen 2008)	Between 2 and 5
GFI	The Goodness-of-fit index is the proportion of variance in the sample correlation/covariance accounted for by the predicted model (Meyers, Gamst and Guarino 2013)	> .9
RMSEA	The root mean of squared error of approximation explains the average residuals between the observed correlation/covariance from the sample and the expected model estimated for the population (Meyers, Gamst and Guarino 2013)	< .08
NFI	The normed-fit-index compared the $\chi2$ value of the model to the $\chi2$ of the null model (Hooper, Coughlan, and Mullen 2008)	> .95
CFI	The comparative-fit-index is a revised form of the NFI taking into account the sample size (Byrne 2010)	> .9

A “model respecification” was performed when the indexes' results showed the need for changes in the model. In addition, three more comparative indexes were also calculated: the Akaike Information Criterion (AIC), the Browne-Cudeck criterion (BCC), and the expected cross-validation index (ECVI). Byrne (2010) suggests that they can be used to asses a better fit between two models—the original and a respecified model—in the CFA. Lower values in a respecified model indicate a better fit of data to the theoretical model.

After reaching a satisfactory model fit, the next step involved the analysis of the reliability, convergent validity, and discriminant validity. The composite reliability (CR) determines the reliability and internal consistency of latent constructs (Hair, Ringle, and Sarstedt 2011), where values greater than .7 are considered acceptable. The convergent validity was analyzed with the average variance extracted (AVE), which should be higher than .5 (Hair, Ringle, and Sarstedt 2011). The discriminant validity was assessed by calculating the maximum shared variance (MSV), which should be less than AVE for accepting the discriminant validity of the constructs (Hair et.al 2014).

Once the quality of the model was assured, the next step involved the analysis of the structural model, by testing the path coefficients to determine the relationships and explanations on the adoption and use patterns of GST for teaching geography by geography faculty. For this procedure, I conducted in the SPSS AMOS 26 software a multiple regression analysis using the maximum likelihood method, looking at statistically significant paths on the model. The analysis focused first on the paths from the UTAUT constructs towards the intention to use GST for teaching geography. Then, the attention was placed on the paths towards the use of the GST (see figure 2).

The outcomes showed the amount of variance that is explained by the different constructs and variables in the model for the intention to use GST and the use of GST for teaching geography. A diagram with the variance and standardized β coefficients is shown as part of the outcome that contributes to understanding which constructs explain more the adoption patterns of GST among faculty members.

The third phase consisted of a multi-group invariance analysis of the structural model, with the purpose of identifying the differences in the effect of several moderating variables in the structural paths of the model (see figure 2). Thus, each moderating variable was analyzed by performing a chi-square goodness-of-fit difference test between the unconstraint model—where all structural paths can vary—and a constraint model—where all the structural paths are restricted to be equal—. If the p-value is less than .05 it is possible to conclude that there are differences across groups on the moderating variable (Meyers, Gamst, and Guarino 2013; Abdollahi et al. 2018).

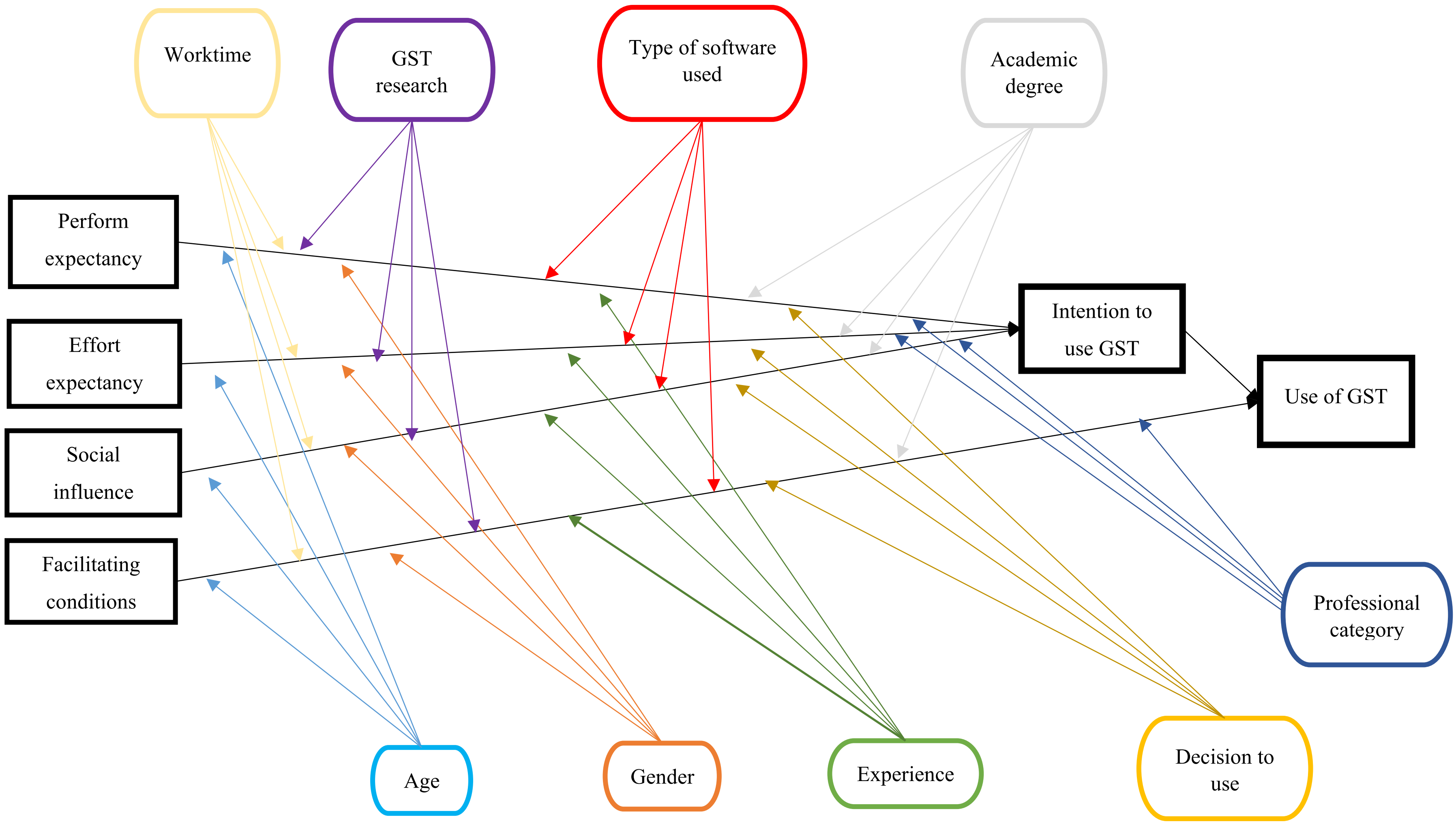

Figure 2. The proposed model adapted from the UTAUT. The rectangular polygons are the model constructs and the circled polygons the moderating variables

Chin et al. (2012) caution about possible equivalence across groups on a global level, when they are different on another level, as invariant items might mask or compensate individual factors. Thus, I also employed a single parameter invariance testing, which "addresses the inconsistencies that can arise when non-equivalences are masked by group effects or the sequencing of the model tests" (Chin et al. 2012, 2) due to the possibility of identifying non-invariance in individual parameters. The individual structural paths were constrained one at the time. Then, a chi-square goodness-of-fit difference test—between an unconstrained and constrained model, with one degree of freedom—looked for differences across groups in each path.

The results informed about the differences among the moderating variables across the structural paths and the different GST. At last, the intraregional variation was also analyzed by also performing the multi-group invariance analysis. This approach allowed the identification of the context by which the adoption and use of a GST could have different interpretations across the Latin American Regions.

V. LIMITATIONS OF THE STUDY

The current research analyses the faculty's adoption and use of GST for teaching geography in higher education. It represents an opportunity for obtaining a first and robust understanding of the level of GST implementation at Latin America universities. Nonetheless, it is important to frame the scope and limitations of the investigation.

The UTAUT framework

The UTAUT has been consistently reported as a good predictor of acceptance and adoption of specific technologies (Venkatesh et al. 2003). The UTAUT integrates technological, societal, and educational factors that influence an individual's adoption of technologies. The research proposes that these factors are internalized and assimilated by the faculty, who ultimately select whether to include these technologies as part of their courses, providing learning opportunities to the students.

However, this theoretical framework offers a partial perspective based on the self-reported attitudes and conditions for implementing the technology. Additional information provided by each geography department would complement the understanding of how external factors might influence the faculty's adoption of GST for teaching geography. The current research cannot follow the latter approach because it is a time-consuming task and a financial burden for the researcher. In addition, there are practical limitations for reaching stakeholders across the 155 geography departments in 17 countries of Latin America.

Another issue with the UTAUT is the limitation for explaining the causes behind the effect of the PE, EE, SI, and FC constructs. The benefit of using a quantitative approach is that the researcher can generalize the findings to Latin America as a region. It is possible to identify the effect and strength of each construct in the faculty's decision and several variables associated with the GST adoption patterns in geography departments.

Research should also look in-depth through qualitative analysis of the underlying causes for differences on moderating variables. They explain the effect of certain constructs and variables on the faculty's adoption and use of GST for teaching geography. Future research should expand on this methodological approach because there are geographic, time, and financial constraints that currently prevent the researcher from incorporating this approach to the current study. In addition, it would be worth of exploring in future research other moderating variables that could influence participants responses and attitudes towards adoption and use of each GST.

There are various technology acceptance frameworks that could contribute to explain patterns of GST adoption. However, the UTAUT was selected for the purpose of this research because it is composed of a statistically tested combination of multiple theoretical constructs, which aim to understand an individual's acceptance and use of technologies. The statistical modeling and generalization of results of the UTAUT methodology also contribute to providing certain answers to the research questions frame in a large Region and heterogeneous population. However, we have to accept some limitations of these modeling procedures. In this way, the UTAUT offers a strong and consistent quantitative explanation of the user's acceptance and use of technology.

The faculty as the focus of the research

Research on GST education has been focused more on exploring student's learning, and the connection with the curriculum and professional development needs (Baker et al. 2015). However, the current study aims to analyze another important component of GST learning, which is the capacity and limitations that faculty encounter when using these technologies for teaching in higher education. The selection of the theoretical and methodological approach for this research responded to the designation of faculty as key actors of the learning process. In this way, future studies including other important stakeholders should consider to what extent the UTAUT and the methods used in this investigation would be adequate for reaching similar outcomes.

The researcher acknowledges that student's GST learning is not bounded to what a faculty can or cannot do in a geography course. There are other instances in which students can be exposed to GST training. However, the current research focuses on the faculty's intention of providing GST learning opportunities, which could reduce or increase the technological gap that those students could experience in the future.

Thus, the study does not address what Baker et al. (2015) called learning about and with GST. Instead, the researcher aims to explain the faculty's adoption patterns of these technologies. The analysis of how the GST are being used for teaching geography would require a completely different theoretical and methodological approach.

The researcher also acknowledges that there might be circumstances the adoption of GST is limited to research activities rather than teaching in higher education. There could be a multiplicity of factors that could lead to this situation. However, it is important to clarify that the research framework, questions, and methodology aims to analyze explicitly the context of faculty's teaching practice, as it has more repercussions on the student's learning process. Future research would be necessary to look in-depth on the context of geography research in higher education.

The analysis of the faculty's adoption and use of GST for teaching geography represents only one approach by which it is possible to understand possible scenarios of the digital divide in higher education geography. Thus, it is recommended that other research should also aim to understand issues like faculty's pedagogical strategies for teaching GST, the learning progressions, the relationship of GST and geospatial learning, the alignment with the curriculum, among others. As a result, it would be possible to have a greater and more integral understanding of the context of GST implementation in the geography departments of Latin America.

The research design

The research employs a cross-sectional survey design rather than a longitudinal design, which implies a conceptual difference between the adoption and diffusion of technology. Although Venkatesh et al. (2003) have proposed ways in which the adoption and diffusion of technology can be understood through their model, there are financial, and time constraints for monitoring changes during a period. Thus, the cross-sectional study focuses on understanding the adoption rather than the diffusion of technology. The former allows obtaining a snapshot of how several factors are internalized and assimilated by geography faculty in higher education at a given time. Future research should aim to develop similar studies following a longitudinal approach.

Since there is a scarcity of studies about the penetration of GST in Latin American higher education, the study aims to investigate the status of each GST in the geography departments. Some of these technologies might have been present for a long time, while others might be new or inexistent. The scope, methods, and objectives of the research would be different if the interest would be to track the diffusion of these technologies in the past, present, and future. The study assumes that the GST might be present in geography departments under different conditions, but it should not be a factor changing the research findings because the UTAUT model addresses the intention to use and the actual implementation of the GST.

Access to GST learning in higher education involves a multiplicity of factors and stakeholders. In this research, I place the attention in the role of the faculty because their ultimate decision to include a GST as part of their geography course can influence the students' capacities for accessing to such knowledge. Thus, the study focusses on understanding the faculty as a key agent of the educational process.

The process of defining the total population involved several decisions about how a scholar would be included as part of potential participants. Online availability of information was critical for including the faculty's profile in the database. It is important to acknowledge that if a university does not appear on the list, it is because there was no available information about the geography department's faculty. Representatives from Panama were not accounted for in the final population list because it was not possible to find any profiles available online. Thus, the faculty included as part of the database represent most of the scholars working in Latin America.

The identification, preparation, and categorization of the population of the study was a five-month process. This was a time-consuming task with its own limitations. For instance, even though the database construction ended in July 2018, it is quite possible that the faculty in any department might have changed since then. There are certain inaccuracies that should be allowed for having an acceptable database to perform the statistical sampling process.

It is important to acknowledge that the database represents a snapshot of geography departments in 2018 and that there are time and resources limitations that prevent the researcher from updating the database, as it would take approximately the same length of time, being a never-ending task. This is also another reason a cross-sectional design was selected for the purpose of the research.

The variables included in the dataset (i.e., country, gender, and field of expertise) are the only ones that are consistently reported by all the geography departments consulted during the online search. These variables are important for capturing the heterogeneity of the scholars teaching geography in Latin America. However, other variables were also considered initially as part of the criteria for defining the stratified random sampling process. The faculty's professional category, as well as the academic degree, were also taken into consideration, but several geography departments show deficiencies presenting that information online. So, they were excluded from the preliminary stratified random sampling process.

The stratified sampling process aims to represent the diversity of the geography faculty in the Region proportionately. However, as the method for gathering information is an online survey, there is a possibility of obtaining low response rates. Thus, it was important to reach in multiple ways the department's authorities for increasing the faculty participation in this research.

VI. ONLINE SURVEY RESULTS

The online survey was sent to all the Latin American geography faculty included in the database. A total of 480 out of 2659 participants responded to the invitation, with a response rate of 18.5 percent throughout the region. The number of responses varied across subregions. For instance, 16.13 percent of Brazilian faculty answered the online survey, compared to 18.8 percent from the other South American countries, and 27.6 percent from Mexico, Central American, and the Caribbean area.

The number of responses exceeded the minimum required for the research, contributing to a more precise selection of participants for the final sample distribution. The faculty were chosen randomly by combining the variables: subregion and country, gender, and field of expertise.

In this way, the 229 Brazilian faculty was selected in a way that accurately represented 58.2 percent of males and 41.8 percent of females. Furthermore, 60.5 percent are human geographers, 22.6 percent are physical geographers, and 11.9 percent are GST specialists. The same procedure was applied for the other two subregions: 1) South America, and 2) Mexico, Central America, and the Caribbean. The participant's selection was made as representative as possible of each country for these two subregions. Table 9 shows the outcomes of this attempt to have the most precise representation of geography faculty from Latin America.

Table 9. Sample size: distribution based on region, gender, and field of expertise.

Subregion	**Gender**					
	Male (n=190)			Female (n=147)		
	Human geography	Physical geography	Geospatial technologies	Human geography	Physical geography	Geospatial technologies
Brazil	73	34	14	65	30	13
South America	30	11	5	10	5	8
Mexico, Central America, and the Caribbean	11	5	7	9	6	1
Total	114	50	26	84	41	22

The final sample distribution included six more females than what was initially estimated, which also means a reduction of male faculty by the same amount. In addition, there were fewer participants from human geography (six) and physical geography (two), while eight more GST faculty were added to the research.

These slight changes sought to capture a more accurate profile of the faculty after the data phase collection finished. Participation in the online survey was higher for certain types of faculty among Latin American countries. In some cases, there was greater participation of males or females as well as human geographers, physical geographers or GST faculty. In general terms, the participation was higher than expected among females and faculty specialized in GST.

The profile of Latin American Faculty

Besides the faculty information about the region, gender, and field of expertise, which were pre-estimated according to the data compiled in the database construction phase, the online survey results also provided a group of demographic, academic, and professional information—the research's moderating variables—. The findings contributed to preparing a more detailed profile of the Latin American geography faculty, which helps the reader to have a more comprehensive perspective on the further statistical analysis of the GST in the next chapters. An additional specification of the categories within each variable was a key element addressed, since it was necessary to re-adequate them to the obtained data.

The faculty members' age was collected as a continuous variable, whose values oscillated from 27 to 84 years old. In order to facilitate the analysis of age as a moderating variable, the participants were grouped into three categories using the Jenk's natural breaks classification method, looking for a good fit to the data (Jenks 1967). The faculty were classified as:

- Young faculty, with ages ranging from 27 to 42 years old;
- Middle-aged faculty, for respondents whose age was between 43 to 53 years old;
- Senior faculty, for those in ages between the 54 to 84 years old.

The research findings show that 40.6 percent were classified as young faculty, whereas 36.8 percent are middle-aged faculty. In addition, 22.6 percent of participants are classified as senior faculty.

Another category collected as a continuous variable was the faculty's professional experience. The values ranged from 1 to 50 years of teaching in higher education. The Jenks natural breaks classification method was also used to create three categories, easing the analysis of the moderating variable in further statistical analysis. The faculty's experience was classified as:

- Low experience, for those respondents who had 1 to 12 years of teaching geography;
- Moderate experience, when faculty members have been working for 13 to 23 years in higher education;
- High experience, for faculty with 24 to 50 years of teaching.

The grouping of the responses with these categories showed that the faculty's level of experience level is low for 40.1 percent of participants and moderate for 38.3 percent. In addition, 21.6 percent of faculty members have a higher experience teaching geography in higher education.

The academic degree obtained by the time of the survey completion was grouped into two categories, based on the responses from participants. The first group comprised the faculty members who have a doctoral degree, while the second category gathers the participants who have a master or lower degree. The research findings showed that 76.6 percent of the geography Latin American faculty possess a doctoral degree, compared to 23.4 percent who obtained a master or lesser degree.

There was an adjustment in the professional category variable, as a result of the diversity of categories and definitions about the faculty's positions across universities in

Latin America. Thus, the variable was divided into two groups: tenured professors and non-tenured professors[3]. The analysis of the responses suggests that only 20.4 percent can be cataloged as tenured faculty, while the remaining 79.6 percent hold a non-tenured position. In addition, 84.3 percent of participants reported having a full-time working schedule, compared to 16.7 percent with a part-time job in their geography department.

The research findings regarding the decision to use variable showed that teaching with these technologies is a compulsory component of the program for 53.1 percent of the participants. The remaining 46.9 percent of faculty mentioned that the use of GST is considered optional in the curriculum. On the other hand, 34 percent of the participants affirmed that their geography departments preferred the use of licensed GST for teaching geography, compared to 66 percent who mentioned that faculty members prefer open-sourced GST. At last, 75.7 percent of faculty mentioned that they have done geographic research using GST in the past, whereas 24.3 percent never did any investigation including these technologies.

An updated view of the moderating variables in the research

The profile showed the characteristics of the faculty members who teach geography in Latin American universities. The outcomes of the data collection phase made necessary to adjust some categories within the moderating variables. Table 10 shows a synthesis of these proposed changes.

[3] This category combined the associate, and adjunct faculty positions as well as the lecturer and substitute professors.

Table 10. Classification of the moderating variables into categories.

Moderating variable	Category
Age	Young faculty Middle-aged faculty Senior faculty
Gender	Male Female
Decision to use	Mandatory Optional
Professional experience	Low Moderate High
Academic degree	Doctor Master or lower
Field of expertise	Human geography Physical geography Geospatial technologies
GST research	Yes No
Work time	Full-time Part-time
Type of software used	Licensed Open-sourced
Professional category	Tenured Non-tenured
Region	Subregion 1 (Brazil) Subregion 2 (South America) Subregion 3 (Mexico, Central America, and the Caribbean)

The following chapters use this updated classification of moderating variables and their categories for conducting a part of the SEM, particularly, when analyzing the effect of the moderating variables in the adoption and use of each GST for teaching geography.

VII. DESKTOP GIS

The following chapter explains the adoption and use of desktop GIS for teaching geography by faculty members at Latin American universities. The discussion is focused on the SEM results, more specifically, on the interpretation of the measurement model outcomes through the confirmatory factor analysis, reliability, and validity, followed by the analysis of the structural model. Descriptive statistics are also included as a way to support the interpretations of the model. The last section addresses the effect of moderating variables in the adoption and use of GST for teaching geography, including the role of the region in the model.

The measurement model

The initial analysis of the desktop GIS database confirmed that there are no issues associated with multivariate normality and multicollinearity. Then, a CFA was conducted for assessing the relationship of the UTAUT model indicators with the latent factors PE, EE, SI, and FC. The empirical data from the online survey was used to test the hypothesized model, this means, the efficacy of the indicators to represent the latent factors (figure 3). The assessment of the model fit indexes is shown in table 11. The outcomes of the original factor model showed unacceptable cut-off values for the model fit indexes, requiring a respecification of parameters.

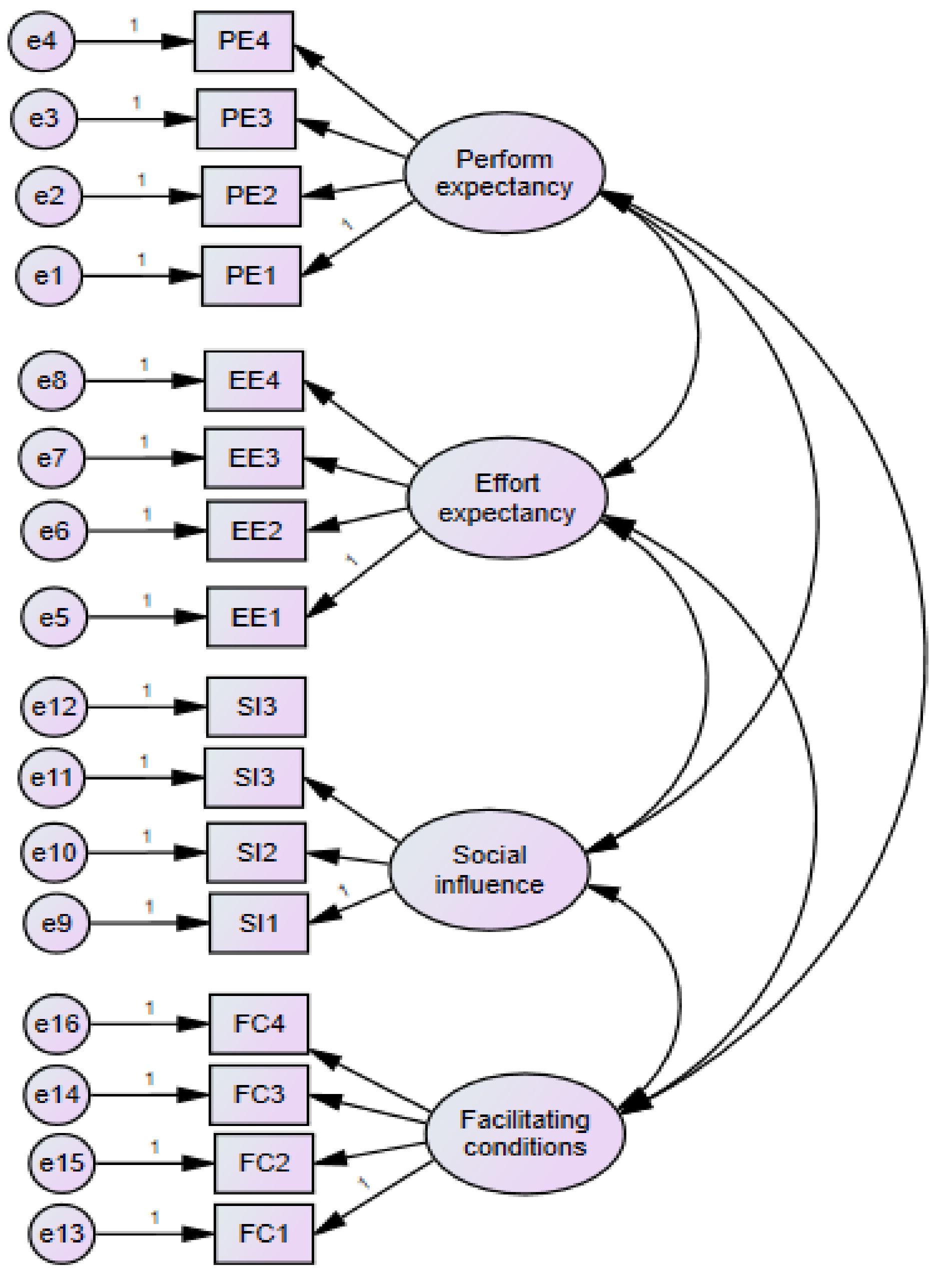

Figure 3. Measurement model analyzed using CFA.

Table 11. Desktop GIS CFA: model fit indexes.

Factor model	χ^2	χ^2 / df	GFI	NFI	CFI	RMSEA	AIC	BCC	ECVI
Original	516.308	5.268	.828	.873	.894	.113	592.308	596.358	1.763
Respecified	147.122	2.627	.935	.957	.973	.074	217.122	220.166	.646

The review of the modification indexes and factor loadings led to respecifying the model by 1) deleting the path from item "PE4[4]" to perform expectancy, since obtaining a raise in their jobs is not perceived as a benefit from using desktop GIS for teaching geography; 2) erasing the path from item "SI4[5]" to social influence, as the geography department as an entity is not seen as influential in the faculty's decision of using desktop GIS; 3) eliminating the path from "FC4[6] to facilitating conditions, as other items subsume the existence of—human—resources for implementing desktop GIS in teaching geography; 4) A Correlation between items "EE2[7]", "EE3[8]", and "EE4[9]" was added in that faculty who consider that desktop GIS is easy to learn may in part also become skillful without any problems, and find the technology easy to use.

After the model respecification, the model fit indexes reached acceptable cut-off values. In addition, the AIC, BCC, and ECVI comparative indexes exhibited a lower value than the original model, indicating an improved fit between the data and the model.

[4] PE4 items stands for: "If I use desktop GIS, I will increase my chances of getting a raise".
[5] SI4 stands for: "In general, the school or department has supported the use of desktop GIS".
[6] FC4 stands for: "A specific person (or group) is available for assistance with desktop GIS difficulties".
[7] EE2 stands for: "It would be easy for me to become skillful at using desktop GIS".
[8] EE3 stands for: "I would find desktop GIS easy to use".
[9] EE4 stands for: "Learning to operate desktop GIS is easy for me".

The respecified model is shown in figure 4, with the deleted paths and the error covariances added into the diagram.

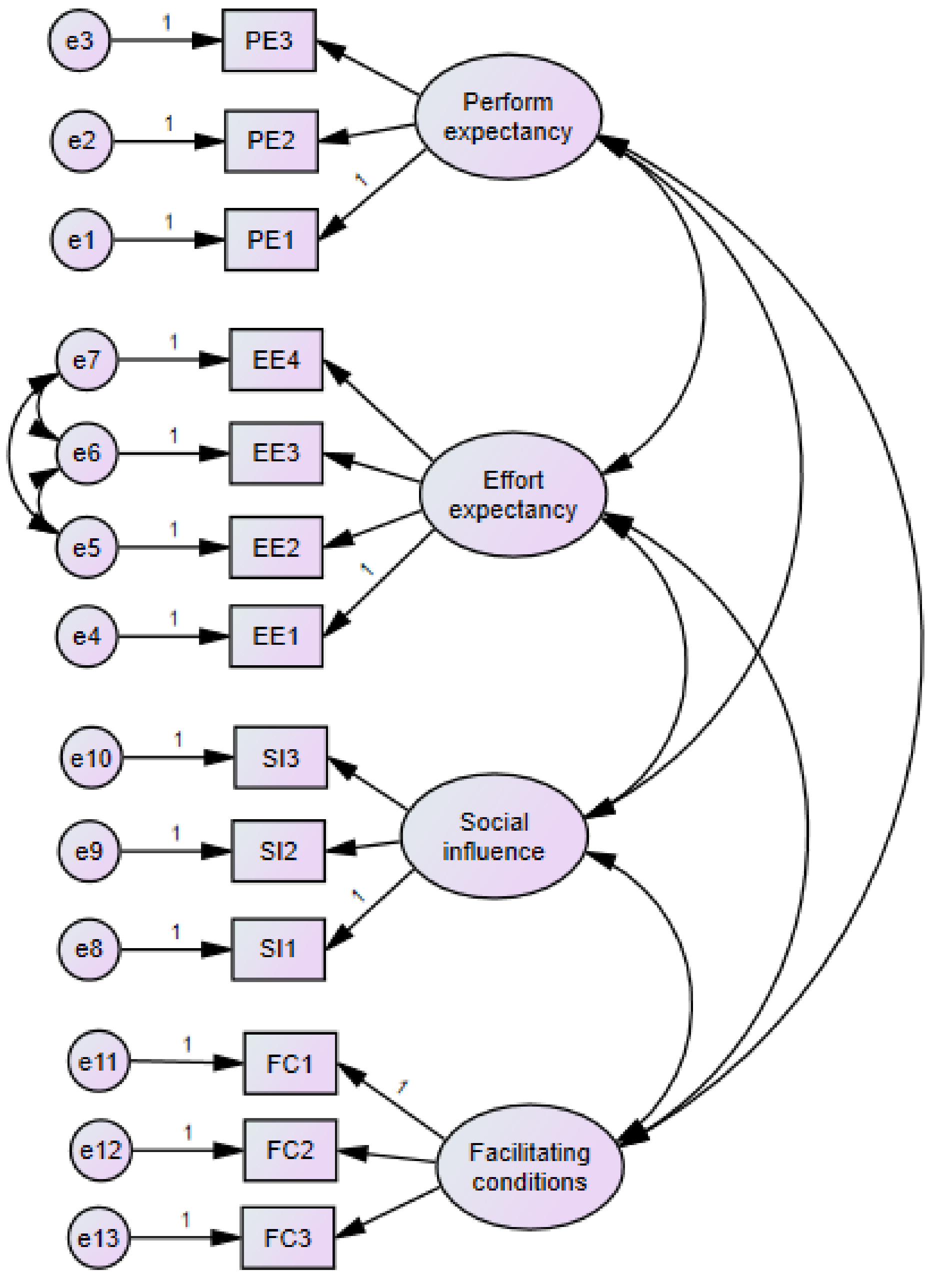

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Figure 4. Respecified measurement model.

Table 12 shows the results of the reliability, convergent validity, and discriminant validity. The CR was greater than .7 for each latent variable, meaning that there is an adequate internal consistency of the items with the constructs.

Table 12. Desktop GIS measurements of reliability, convergent validity, and discriminant validity.

Construct	CR	AVE	MSV
Facilitating conditions	.819	.605	.594
Perform expectancy	.932	.820	.496
Effort expectancy	.854	.595	.594
Social influence	.880	.715	.389

The AVE values exceeded the 0.5 threshold, indicating that the items measuring each construct are in fact related. In addition, the discriminant validity analysis showed that the MSV for each construct was lower than the AVE, meaning that the constructs that are supposed to be not related, might be in fact unrelated. All the measurements suggested that the model was ready for the next phase of the SEM analysis.

The structural model

The next phase in the SEM involved the analysis of the structural path coefficients among PE, EE, and SI as independent variables and intention to use desktop GIS as the dependent variable. In addition, the model assessed the path coefficients of FC and intention to use desktop GIS as independent variables, and the use of desktop GIS as the dependent variable. Figure 5 shows the structural model under analysis.

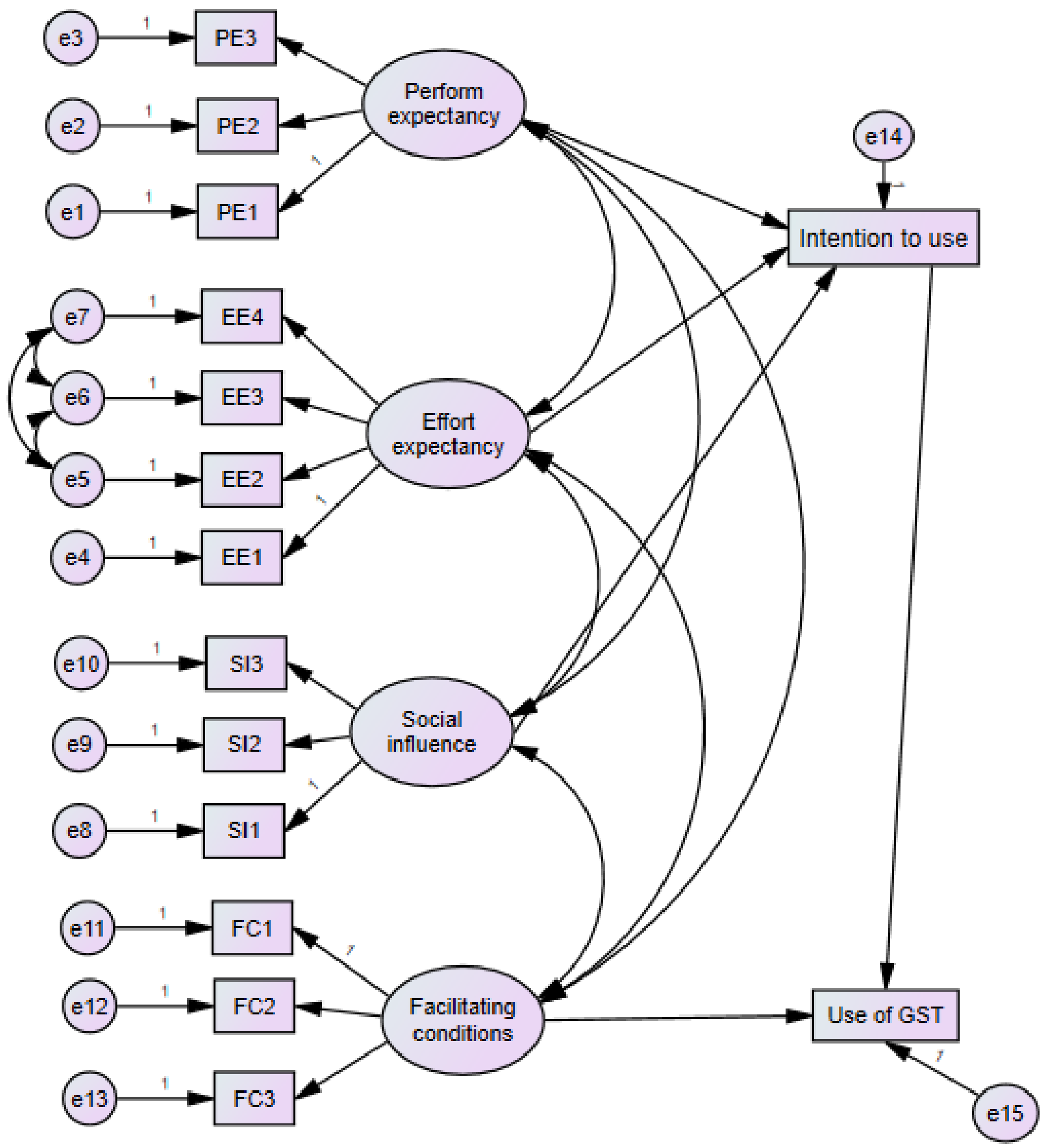

Figure 5. The structural model.

The results of the model fit indexes for the structural model showed acceptable cut-off values (χ^2/df = 2.858; GFI=. 917; NFI= .951; CFI = .964; RMSEA= .074), meaning an adequate fit of data with the model. The maximum likelihood method was used to estimate the parameters of each path coefficient and the variance. Figure 6 shows the overall results of the analysis in the diagram. The next sections discuss in detail the path outcomes presented in the diagram.

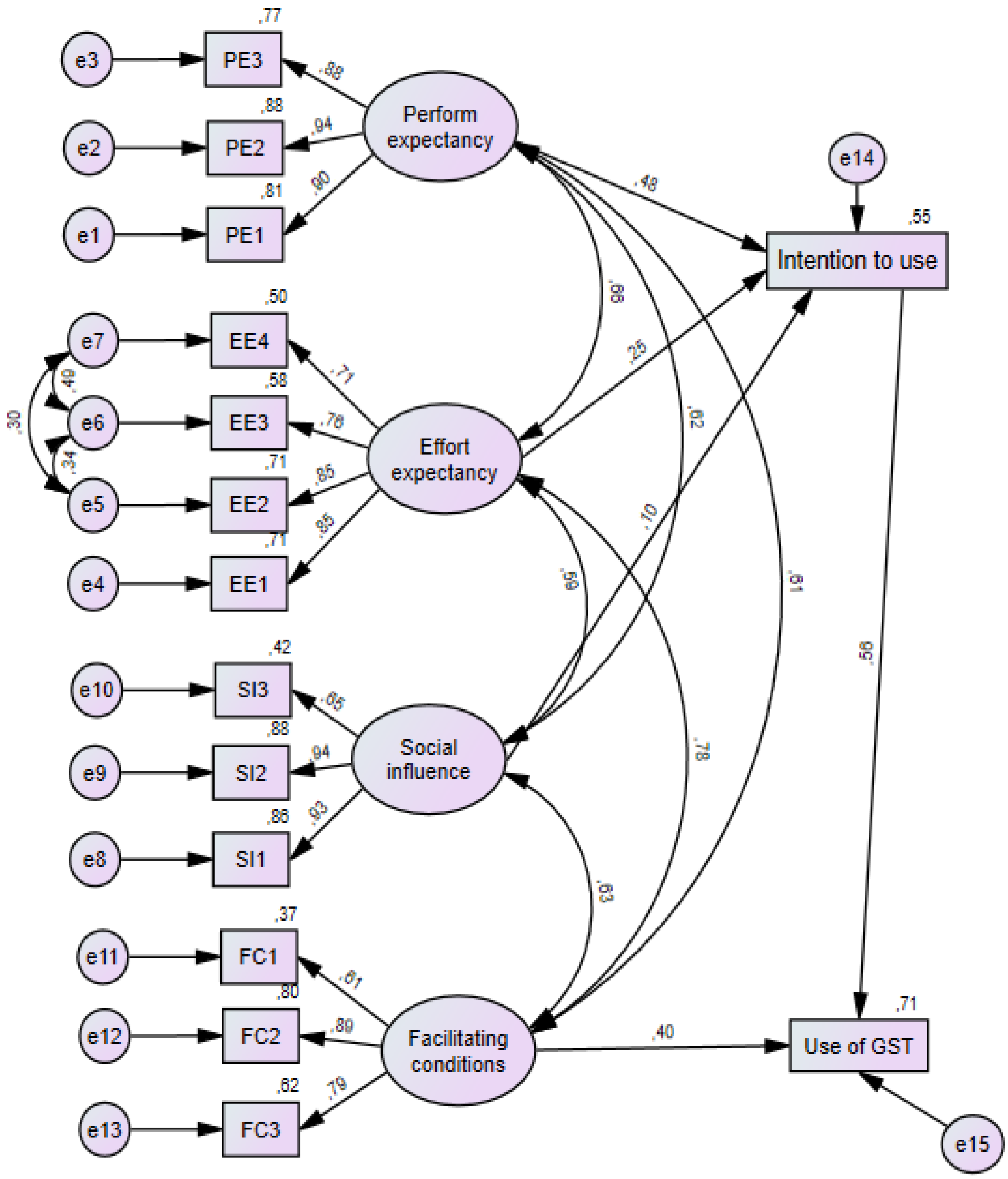

Figure 6. Desktop GIS structural model.

The intention to use desktop GIS for teaching geography

Table 13 shows the path coefficients from PE, EE, and SI to the intention to use desktop GIS. The results revealed that 55% of the variance in the intention to use desktop GIS for teaching geography was driven mainly by PE, EE to a lesser extent, and not by the SI, which was not statistically significant. Since the hypothesis for the first question indicates that the three factors predict intention to use, the research findings suggest that it is partially true in the case of desktop GIS.

Table 13. Desktop GIS: path coefficients towards intention to use.

Path	B	SE	β	p-value
Perform expectancy ➔ Intention to use	.722	.093	.477	< .001
Effort expectancy ➔ Intention to use	.369	.092	.249	< .001
Social influence ➔ Intention to use	.121	.064	.104	.061

The study suggests that when faculty foresee an educational and pedagogical benefit of using desktop GIS in their courses, and when they consider desktop GIS is relatively easy to learn and use, they would have more willingness to adopt the GST for teaching geography. On the other hand, the influence or pressure from their peers does not seem as influential for faculty in their interests of using this technology in their courses.

The average scores for the latent variables (table 14) reinforce the importance that faculty members placed on the PE and EE. Not only both factors are statistically significant predictors of the intention to use desktop GIS, but also most of the respondents tend to agree that there is a pedagogical benefit of including this technology as part of the teaching strategies. In addition, most faculty members also hold a positive opinion about the easiness of use of desktop GIS.

Table 14. Scores of independent and dependent variables in the desktop GIS model

Construct	Mean	SD
Perform expectancy	4.05	1.03
Effort expectancy	3.5	0.99
Social influence	3.02	1.21
Facilitating conditions	3.51	1.12
Intention to use desktop GIS	3.6	1.4
Use of desktop GIS	3.02	1.49

The use of desktop GIS for teaching geography

Table 15 shows the path coefficients from intention to use desktop GIS and FC towards the use behavior of this GST for teaching geography. The research findings indicated that 71% of the variance in the faculty's use of desktop GIS for teaching geography was driven mainly by their intention to use the technology, closely followed by the FC. The results offered a similar outcome as the one suggested by Venkatesh et al. (2003) for the UTAUT model. In addition, the information obtained supported the hypothesis of the second research question, in which FC and intention to use are predictors of the use of GST.

Table 15. Path coefficients towards the use of desktop GIS for teaching geography.

Path	B	SE	β	p-value
Intention to use ➔ Use of desktop GIS	.712	.088	.566	< .001
Facilitating conditions ➔ Use of desktop GIS	.573	.039	.399	< .001

The research findings suggest that the faculty members who have more intentions to use the GST for teaching are more likely to have a frequent use of desktop GIS. In addition, these faculty were more likely to report adequate administrative and organizational resources for implementing the technology as part of their teaching practices.

The information about the average scores of the independent variables predicting the use of desktop GIS offers an additional perspective (see table 14). Even though the participants reported that they use desktop GIS occasionally, as part of their teaching practices, most of them do have a positive attitude towards using this technology in the future. They also reported relatively good conditions for implementing desktop GIS in the classroom.

The SEM results showed that the faculty considered the intention to use (driven by their perform and effort expectations) as a stronger predictor of the use of desktop GIS than the FC. Thus, it is possible also to argue that even in contexts of deficient administrative and organizational resources, the faculty member's willingness to use the technology—in any possible way—might be the prominent factor that explains the utilization of desktop GIS in the classroom for teaching geography.

The effect of the moderating variables

The next phase involved the multigroup invariance analysis of the moderating variables in the structural model. Due to the nature of the research that is a pioneer in the context of geography education, besides the desire to have a more comprehensive perspective about the effect of these variables, the p-value cut-off was set as .1 to reach statistical significance. The use of a p-value of .05 would mask some results that are worthy of exploring in further research. In this way, the research findings provide a wider perspective about how different faculty's characteristics can have an effect on the adoption and use of any GST for teaching geography.

The multigroup invariance analysis was conducted in two phases. The first one involved the analysis of the global effect (table 16) of the moderators in all the links among the constructs and observed variables.

Table 16. Results of the tests for the global effect of moderating variables in the model.

Moderating variable	**$\Delta\chi^2$ (df)**	**Invariant**
Gender	15.564 (13)	Yes
Academic degree	48.598 (13) **	No
Decision to use	24.135 (13) **	No
GST research	11.518 (13)	Yes
Work time	19.953 (13) ***	Yes
Type of software used	9.412 (13)	Yes
Professional category	12.055 (13)	Yes
Age*	32.984 (28)	No
Professional experience*	37.399 (28)	Yes
Field of expertise*	42.632 (28) **	No

* Multigroup analysis of three categories using the emulisrel6 correction, suggested by Byrne (2010).
** p-value < .05
*** p-value < .1

The chi-square difference test showed that academic degree, decision to use, work time, and field of expertise had a statistically significant global moderator effect in the model. The field of expertise was also analyzed by performing a pairwise comparison of their categories (table 17). The results suggest that there is a statistically significant difference in the global effect for physical geography faculty when compared to human geography and GST colleagues.

Table 17. Global effect of the categories within specific fields of expertise in desktop GIS

Field of expertise	**$\Delta\chi^2$ (df)**	**Invariant**
Human geography – Physical geography	21.503 (14) *	No
Human geography – Geospatial technologies	16.45 (14)	Yes
Physical geography – Geospatial technologies	25.341 (14) **	No

* p-value < .05; ** p-value < .1

The second phase determined the moderator effect for each specific path in the structural model. In this case, the chi-square different tests between an unrestricted model and another in which each path is restricted. The p-value cut-off was set as .1 for reaching statistical significance.

Even though the global moderating effects suggest only four variables as having differences across the model, an individual path analysis was conducted for each variable because there might be individual differences that were hidden or masked by the results of the general assessment (Chin et al., 2012). With the purpose of easing the interpretation, only the statistically significant values were shown for each specific path[10].

Perform expectancy

Table 18 shows the results of the chi-square difference tests on the path between PE and intention to use desktop GIS. Only three variables have a moderating effect, and contrary to Venkatesh et al. (2003) findings, gender did not play a role in this particular path.

Table 18. The moderating effects in the desktop GIS perform expectancy path

Moderating variable	**Category (β)**		**Δχ² (df)**
Academic degree	Doctor .551	Master or lower .061	3.007 (1) *
Age	Young faculty .553	Senior faculty .542	3.562 (1) *
Professional experience	Low .605	Moderate .352	2.919 (1) *

* p-value < .1

The findings partially support Venkatesh et al. (2003) position that age has a role in the PE, although other variables were also relevant. Age and professional experience were not statistically significant in the global effect, but they do have a moderating effect on the individual PE path. When faculty believe that using the technology brings educational benefits into the classroom, it is more likely for them to have more intentions to use desktop GIS for teaching geography, being this effect is stronger for faculty

[10] The same approach will be performed for the remaining four GST.

members with a doctoral degree or post-doctoral expertise, young faculty (compared with senior faculty), and low-experienced professors (compared to moderate-experienced faculty).

Effort expectancy

The outcome of the chi-square difference tests on the path between EE and intention to use desktop GIS are expressed in table 19. Only two variables have a moderating effect, and contrary to Venkatesh and Davis (2003), age and gender do not pose an effect in the EE path.

Table 19. The moderating effects in desktop GIS effort expectancy path

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Professional experience	Low .198	Moderate .432	2,919 (1) *
Field of expertise	Human geography .174	Physical geography .379	3,575 (1) *

* p-value < .1

Professional experience has also an effect on the individual link from EE to intention to use, but not in the global effect model. The results indicated that faculty that consider desktop GIS as easy to use and learn were likely to have more intentions to use the technology for teaching geography, being this effect is greater for faculty with a moderate level of experience (compared to low-experienced colleagues) and among those working in physical geography (compared to human geographers, but not to GST faculty).

The evidence suggests placing attention to the differences among geography sub-fields and provides a different perspective from Venkatesh et al. (2003), as the ease of using is higher until a certain level of experience (there is no statistically significant difference between moderated and highly experienced faculty).

Social influence

The research findings showed that SI was not a statistically significant predictor of intention to use desktop GIS for teaching geography. Thus, no individual paths were analyzed for this latent variable.

Facilitating conditions

The outcome of the chi-square difference tests for this path showed that only the variable decision to use—which is not statistically significant in the global effect analysis, but it is in this particular link—reported a difference across groups ($\Delta\chi^2 = 3.240$, df = 1, $p < .072$). The organizational and infrastructure conditions were reported as a predictor of the faculty's intention to use desktop GIS. This effect is stronger for faculty who claimed that the use of desktop GIS for teaching geography is mandatory ($\beta= .427$) in their department, compared to departments where it is optional ($\beta = .359$). The research findings offer a different perspective from Venkatesh et al. (2003), who argued that age and experience are moderating variables for FC. This research showed that there is no difference across groups in these variables.

Intention to use desktop GIS

The results of the multigroup invariance analysis (table 20) showed that there is a statistically significant difference in five moderating variables. The variables of gender and professional category were not significant in the global effect analysis, but they are in the individual path analysis.

Table 20. The moderating effects in the intention to use desktop GIS

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Gender	Male .632	Female .454	5.236 (1) *
Academic degree	Doctor .517	Master or lower .657	3.654 (1) **
Professional category	Tenured .711	Non-tenured .502	5.048 (1) *
Age	Young faculty .646	Senior faculty .298	11.387 (1) *
	Middle-aged faculty .568	Senior faculty .298	5.215 (1) *
Field of expertise	Human geography .485	Physical geography .629	3.716 (1)

* p-value < .05; ** p-value < .1

The findings showed that the use of desktop GIS for teaching geography is mainly driven by the intention of faculty members of using such technology, being the effect greater for males and tenured faculty. In addition, the effect of intention to use is stronger for those having a doctoral degree, young and middle-aged faculty, and for those working in physical geography areas (compared to human geographers).

A synthesized interpretation of the moderating variables

The multigroup invariance analysis of the individual paths in the structural showed the complexity of the adoption and use of desktop GIS for teaching geography among Latin American faculty. However, the research findings also suggest that some variables had a more prominent role than others. Together, these outcomes provide a more comprehensive perspective on the topic under analysis.

The results suggest that low-experienced faculty with more intentions to use desktop GIS were more likely to have a better perception about the benefits of using the technology for teaching geography, and to experience more difficulties for mastering and learning to use the GST, as compared to moderate-experienced colleagues—there were no statistically significant differences with highly experienced faculty—.

The research findings also pointed out that faculty with a doctoral degree who have more intentions to use desktop GIS were also more prone to have better expectations about the pedagogical potential of the technology. On the other hand, participants with a Master of lesser degree with more intentions to use the technology were more likely to report a frequent use of desktop GIS in the classroom.

The differences across fields of expertise are also evident in this technology. Physical geography faculty with fewer issues mastering and using the technology were likely to have better intentions to use desktop GIS. In addition, physical geographers who are more willing to use the technology were more likely to report a frequent use of desktop GIS. These results, however, are based on the comparison with human geography colleagues, as there were no statistically significant differences with GST faculty.

In the case of age as a moderator, the effect was significant in PE and intention to use paths. The research revealed that young faculty who detected the benefits of using the technology purposes was more likely to have more intentions to use desktop GIS, as compared to senior faculty. In addition, young and middle-aged faculty with more intentions to use the GST for teaching geography are more likely to with exhibit a frequent use of desktop GIS, compared to senior faculty. In both cases, it seems that senior faculty are less interested in adopting and using desktop GIS.

Finally, it is important to mention that decision to use, gender, and professional category only had an effect on the paths leading to the use of desktop GIS. The research findings suggested that male and tenured faculty with more intentions to use desktop GIS for teaching geography were more likely to have a more frequent use of the GST, as compared to female and non-tenured colleagues. Furthermore, faculty working in departments where GST is a mandatory component of the curriculum were also more likely to mention adequate organizational and administrative resources when reporting more frequent use of desktop GIS for teaching geography.

Intra-regional differences in the adoption and use of desktop of GIS

The analysis of subregional differences in the structural model was also assessed through the multi-group invariance analysis. The outcome of the chi-square difference tests, assessing the global effect of the moderator variable of the region in the links among the constructs and observed variables ($\Delta\chi^2 = 51.169$, df = 28, $p<.001$)[11], showed that there are differences between the subregions in the structural model. An additional review of the global effect through pairwise comparisons of the three categories (Table 21) showed a global statistically significant difference between Brazilian faculty and colleagues from the other two subregions; but not between faculty from South American (Region 2) and Mexico, Central America, and the Caribbean countries (Region 3).

Table 21. Global effect of the categories within the variable region in desktop GIS

Subregion	**$\Delta\chi^2$ (df)**	**Invariant**
Brazil – South America	29.348 (14) *	No
Brazil – Mexico, Central America and the Caribbean	23.988 (14) *	No
South America – Central America and the Caribbean	18.047 (14)	Yes

* p-value < .05; ** p-value < .1

Then, the next step involved the analysis of the moderating variables effect—using the pairwise comparison—for each specific path in the structural model. In this case, the chi-square different tests were conducted between an unrestricted model and a model in which each path was restricted to be equal, searching for individual differences

[11] Multigroup analysis with three groups using the emulisrel6 correction, as referred by Byrne (2010).

that were hidden or masked by the outcomes of the global assessment. Table 22 shows the multi-group invariance analysis for the region variable.

Table 22. Results of the multi-group invariance analysis for the pairwise comparison of categories within the variable region for desktop GIS

Path	**Category (β)**		**Δχ² (df)**
Perform expectancy ➔ Intention to use	Brazil .487	South America 1.422	18.745 (1) *
	Mexico, Central America, and the Caribbean .671	South America 1.422	12.544 (1) *
Effort expectancy ➔ Intention to use	Brazil .304	South America .624	17.036 (1) *
	Mexico, Central America, and the Caribbean .236	South America .624	11.852 (1) **
Intention to use ➔ Use of desktop GIS	Brazil .525	Mexico, Central America, and the Caribbean .691	3.716 (1) ***

* p-value < .001; ** p-value < .05; *** p-value < .1

The faculty's intention to use desktop GIS is driven mainly by the expectations that the technology contributes to teaching their courses, being this effect stronger among South American faculty[12] than colleagues in other parts of Latin America. This means that South American faculty who perceived the pedagogical benefits of using desktop

[12] As it was stated at the beginning of the chapter, the database was reviewed for issues of multivariate normality and multicollinearity, which were not present. Therefore, the interpretation was conducted based on the arguments provided by Deegan (1978) and Courville and Thompson (1999) for β greater than 1.

GIS, and to report an easiness of use of the technology were more likely to have greater intentions to use desktop GIS, compared to the rest of Latin American colleagues.

At last, the research findings showed that the use of desktop GIS was driven by the intention to use the GST in the classroom, being this effect stronger for faculty working in Mexico, Central America, and the Caribbean. This means that faculty from this subregion who reported greater intentions to implement desktop GIS in the classroom were more likely to exhibit a frequent use of the GST, as compared to the Brazilian faculty, but not necessarily with South American professors, as there were no statistically significant differences with them.

VIII. WEB-BASED GIS

This chapter addresses the adoption and use of web-based GIS for teaching geography by Latin American faculty in geography departments. The methods and discussion expressed in the following sections are similar to what has been expressed in the desktop-GIS chapter. The SEM analysis also involved the measurement and structural model, followed by the multi-group invariance analysis for testing the moderating effect of several variables in the model, including the intraregional differences of the model.

The measurement model

The analysis of multivariate normality and collinearity found that these issues were not present in the web-based GIS dataset. Then, the measurement model was evaluated through a CFA with the purpose of testing the association of the UTAUT independent variables with the latent factors of PE, EE, SI, and FC. The information from the web-based GIS database was used for testing the hypothesized model, meaning how efficiently the latent factors are measured by the indicators[13]. Table 23 showed the outcomes of the CFA model fit assessment using different indexes, where none of the measurements from the original model reached the cut-off value. Thus, a model respecification was necessary looking at the modification indexes and factor loadings.

[13] For a graphic description, see figure 3 on page 58

Table 23. Web-based GIS CFA: model fit indexes.

Factor model	χ^2	χ^2 / df	GFI	NFI	CFI	RMSEA	AIC	BCC	ECVI
Original	640.806	5.539	.8	.843	.889	.128	720.806	720.856	2.133
Respecified	155.697	2.780	.932	.964	.977	0.073	225.697	228.741	.672

The process was similar to the one performed for desktop GIS, as the model was respecified by 1) deleting the path from item "PE4[14]" to perform expectancy, since obtaining a raise in their jobs is not perceived as a benefit from using web-based GIS for teaching geography; 2) erasing the path from item "SI4[15]" to social influence, as the geography department as an entity is not seen as influential in the decision of using web-based GIS; 3) eliminating the path from "FC4[16] to facilitating conditions, as other items subsume the existence of—human—resources for implementing web-based GIS in teaching geography; 4) A Correlation between items "EE2[17]", "EE3[18]", and "EE4[19]" was added in that faculty who consider web-based GIS is easy to learn may in part also master the technology without any problems, finding it easy to use.

The fit indexes obtained after the respecification surpassed the cut-off values, meaning a better fit of the data with the model[20], also supported by a reduction in the

[14] PE4 items stands for: "If I use web-based GIS, I will increase my chances of getting a raise".
[15] SI4 stands for: "In general, the school or department has supported the use of web-based GIS".
[16] FC4 stands for: "A specific person (or group) is available for assistance with web-based GIS difficulties".
[17] EE2 stands for: "It would be easy for me to become skillful at using web-based GIS".
[18] EE3 stands for: "I would find web-based GIS easy to use".
[19] EE4 stands for: "Learning to operate web-based GIS is easy for me".
[20] The respecified model graphic representation is similar to the figure 4 in page 60

AIC, BCC, and ECVI comparative indexes. Table 24 shows the analysis of reliability, convergent validity, and discriminant validity.

Table 24. Web-based GIS measurements of reliability, convergent validity, and discriminant validity.

Construct	CR	AVE	MSV
Facilitating conditions	.882	.716	.651
Perform expectancy	.932	.821	.477
Effort expectancy	.904	.703	.651
Social influence	.891	.737	.477

These results confirm the aspects: 1) there is an adequate internal consistency of the items with the constructs; 2) the items that measure each construct are related; 3) the constructs are unrelated to each other. Thus, the model fit indexes, the reliability, and the validity measures confirmed the fit of the data with the UTAUT model.

The structural model

The structural model analyzed the path coefficients among PE, EE, and SI as independent variables and intention to use web-based GIS as a dependent variable. Moreover, the model also tested for statistically significance the FC and intention to use paths as independent variables and the use of web-based GIS as the dependent variable[21]. The model fit indexes (χ^2 / df = 2.745; GFI= .921; NFI= .957; CFI = .972; RMSEA= .072) confirmed the fit of the dataset with the proposed model. Then, the maximum

[21] The graphic representation of the structural model is shown in figure 5, page 62

likelihood method was used to estimate the parameters of each path coefficient and the variance (see figure 7), explained in the next paragraphs.

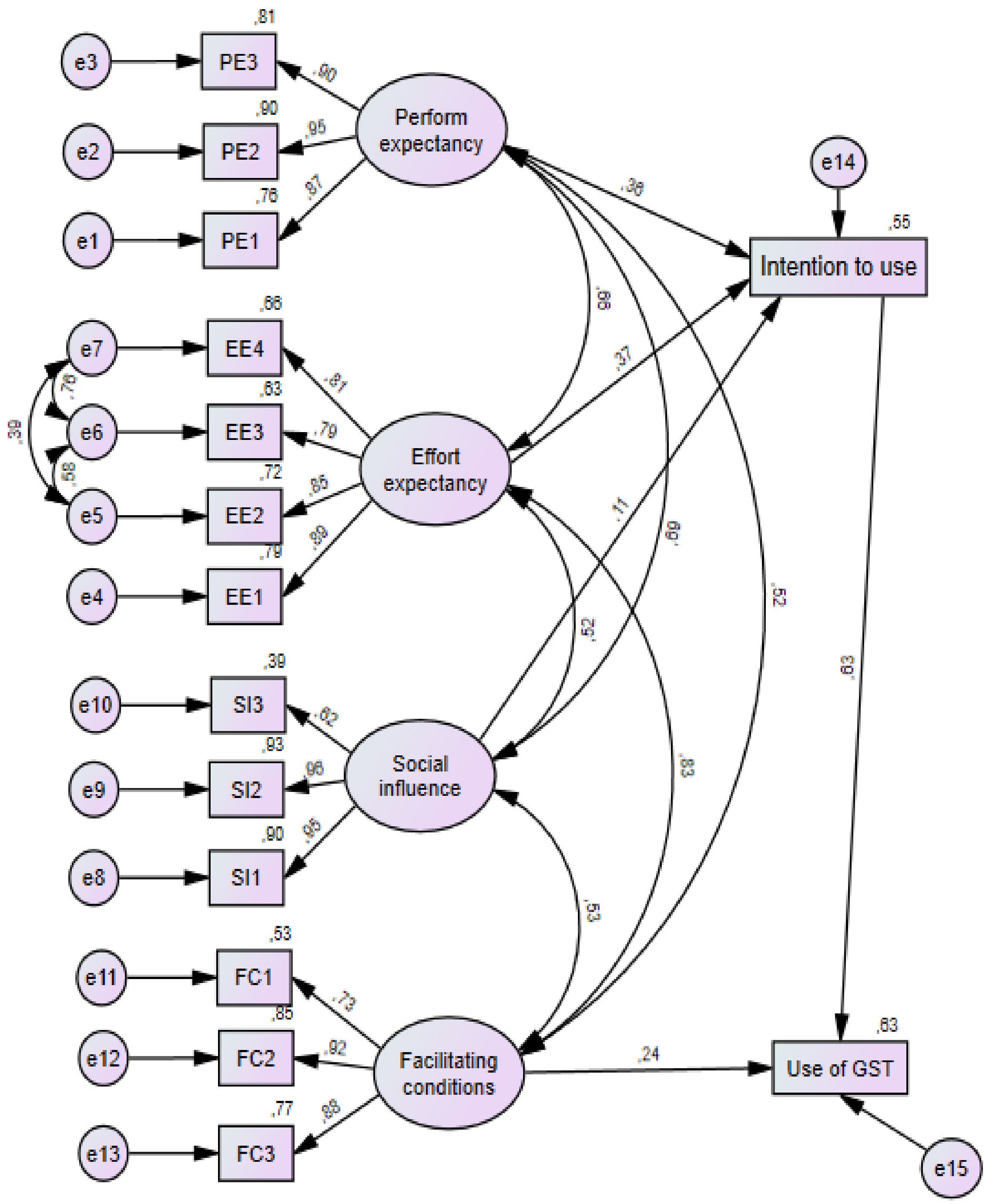

Figure 7. Web-based GIS structural model

The intention to use web-based GIS for teaching geography

The outcome of the multiple regression analysis (table 25) confirmed the hypothesis of the first research question since 55 percent of the variance in the intention to use web-based GIS is predicted by PE and EE in almost a similar proportion, followed by SI to a lesser extent.

Table 25. Web-based GIS: path coefficients towards intention to use.

Path	B	SE	β	p-value
Perform expectancy ➔ Intention to use	.516	.096	.360	< .001
Effort expectancy ➔ Intention to use	.496	.078	.366	< .001
Social influence ➔ Intention to use	.131	.065	.114	.043

Faculty who consider beneficial including this type of GST in their teaching practices as well as those that perceived web-based GIS as relatively easy to use were more prone to have more intentions to use the technology. The influence of the faculty's peers also had an effect on the intention to use web-based GIS.

The information from the average scores for the latent variables (table 26) contributes to the interpretation of the results. Besides being PE and EE strong predictors of the intention to use, most of the respondents also have a general opinion that there is a benefit on using web-based GIS for teaching geography and positive perception of the easiness of use of this GST, which is reflected in a greater intention to use the technology.

Table 26. Scores of independent and dependent variables in the web-based GIS model

Construct	Mean	SD
Perform expectancy	3.84	1.06
Effort expectancy	3.53	.992
Social influence	2.92	1.14
Facilitating conditions	3.35	1.11
Intention to use web-based GIS	3.41	1.37
Use of web-based GIS	2.75	1.39

On the other hand, faculty have a very slight negative perception about the importance of others believing that web-based GIS should be used. In general terms, there are more faculty who do not consider as relevant what other peers or the chair believe about the importance of the technology for teaching geography.

The use of web-based GIS for teaching geography

Table 27 shows the outcome of the multiple regression analysis for the path coefficients intention to use and FC towards the use of web-based GIS. The research findings revealed that 63% of the variance in the faculty's use of web-based GIS for teaching geography is mainly driven by their intention to use the technology, followed by FC. Although the variance is not as high as hypothesized by Venkatesh et al. (2003), the result still shows a strong effect size in the context of a pioneer study in geography education.

Table 27. Path coefficients towards the use of web-based GIS for teaching geography.

Path	B	SE	β	p-value
Intention to use ➔ Use of web-based GIS	.638	.041	.634	< .001
Facilitating conditions ➔ Use of web-based GIS	.357	.065	.244	< .001

The findings propose that when faculty members have more willingness to implement the technology for teaching geography, it is more likely for them to have a frequent use of the technology. Having adequate administrative and organization conditions for using web-based GIS also increases the use of the GST, although to a lesser extent.

The average scores in table 26 showed low use of web-based GIS for teaching geography, a slightly positive intention to use and a positive perception of the FC. In this context of low use of the GST, it becomes more important to identify the patterns associated with greater adoption of web-based GIS, as it might be of interest for the geography department to develop strategies for increasing the adoption rate of the technology.

The effect of the moderating variables

The web-based GIS multi-group invariance analysis followed the same approach as with desktop GIS. The value of .1 was also set for reaching statistical significance in the chi-square different tests. The purpose is to expand the identification of possible variable differences across geography faculty, which would be more restrictive if the p-value is set as .05 for statistical significance.

The first step in the multi-group analysis consisted of the general effect analysis for each moderator variable (table 28) among all the paths between constructs and observed variables.

Table 28. Results of the tests for the global effect of moderating variables in the web-based GIS model.

Moderating variable	**$\Delta\chi^2$ (df)**	**Invariant**
Gender	13.552 (14)	Yes
Academic degree	14.409 (14)	Yes
Decision to use	16.180 (14)	Yes
GST research	18.744 (14)	Yes
Work time	9.713 (14)	Yes
Type of software used	19.786 (14)	Yes
Professional category	11.661 (14)	Yes
Age*	36.889 (28)	Yes
Professional experience*	38.877 (28) ***	No
Field of expertise*	62.953 (28) **	No

* Multigroup analysis of three categories using the emulisrel6 correction, suggested by Byrne (2010).
** p-value < .05
*** p-value < .1

The outcomes of the chi-square difference tests revealed that only the variables professional experience and field of expertise had a statistically significant global moderator effect across the model. Since these two variables have three different categories, a pairwise comparison was performed for checking also the global effect (table 29) on the model.

Table 29. Global effect of the categories within specific fields of expertise and professional experience in web-based GIS

Field of expertise	$\Delta\chi^2$ (df)	Invariant
Human geography – Physical geography	33.581 (14) *	No
Human geography – Geospatial technologies	30.190 (14) *	Yes
Physical geography – Geospatial technologies	30.542 (14) *	No
Professional experience	**$\Delta\chi^2$ (df)**	**Invariant**
Low – Moderate	11.328 (14)	Yes
Low – High	22.477 (14) **	No
Moderate – High	26.192 (14) **	No

* p-value < .05; ** p-value < .1

The analysis confirmed the existence of differences in the global effect across all categories for the field of expertise variable. In addition, there is a general effect on the highly experienced faculty. The next step aimed to confirm the presence of moderating variables effects in the individual paths of the model, as it was performed in the desktop GIS chapter. The results are discussed in the next sub-sections, according to each path.

Perform expectancy

The outcomes of the chi-square difference test (table 30) on the PE path showed that from all the moderating variables, there were statistically significant differences across groups on the field of expertise only. These results contradict Venkatesh et al. (2003) argument about gender and age having an effect on PE.

Table 30. The moderating effects in the web-based GIS perform expectancy path

Moderating variable	Category (β)		$\Delta\chi^2$ (df)
Field of expertise	Human geography .275	Physical geography .786	16.652 (1) *
	Human geography .275	Geospatial technologies -.176	3.012 (1) **
	Physical geography .786	Geospatial technologies -.176	12.485 (1) *

* p-value < .01; ** p-value < .1

The research findings suggest that the effect perceived by faculty members on the benefits or gains of including web-based GIS for teaching geography is stronger for those working in physical geography, followed by human geographers. Although it may be expected that GST faculty would have a stronger perception of these benefits, research shows the contrary. A possible explanation is that physical and human geography faculty have shown more interest on the pedagogical advantage of including this type of technology, as they might provide a source of examples, case studies, or information for their courses, compared to GST faculty who might be more interested in technical and procedural knowledge. This hypothesis should be explored in further research.

Effort expectancy

The table 31 revealed the variables that have a statistically significant difference across groups in the EE path. In addition to the field of expertise, the statistical analysis confirmed that there are differences among the type of curriculum and the type of software used in the department.

Table 31. The moderating effects in the web-based GIS effort expectancy path

Moderating variable	Category (β)		$\Delta\chi^2$ (df)
Field of expertise	Human geography .359	Physical geography .134	3..823 (1) *
	Human geography .359	Geospatial technologies .869	5.322 (1) *
	Physical geography .134	Geospatial technologies .869	11.345 (1) *
Decision to use	Mandatory .500	Optional .267	3.860 (1) *
Type of software used	Licensed .134	Open-sourced .467	4.912 (1) *

* p-value < .05

The research findings indicate that when participants considered the mastering and use of this technology as relatively easy, they were more likely to have greater intentions to use web-based GIS, being this effect stronger mostly for GST faculty, followed by human geographers, as compared to physical geography colleagues. Moreover, the effect is also greater for faculty working in places where the use of web-based GIS for teaching geography is seen as mandatory and where open-sourced software is mostly used. The findings do not support Venkatesh et al (2003) notion that gender and experience moderate the EE effect since they were found as not statistically significant in this case.

Social influence

The multi-group invariance tests (table 32) revealed that professional experience, type of software used, and field of expertise reported differences across groups. The findings partially support Venkatesh et al. (2003) position, who indicated that professional experience moderates the effect of SI. However, the results do not show a statistically significant difference in gender, and voluntariness of use—decision to use variable—who were suggested by the authors as having a moderating effect.

Table 32. The moderating effects in the web-based GIS social influence path

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Professional experience	Low .022	High .351	3.919 (1) *
	Moderate .063	High .351	5.175 (1) **
Field of expertise	Human geography .200	Physical geography -.089	4.988 (1) *
Type of software used	Licensed .197	Open-sourced -.01	3.035 (1) **

* p-value < .05; ** p-value < .1

The research findings suggest that when faculty appreciate the ideas of people who are influential to them (e.g., peers, the department's chair) about the use of this GST for teaching geography, they are likely to have more intentions to use web-based GIS. The effect is stronger for faculty with the highest number of years teaching in higher education, compared to low and moderate experienced colleagues, and for departments where most faculty members use licensed web-based GIS software. Furthermore, the effect is greater among human geographers, when compared to physical geographers. No statistically significant differences were detected with GST faculty.

Facilitating conditions

Table 33 shows the outcomes of the multi-group invariance analysis. The findings suggest that age, professional experience, field of expertise, and academic degree have a moderating effect on the FC path towards the use of web-based GIS for teaching geography.

Table 33. The moderating effects in the web-based GIS facilitating conditions path

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Age	Young faculty .268	Senior faculty .082	5.540 (1) *
	Middle-aged faculty .326	Senior faculty .082	5.301 (1) **
Professional experience	Low .290	High .046	6.858 (1) *
	Moderate .347	High .046	7.169 (1) *
Field of expertise	Human geography .022	Geospatial technologies .351	3.503 (1) **
	Physical geography .063	Geospatial technologies .351	5.774 (1) *
Academic degree	Doctor .199	Master or lower .422	4.988 (1) *

* p-value < .05; ** p-value < .1

In this way, when faculty members report better organizational and administrative conditions for using the technology, it is more likely for them to have a frequent use of the GST. This effect is weaker among senior and high-experienced faculty, but greater among young and middle-aged faculty as well as those with a low and moderate experience teaching geography. The findings suppose a different perspective from Venkatesh et al. (2003), who argued that FC increases with age and experience, being the opposite in the context of the current research. The effect is also stronger among human and physical geographers (compared to GST faculty) and among respondents who have a master or lower degree.

Intention to use web-based GIS

The outcome of the chi-square difference tests for this path is shown in table 34. The results show a statistically significant moderating effect in the variables of professional experience, age, field of expertise, and academic degree.

Table 34. The moderating effects in the web-based GIS intention to use path

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Professional experience	Low .574	High .871	8.175 (1) *
	Moderate .514	High .871	11.042 (1) *
Age	Middle-aged faculty .516	Senior faculty .852	9.214 (1) *
Field of expertise	Human geography .648	Geospatial technologies .735	4.143 (1) *
Academic degree	Doctor .197	Master or lower -.01	3.396 (1) **

* p-value < .05; ** p-value < .1

The data revealed that the use of web-based GIS is mainly driven by the intention to use, whose effect is stronger in faculty with a higher level of experience (compared to low and moderate experience colleagues) and those who have a doctoral degree. In addition, the effect is greater among senior-aged faculty, but only when compared to middle-aged faculty, since there were no statistically significant differences between these two groups and young faculty. At last, the effect of intention to use was stronger in GST faculty than human geographers, although it was not statistically different from physical geographers.

A synthesized interpretation of the moderating variables

The multigroup invariance analysis showed the differences that exist on the effect of several variances across individual paths. There were six variables whose effect was stronger at least in one relationship. However, there were two variables whose influence was more evident throughout the model: the field of expertise and professional experience.

The differences across groups were evident in all paths for respondents according to the field of expertise, being more visible in the role of GST and human geography faculty. The moderating effect of PE was weaker for GST faculty, but at the same time stronger in the EE and FC path. The findings suggest that GST faculty who were more likely to refer this technology as easy to use and to pay more attention to the importance set by the people who are influential to them about the use of web-based GIS for teaching geography, were more likely to have greater intentions to use the technology. However, they were also less prone to perceive the benefits of teaching with this GST.

The moderating effect of field of expertise on the FC and intention to use was also statistically significant and stronger for GST faculty, although the results should be interpreted carefully. In this case, GST faculty who perceived greater organizational and administrative conditions as well as more intentions to use the technology were more likely to have a frequent use of web-based GIS for teaching geography. However, the intention to use is only high when compared to human geographers, not necessarily with physical geographers.

Another outcome of the multi-group invariance analysis is the differences between human and physical geographers. The findings indicate that the human geography faculty who perceived the benefits of teaching with this GST, found easy to use the technology, and had a greater appreciation for other belief's about the importance of teaching with web-based GIS, were likely to have more intentions to use the technology, as compared to physical geographers, who in general terms exhibit the weakest effect on both FC and intention to use paths.

The professional experience was the second statistically significant variable across several paths. The research findings suggest differences in the SI, FC, and intention to use path. In this case, low and moderate-experienced faculty intentions to use web-based for teaching geography increases when the other people who are influential to them also think they should be using the technology, as compared to high experienced faculty. Furthermore, highly experienced faculty was less prospective to perceive adequate organizational and administrative conditions, but more likely to have greater intentions to use the technology, when compared to low and moderate-experienced faculty, whose effect was the contrary.

The type of software used in the departments also had a relevant role in the adoption patterns of web-based GIS. The findings indicate that faculty using mostly open-sourced GST who identified this technology as easy to learn and use, but did not perceived as relevant the influence of the beliefs of people who are important to them regarding the use of web-based GIS for teaching, were more likely to have intentions to use the technology, as compared to faculty who used licensed software.

The moderating effect of academic degree is statistically significant only when exploring the paths associated with the use of web-based GIS. In this case, faculty who have a doctoral degree with more intentions to use the GST were likely to have a frequent use of the technology. However, they reported less organizational and administrative conditions to use the technology, compared to faculty with a master or lesser degree.

At last, the age of participants was also a moderating variable on the paths for use of web-based GIS. Senior faculty that referred adequate conditions for its implementation, were more likely to have a frequent use of the GST, as compared to young and middle-aged faculty. Moreover, they were also less likely to have higher intentions to use the technology, as compared to middle-aged faculty.

Intra-regional differences in the adoption and use of web-based GIS

The multi-group invariance analysis for the variable region showed the existence of differences across subregions. The chi-square difference test, looking at the global effect of the variable region in all the links of the model at once ($\Delta\chi^2 = 62.261$, df = 28, $p<.001$)[22], corroborated the existence of such differences. An additional pairwise comparison of the three categories within the region (table 35) also confirmed a global

[22] Multigroup analysis with three groups using the emulisrel6 correction, as referred by Byrne (2010).

effect when comparing Brazilian faculty and colleagues from other South American countries. There is also a moderating effect in the general model when comparing Brazil with Mexico, Central America, and the Caribbean area.

Table 35. Global effect of the categories within the variable region in web-based GIS

Subregion	$\Delta\chi^2$ (df)	Invariant
Brazil – South America	34.793 (14) *	No
Brazil – Mexico, Central America and the Caribbean	22.219 (14) **	No
South America – Central America and the Caribbean	18.479 (14)	Yes

* p-value < .05; ** p-value < .1

Then, the analysis continued by testing if these global effect holds for each specific path in the model. Chi-square different tests were conducted between an unrestricted model and a model in which each path was restricted one at the time. The statistical tests were conducted for each pairwise comparison. Table 36 shows the multi-group invariance for the variable.

The findings showed that the variable region had a moderating effect, but only on two paths related to the intention to use. Thus, the intention to use is driven by PE. In this context, faculty from Mexico, Central America, and the Caribbean[23] who identified greater pedagogical benefits of using this GST for teaching geography were likely to

[23] The database preliminary analysis did not detect any issues associated with multivariate normality and multicollinearity. Thus, the interpretation of this result was conducted according to the arguments provided by Deegan (1978) and Courville and Thompson (1999) for β greater than 1.

have more intentions to use the GST, as compared to faculty from Brazil or other South American countries.

Table 36. Results of the multi-group invariance analysis for the pairwise comparison of categories within the variable region for web-based GIS

Path	**Category (β)**		**Δχ² (df)**
Perform expectancy ➔ Intention to use	Brazil	Mexico, Central America, and the Caribbean	4.452 (1) *
	.367	1.02	
	South America	Mexico, Central America, and the Caribbean	4.163 (1) *
	.349	1.02	
Social influence ➔ Intention to use	Brazil	Mexico, Central America, and the Caribbean	5.175 (1) *
	.159	-.528	
	South America	Mexico, Central America, and the Caribbean	3.845 (1) *
	.076	-.528	

* p-value < .05

The chi-square difference tests also confirmed that faculty from Mexico, Central America, and the Caribbean who have a negative view of the opinion of people who are influential to them about the use of this technology for teaching geography, were more likely to have greater intentions to use the technology, as compared to faculty from Brazil and other South American countries. The lower the perception about their peers, the higher the intention to use the technology, which could be seen as a challenging posture from faculty, in which individual decisions—not peer pressure—might be more determinant.

At last, the statistical analysis also showed that there were no group differences for the path heading towards the use of web-based GIS for teaching geography. Since the use of this technology increases when there is a more intention to use and better FC, the evidence suggests that the predictor's behavior is similar across all faculty members in Latin America.

IX. REMOTE SENSING

The chapter discusses the adoption and use of remote sensing for teaching geography by Latin American geography faculty. Using the same approach as the last two chapters, the analysis starts by showing the outcomes of the measurement and structural model. Then, the multi-group invariance tests assessed the moderating effect of the variables on the structural model. The final part addressed the intraregional variations of the adoption of remote sensing for each specific path in the intention and use of the GST.

The measurement model

The remote sensing database was tested initially for multivariate normality and multicollinearity. The analysis confirmed that there were no issues found in the collected data. Then, a CFA was conducted looking at the associated of the UTAUT independent variables with the latent factors PE, EE, SI, and FC, as the purpose was to analyze the efficiency by which the indicators measure the factors. The model fit indexes used for assessing the original factor model (table 37) did not reach the desired cut-off values. It was necessary a model respecification by checking modification indexes and factor loadings.

Table 37. Remote sensing CFA: model fit indexes.

Factor model	χ^2	χ^2 / df	GFI	NFI	CFI	RMSEA	AIC	BCC	ECVI
Original	776.057	7.919	.769	.887	.899	.143	852.057	856.107	2.523
Respecified	165.339	2.952	.926	.974	.982	.076	235.339	238.383	.7

Similar to the previous technologies, the model was respecified by: 1) deleting the path from item "PE4[24]" to perform expectancy, since obtaining a raise in their jobs is not perceived as a benefit from using remote sensing for teaching geography; 2) erasing the path from item "SI4[25]" to social influence, as the geography department as an entity is not seen as influential in the decision of using remote sensing; 3) eliminating the path from "FC4[26] to facilitating conditions, as other items subsume the existence of—human—resources for implementing remote sensing in teaching geography; 4) A Correlation between items "EE2[27]", "EE3[28]", and "EE4[29]" was added in that faculty who consider remote sensing as easy to learn may in part also become master the technology without any problems, finding it easy to use.

The respecified model fit indexes were acceptable, indicating a fit of the data with the proposed model[30], which is also supported by the lower values obtained in the AIC, BCC, and ECVI comparative indexes, as compared to the original model. Then, the

[24] PE4 items stands for: "If I use remote sensing, I will increase my chances of getting a raise".
[25] SI4 stands for: "In general, the school or department has supported the use of remote sensing".
[26] FC4 stands for: "A specific person (or group) is available for assistance with remote sensing difficulties".
[27] EE2 stands for: "It would be easy for me to become skillful at using remote sensing".
[28] EE3 stands for: "I would find remote sensing easy to use".
[29] EE4 stands for: "Learning to operate remote sensing is easy for me".
[30] The respecified model graphic representation is similar to the figure 4 in page 60

analysis continued by checking the reliability, convergent validity, and discriminant validity of the constructs. Table 38 shows the outcomes for this model.

Table 38. Remote sensing measurements of reliability, convergent validity, and discriminant validity

Construct	CR	AVE	MSV
Facilitating conditions	.935	.829	.615
Perform expectancy	.965	.903	.494
Effort expectancy	.961	.860	.615
Social influence	.922	.801	.486

The CR scores for each latent variable were higher than .7, indicating a good internal consistency of the items with the constructs. In addition, the AVE values were higher than .5, meaning the indicators measuring the constructs are related. The MSV values were also lower than AVE indicating that the constructs might be unrelated to each other.

The structural model

The structural model[31] was also tested looking at the relationships between dependent and independent variables. The analysis of the model fit indexes confirmed model fit with the data (χ^2 / df = 2.912; GFI= .909; NFI= .969; CFI = .979; RMSEA= .075). The maximum likelihood method was performed to estimate the parameters for

[31] The graphic representation of the structural model is shown in figure 5, page 62

each path coefficient and the variance. Figure 8 shows the outcomes of this process as a diagram.

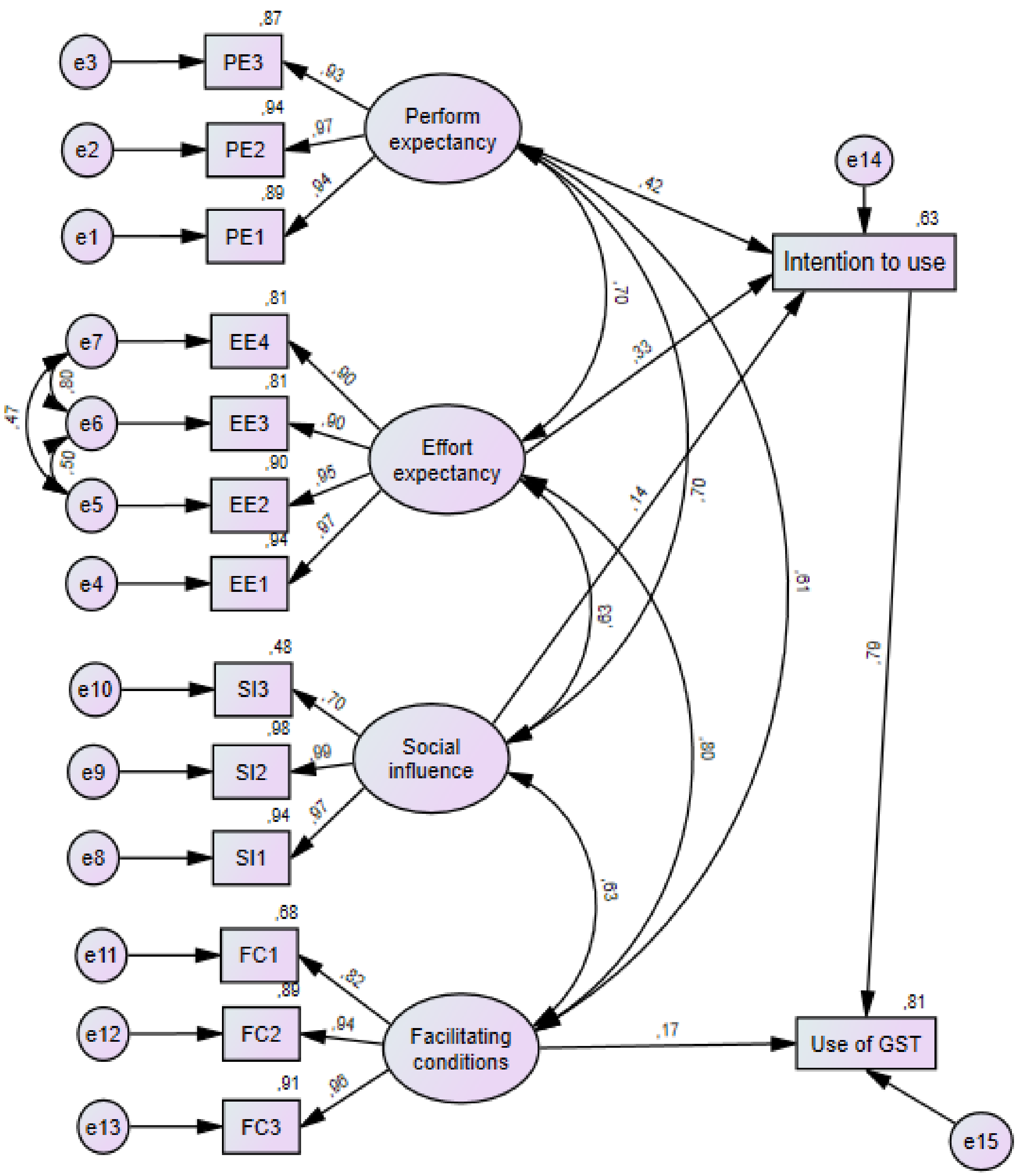

Figure 8. Remote sensing structural model

The intention to use remote sensing for teaching geography

The outcomes of the multiple regression are shown in table 39. The information suggests that 63 percent of the variance in the intention to use remote sensing for teaching geography is driven by PE, and EE, followed by SI to a lesser extent.

Table 39. Remote sensing: path coefficients towards intention to use

Path	B	SE	β	p-value
Perform expectancy ➔ Intention to use	.578	.076	.424	< .001
Effort expectancy ➔ Intention to use	.416	.066	.325	< .001
Social influence ➔ Intention to use	.162	.059	.137	.006

The study found that faculty who identify the pedagogical benefits of using remote sensing in their courses, and also tend to consider the technology easy to use and learn are more likely to have intentions to use the GST. Furthermore, faculty are more prone to value the opinion of people important to them about the use of the GST for teaching geography, as a predictor of intention to use remote sensing.

An additional perspective is obtained from the average scores for the dependent and independent variables of the model (Table 40). In addition, to being PE and EE predictors of the intention to use, most of the respondents reported a positive perception about the pedagogical benefits of using the GST and slightly positive perception about the easiness of use of remote sensing.

Table 40. Scores of independent and dependent variables in the remote sensing model

Construct	Mean	SD
Perform expectancy	3.62	1.21
Effort expectancy	3.27	1.18
Social influence	2.86	1.24
Facilitating conditions	3.10	1.25
Intention to use remote sensing	3.02	1.56
Use of remote sensing	2.62	1.50

Despite being SI a predictor of intention to use remote sensing, the overall impression is that most faculty have a negative view of peer pressure related to the use of the technology. The results suggest that the factors driving the faculty's adoption of technology are not necessarily representative of the majority of participants. This means that the understanding of the context by which people are more willing to adopt the GST is fundamental to increase the adoption rates in Latin America.

The use of remote sensing for teaching geography

The outcomes of the multiple regression analysis are shown in table 41. The data revealed that 81 percent of the variance in the use of remote sensing for teaching geography is predicted by the intention to use the technology, followed by FC to a lesser extent. The variance obtained was even greater than what has been referred by Venkatesh et al. (2003) for the UTAUT, reflecting the efficacy of the model for predicting the adoption of remote sensing.

Table 41. Path coefficients towards the use of remote sensing for teaching geography.

Path	B	SE	β	p-value
Intention to use ➔ Use of remote sensing	.749	.029	.785	< .001
Facilitating conditions ➔ Use of remote sensing	.240	.043	.175	< .001

Faculty who have more intentions of adopting the technology and tend to perceive better administrative and organizational conditions for implementing the technology in the classroom (to a lesser extent), were more likely to have a frequent use of the technology. Since the average score for use of remote sensing (table 40) is quite low, the multiple regression analysis provides valuable information for knowing the circumstances by which remote sensing is used by faculty across Latin America and how more faculty can eventually use the technology, by understanding the drivers of intention to use this GST.

The effect of moderating variables

The analysis of the moderating effect of several variables in the structural model was performed using the multi-group invariance analysis, setting a p-value of .1 as the cut-off value for a statistically significant difference. The approach is the same as the one employed for the past two technologies, expanding the scope of possible variations on the faculty's adoption and use patterns. In this way, the first phase analyzed the global effect (table 28) of the moderating variables among all the links between the observed variables and latent factors.

Table 42. Results of the tests for the global effect of moderating variables in the remote sensing model

Moderating variable	**$\Delta\chi^2$ (df)**	**Invariant**
Gender	16.456 (14)	Yes
Academic degree	10.914 (14)	Yes
Decision to use	6.360 (14)	Yes
GST research	20.700 (14)	Yes
Work time	13.137 (14)	Yes
Type of software used	29.760 (14) ***	No
Professional category	14.128 (14)	Yes
Age*	33.782 (28)	Yes
Professional experience*	29.997 (28)	Yes
Field of expertise*	84.791 (28) **	No

* Multigroup analysis of three categories using the emulisrel6 correction, suggested by Byrne (2010).
** p-value < .01
*** p-value < .05

The results indicated that only the variables type of software used and field of expertise had a statistically significant global effect on the relationships between all paths. Table 43 shows the outcomes of the analysis of a pairwise comparison of the three categories within the field of expertise, looking at significant global effects in the model.

Table 43. Global effect of the categories within specific fields of expertise in remote sensing

Field of expertise	**$\Delta\chi^2$ (df)**	**Invariant**
Human geography – Physical geography	51.517 (14) *	No
Human geography – Geospatial technologies	43.149 (14) *	No
Physical geography – Geospatial technologies	17.623 (14)	Yes

* p-value < .001

The findings suggest a statistically significant global effect on human geography as compared to physical geography and GST faculty. Following the suggestions of Chin et al. (2012), the next step involved a detailed analysis of moderating effects across individual paths. Chi-square difference tests were included between an unconstrained model where parameters were set to be free and another model where each path is constrained, one at the time. The results are presented in the following sub-sections.

Perform expectancy

Table 44 shows the outcomes of the chi-square difference tests for the PE path. Only three variables—type of software used, professional category, and field of expertise—reported statistically significant differences across groups. Venkatesh et al. (2003) suggested that gender and experience do have a moderating effect on the PE path. However, the research findings suggest the lack of differences in those variables for the remote sensing model.

Table 44. The moderating effects in the remote sensing effort expectancy path

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Field of expertise	Human geography .313	Physical geography .731	18.831 (1) *
	Human geography .313	Geospatial technologies .835	6.718 (1) **
Professional category	Tenured .500	Non-tenured .267	5.789 (1) **
Type of software used	Licensed .772	Open-sourced .326	12.160 (1) *

* p-value < .001; ** p-value < .05

The intention to use remote sensing for teaching geography is driven by the PE, being the effect stronger for physical geography and GST faculty, as compared to human geographers. Furthermore, the strength of these relationships is greater for faculty holding tenured positions as well as those using licensed remote sensing software.

Effort expectancy

The multi-group invariance tests for this path showed that there are only two variables showing statistically significant differences across groups. These variables are type of software used ($\Delta\chi^2 = 11.755$, df = 1, p= .001) and professional category ($\Delta\chi^2 = 3.505$, df = 1, p= .061). The intention to use remote sensing for teaching geography is driven by faculty's opinion about the easiness of use of the technology, being this effect stronger for faculty who used remote sensing open-sourced software ($\beta = .493$) as compared to licensed products ($\beta= .120$). This effect was also found greater for non-tenured faculty ($\beta=.374$) than tenured faculty ($\beta=.151$). It is interesting to notice that gender or professional experience did not moderate the effects on EE, as suggested by Venkatesh et al. (2003) for the UTAUT model.

Social influence

The outcomes of the multi-group invariance analysis (table 45) revealed that the variables gender, age, and field of expertise had statistically significant differences across groups in the SI path. In this case, Vekatesh et al. (2003) suggested that gender, the voluntariness of use—decision to use variable—, and professional experience act as moderators of SI. However, just gender was found as significant for the remote sensing model.

Table 45. The moderating effects in the remote sensing social influence path

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Field of expertise	Human geography .225	Physical geography -.112	8.705 (1) *
	Human geography .225	Geospatial technologies -.179	8.715 (1) *
Gender	Male .255	Female .016	5.019 (1) *
Age	Young faculty -.008	Senior faculty .372	9.360 (1) *

* p-value < .05

In this way, the results confirm that the faculty's with a better perception of the opinion of people who are influential to them about the use of remote sensing are more likely to have intentions to use the technology, being this effect greater for human geographers as compared to physical and GST faculty. In addition, the strength of the relationship was greater for senior faculty, when compared to young faculty, and among male faculty.

Facilitating conditions

The chi-square difference tests indicated the moderating effect of the field of expertise and geographic research (table 46). The findings did not corroborate Venkatesh et al. (200) arguments that FC increases with age and experience. Both variables were found not to be statistically significant.

Table 46. The moderating effects in the remote sensing facilitating conditions path

Moderating variable	**Category (β)**		**Δχ² (df)**
Field of expertise	Human geography .152	Geospatial technologies -.065	4.937 (1) *
	Physical geography .197	Geospatial technologies -.065	8.715 (1) *
GST research	Yes .211	No .064	5.574 (1) *

* p-value < .05

The use of remote sensing for teaching geography was predicted by the faculty's identification of adequate administrative and organizational resources for implementing the technology. This effect is greater for human and physical geographers (as compared to GST faculty) as well as among faculty members who use to do research by using remote sensing software.

Intention to use remote sensing

The multi-group invariance analysis for this last path is represented in table 47. The results confirmed that the field of expertise and professional category moderate the effect of intention to use remote sensing for teaching geography.

Table 47. The moderating effects in the remote sensing intention to use path

Moderating variable	Category (β)		$\Delta\chi^2$ (df)
Field of expertise	Human geography .721	Physical geography .747	6.196 (1) **
	Human geography .721	Geospatial technologies .903	16.046 (1) *
Professional category	Tenured .211	Non-tenured .064	2.966 (1) ***

* p-value < .01; ** p-value < .05; *** p-value < .1

The research findings revealed that the use of remote sensing is driven mainly by the faculty's intention to use this technology, being this effect greater for GST and physical faculty, as compared to human geographers. In addition, the effect was found to be stronger for faculty holding a tenured position.

A synthesized interpretation of the moderating variables

The overall results of the multi-group invariance analysis identified six variables moderating the effect of individual paths across the model. Three of these variables had a more prominent role: field of expertise, professional category, and type of software used.

The moderating effect of the categories within the field of expertise was different in PE and SI paths. The research findings suggest that physical geography and GST faculty who identified the pedagogical benefits of using the technology in their courses, but less prone to value the opinions of other people who are influential to them about the use of remote sensing for teaching, were more likely to have intentions to use remote sensing, as compared to human geographers. The findings indicate that peer pressure might have an important role in the intention to use remote sensing for teaching by human geographers. Furthermore, GST faculty with greater intentions to use the technology for teaching geography, but less prone to identify adequate resources and organizational conditions, were more likely to have a frequent use of remote sensing, as compared to human geographers and physical geographers.

The analysis of professional category indicated that tenured faculty who have greater expectations of teaching with remote sensing were more likely to report a frequent use of the GST, as compared to non-tenured faculty, who instead were more likely to consider remote sensing as a technology easy to use and learn. On the other hand, tenured faculty with greater intentions to use the GST for teaching were more likely to have a frequent use of remote sensing, compared to non-tenured faculty. No differences were reported between these two faculty groups for FC.

The type of software moderated the effect only in paths predicting intention to use, but not the use of the technology itself. In this way, faculty who mostly use of licensed products identified the benefits of using this GST for teaching purposes were more likely to have more intentions to use remote sensing, as compared to faculty using used open-sourced software to a greater extent, who instead were more likely to report an easiness of use of the technology as a predictor of intention to use.

The variables that are suggested by Venkateh et al. (2003) as predictors of different paths were mostly not statistically significant. The only exceptions were for gender and age in the PE path, since male faculty paying more attention to their peers' opinion about the importance of the technology for teaching geography were more likely to have greater intentions to use remote sensing, which was a similar case for senior faculty, as compared to young faculty. Faculty who did research using GST and reported frequent use of GST was also likely to identify adequate administrative and organizational conditions for implementing the technology. It is interesting to note that this variable exhibited a moderating effect only for this technology and this specific path, reflecting a particular connection between research and teaching which is not present for other GST in the study.

Intraregional differences in the adoption and use of remote sensing

The last phase of the statistical analysis consisted of looking for the moderating effect of the variable region in the model. The outcomes of the multi-group invariance tests ($\Delta\chi^2 = 59.227$, df = 28, $p<.001$)[32] indicated a global effect of the regions across the links in the structural model. A follow-up pairwise comparison for testing this effect across categories (table 48) revealed statistically significant differences in each pair of categories across the model.

Table 48. Global effect of the categories within the variable region in remote sensing

Subregion	$\Delta\chi^2$ (df)	Invariant
Brazil – South America	12.617 (14) *	No
Brazil – Mexico, Central America and the Caribbean	24.543 (14) *	No
South America – Central America and the Caribbean	31.262 (14) *	No

* p-value < .05

[32] Multigroup analysis with three groups using the emulisrel6 correction, as referred by Byrne (2010).

The next step identified statistically significant differences across groups for each individual path in the model. Chi-square difference tests were performed between an unrestricted model were parameters are estimated freely and a model where each path is set to be constrained, one at the time. Table 49 shows the outcomes of the multi-group invariance analysis.

Table 49. Results of the multi-group invariance analysis for the pairwise comparison of categories within the variable region for remote sensing

Path	**Category (β)**		**Δχ² (df)**
Perform expectancy ➔ Intention to use	Brazil .319	Mexico, Central America, and the Caribbean .739	12 (1) *
	South America .439	Mexico, Central America, and the Caribbean .739	5.453 (1) *
Social influence ➔ Intention to use	Brazil .183	South America -.061	4.003 (1) *
Facilitating conditions ➔ use of remote sensing	Brazil .216	Mexico, Central America, and the Caribbean -.200	10.601 (1) *
	South America .210	Mexico, Central America, and the Caribbean -.200	9.778 (1) *
Intention to use ➔ use of remote sensing	Brazil .747	Mexico, Central America, and the Caribbean 1.04	5.964 (1) *
	South America .794	Mexico, Central America, and the Caribbean 1.04	2.994 (1) *

* p-value < .05

There is a moderating effect of region across four paths. In this context, faculty from Mexico, Central America, and the Caribbean[33] who identify the potential benefits of using remote sensing for teaching purposes were likely to have more intentions to use the GST, as compared to Brazilian or other South American countries.

The results also showed that Brazilian faculty who have a better appreciation of other people ideas about the importance of using remote sensing for teaching geography, were likely to have more intentions to use the GST, as compared to South American countries—no differences were found with Mexican, Central American, and the Caribbean faculty—.

The differences among subregions are also present on the use of remote sensing path, as Brazilian and South American faculty tend to report better administrative and organizational conditions for implementing the technology as a predictor of remote sensing use, but less likely to have intentions to use the technology, compared to Mexican, Central-American, and the Caribbean faculty, who have an opposite view—greater intentions but less FC—about remote sensing.

[33] As it was stated at the beginning of the chapter, the database was checked for issues of multivariate normality and multicollinearity. Since there were no problems detected, the interpretation of this value was based on the arguments provided by Deegan (1978) and Courville and Thompson (1999) for β greater than 1.

X. GPS

The following chapter addresses the adoption and use of GPS for teaching geography by faculty working at Latin American universities. Using the same approach as the previous GST, the discussion begins with an explanation of the SEM measurement model, then followed by the outcomes of the structural model. Then, the study continues with the multi-group invariance analysis of the moderating variables across the paths in the model, ending with the analysis of intra-regional variations in the adoption and use of GPS.

The measurement model

The preliminary analysis of the GPS database did not detect any issues related to multivariate normality and collinearity. In this way, the data was ready for the CFA with the purpose of exploring the relationships between the UTAUT items and the PE, EE, SI, and FC constructs, including the analysis of the efficiency by which these indicators measure the factors. The results of the model fit indexes (table 50) assessing the original model did not reach the acceptable cut-off values. Thus, the next step consisted of performing a model respecification by looking at the factor loadings and modification indexes.

Table 50. GPS CFA: model fit indexes

Factor model	χ^2	χ^2 / df	GFI	NFI	CFI	RMSEA	AIC	BCC	ECVI
Original	673.117	6.869	.810	.901	.914	.132	749.117	753.167	2.230
Respecified	147.383	2.632	.937	.975	.984	.070	217.383	220.427	.647

The GPS original model was respecified using the following criteria: 1) deleting the path from item "PE4[34]" to perform expectancy, since obtaining a raise in their jobs is not perceived as a benefit from using GPS for teaching geography; 2) erasing the path from item "SI4[35]" to social influence, as the geography department as an entity is not seen as influential in the decision of using GPS; 3) eliminating the path from "FC4[36] to facilitating conditions, as other items subsume the existence of—human—resources for implementing GPS in teaching geography; 4) A Correlation between items "EE2[37]", "EE3[38]", and "EE4[39]" was added in that faculty who consider GPS as easy to learn may in part also use the technology without any problems, finding it easy to use.

After performing these changes, the model fit indexes obtained were greater than the cut-off values. In addition, the comparative indexes AIC, BCC, and ECVI for the respecified model were consistently lower than in the original model. These results confirmed a better fit of data to the proposed model. Table 51 shows the follow-up analysis of reliability and validity for the latent constructs in the model.

[34] PE4 items stands for: "If I use GPS, I will increase my chances of getting a raise".
[35] SI4 stands for: "In general, the school or department has supported the use of GPS".
[36] FC4 stands for: "A specific person (or group) is available for assistance with GPS difficulties".
[37] EE2 stands for: "It would be easy for me to become skillful at using GPS".
[38] EE3 stands for: "I would find GPS easy to use".
[39] EE4 stands for: "Learning to operate GPS is easy for me".

Table 51. GPS measurements of reliability, convergent validity, and discriminant validity

Construct	CR	AVE	MSV
Facilitating conditions	.926	.808	.640
Perform expectancy	.957	.882	.458
Effort expectancy	.947	.818	.640
Social influence	.919	.795	.458

The findings suggest that there is an appropriate internal consistency of the items with the construct. Moreover, the validity results revealed that the indicators measuring the construct are in fact related and that the constructs might be unrelated to each other.

The structural model

The next phase involved the analysis of the structural model[40] looking at the path coefficients among PE, EE, and SI as independent variables and intention to use web-based GIS as a dependent variable. Additionally, the model was also tested for statistically significance the FC and intention to use as independent variables and the use of web-based GIS as the dependent variable.

The outcomes of the model fit indexes (χ^2 / df = 2.691; GFI= .920; NFI= .969; CFI = .980; RMSEA= .071) indicated an adequate fit of the data with the model, thus no further respecifications were needed. The parameters of the path coefficients and variances were calculated using the maximum likelihood method, and the results were

[40] The graphic representation of the structural model is shown in figure 5, page 62

represented as a diagram in figure 9. The next sections explain the outcomes for each path.

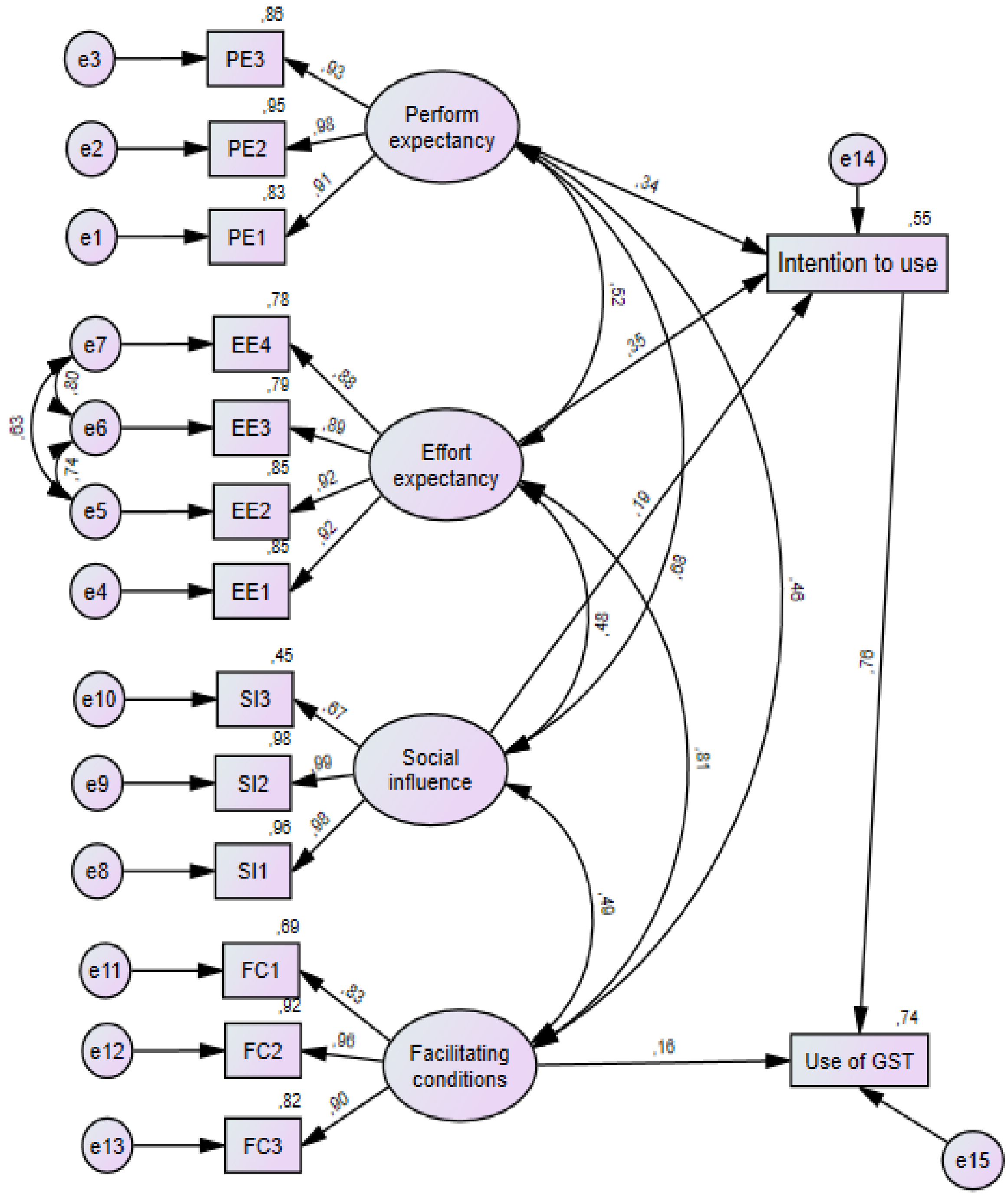

Figure 9. GPS structural model

The intention to use GPS for teaching geography

Table 52 presents the results of the multiple regression analysis. The research findings revealed that 55 percent of the variance in the faculty's intention to use GPS for teaching geography is driven mainly by PE and EE, followed by SI to a lesser extent.

Table 52. GPS: path coefficients towards intention to use

Path	B	SE	β	p-value
Perform expectancy ➔ Intention to use	.455	.074	.344	< .001
Effort expectancy ➔ Intention to use	.484	.066	.348	< .001
Social influence ➔ Intention to use	.205	.058	.187	.006

Faculty who identify the benefits of using this technology for teaching, report fewer problems mastering and learning about this GST, and have a better perception of the ideas of people who are influential to them about the use of GPS, were more likely to have intentions to use the technology. The construct's average values (table 53) contribute to having a better appreciation of the adoption patterns.

Table 53. Scores of independent and dependent variables in the GPS model

Construct	Mean	SD
Perform expectancy	3.65	1.16
Effort expectancy	3.8	1.01
Social influence	3.07	1.22
Facilitating conditions	3.5	1.18
Intention to use GPS	3.33	1.43
Use of GPS	2.89	1.42

In general terms, PE, EE, are not only predictors of the intention to use GPS, but most faculty members tend to agree on the pedagogical benefits and easiness of using the technology. In the case of SI, the participants tend to have a more balanced perspective of the peer's opinion of why they should use GPS for teaching geography. This information is framed in a context where most faculty members showed a slightly positive attitude towards the willingness to adopt this GST.

The use of GPS for teaching geography

The outcomes of the statistical analysis for the paths leading to the use of GPS are shown in table 54. In this case, 74 percent of the variance explained by the use of GPS is mainly driven by the intention to use this technology for teaching geography followed by the FC. The variance is similar to what Venkatesh et al. (2003) proposed for the UTAUT.

Table 54. Path coefficients towards the use of GPS for teaching geography

Path	B	SE	β	p-value
Intention to use ➔ Use of GPS	.756	.033	.763	< .001
Facilitating conditions ➔ Use of GPS	.206	.044	.161	< .001

The study confirms that faculty members with greater intention to use this GST for teaching geography as well as to report adequate organizational and administrative conditions for implementing the technology, were more likely to have a frequent use of remote sensing for teaching geography. These results are interesting in a context where

Latin American faculty do not use as regularly GPS for teaching geography (table 53), even though they report appropriate conditions for their implementation and a slightly positive intention to try including the GST in their courses.

The effect of the moderating variables

The next phase involved the analysis of the effect of moderating variables in the adoption and use of GPS for teaching geography. Using the same approach as the other GST, a multi-group invariance analysis was performed testing differences across groups, setting a p-value of .1 for statistical significance. The outcomes of the global moderating effects (table 55) showed that only gender and field of expertise have a general effect on the structural model paths.

Table 55. Results of the tests for the global effect of moderating variables for GPS

Moderating variable	**$\Delta\chi^2$ (df)**	**Invariant**
Gender	25.541 (14) ***	No
Academic degree	15.004 (14)	Yes
Decision to use	10.564 (14)	Yes
GST research	13.904 (14)	Yes
Work time	3.646 (14)	Yes
Type of software used	13.831 (14)	Yes
Professional category	10.824 (14)	Yes
Age*	26.104 (28)	Yes
Professional experience*	26 (28)	No
Field of expertise*	47.17 (28) **	No

* Multigroup analysis of three categories using the emulisrel6 correction, suggested by Byrne (2010).
** p-value < .01
*** p-value < .05

Since the field of expertise is comprised of three categories, it was necessary to perform a pairwise comparison of the global effect. Table 56 shows the outcomes of the multi-group invariance analysis.

Table 56. Global effect of the categories within specific fields of expertise in the GPS model

Field of expertise	**$\Delta\chi^2$ (df)**	**Invariant**
Human geography – Physical geography	35.65 (14) *	No
Human geography – Geospatial technologies	23.909 (14) *	No
Physical geography – Geospatial technologies	6.015 (14)	Yes

* p-value < .001

The findings show a statistically significant difference for human geographers when compared to physical geographers and GST faculty. With the purpose of confirming the presence of these effects—or other hidden—in each path, the next step consisted of checking the multi-group invariance using chi-square difference tests between an unconstrained model, and another model where each path is constrained one at the time. The findings are shown in the following sub-sections.

Perform expectancy

The outcomes of the multi-group invariance analysis indicated that none of the variables under analysis reported statistically significant differences across groups in the PE path. Contrary to Venkatesh et al. (2003) propositions, gender and experience did not have a moderating effect in the case of GPS.

Effort expectancy

The chi-square differences tests analysis revealed that none of the variables under analysis had a statistically significant moderating effect of the EE path. Although Venkatesh et al. (2003) indicated that gender and experience do have an effect on EE, the findings indicated that this is not the case for GPS.

Social influence

Table 57 represents the results of the multi-group invariance analysis. In this case, gender—as suggested by Venkatesh et al. (2003) and field of expertise had a statistically significant effect on SI.

Table 57. The moderating effects in the GPS social influence path

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Field of expertise	Human geography .286	Physical geography .005	4.442 (1) *
	Human geography .286	Geospatial technologies -.094	5.431 (1) *
Gender	Male .311	Female .052	5.008 (1) *

* p-value < .05

The research findings indicated that the intention to use GPS is driven by the faculty's opinion of the importance of other people's thoughts about the use of this GST.

This effect is stronger among male faculty, and those working in human geography related areas, compared to physical geography and GST colleagues.

Facilitating conditions

The outcomes of the multi-group invariance analysis also found—as in PE and EE—that none of the selected variables showed a statistically significant moderating effect on the FC. These results are contrary to Venkatesh et al. (2003) argument that age and experience moderate the effect on FC.

Intention to use

The chi-square difference tests show that only field of expertise had a statistically significant moderating effect on the intention to use path. In this case, the analysis indicated a difference between human and physical geographers ($\Delta\chi^2 = 6.377$, df = 1, p= .012) as well as human geography and GST faculty ($\Delta\chi^2 = 4.535$, df = 1, p= .033). The use of GPS is driven mainly by intention to use the technology for teaching geography, being this effect greater for human geographers (β =.747) than physical geographers (β =.736) and GST faculty ((β =.739).

A synthesized interpretation of the moderating variables

The findings for GPS are contrary to other technologies analyzed in the study since there is a limited role of the moderating variables across the model and the individual paths. Just the field of expertise and gender were accepted as having an effect on specific links in the model.

The study results revealed that faculty that perceived the benefits of using this GST for teaching geography and the easiness of use of GPS, were more likely to have intentions to use the technology, independently of any differences in the faculty's profile. The statistical analysis showed that male faculty who had a better perception of their peer's opinion about the use of the technology for teaching geography were likely to have more intentions to use the GST, as compared to female faculty. The same perspective was found for human geographers, as compared with physical geographers and GST colleagues.

On the other hand, the research also showed a limited moderating effect on the use of GST paths. Human geography faculty who had more intentions to use this technology were more likely to report a frequent use of GPS, as compared to physical geographers and GST faculty. Nonetheless, the results also showed that participants with perceive adequate organizational and administrative conditions for using the technology, a consistent finding across all faculty members, independently of their field of expertise or any other variable. In general terms, this is the only GST were the adoption process is relatively similar to all faculty members across the region.

Intraregional differences in the adoption and use of GPS

The analysis of regional differences in the structural model involved a multi-group invariance analysis. The results confirmed the existence of a global moderating effect of the variable region in the model ($\Delta\chi^2 = 51.596$, df = 28, p= .004)[41]. Table 58 displays the outcomes of the follow-up pairwise comparison, looking at the global effect for the three subregions. The research findings revealed a statistically significant moderating effect across the model for Brazilian faculty as compared to colleagues from other Latin American countries.

Table 58. Global effect of the categories within the variable region in the GPS model

Subregion	**$\Delta\chi^2$ (df)**	**Invariant**
Brazil – South America	29.348 (14) *	No
Brazil – Mexico, Central America and the Caribbean	23.988 (14) *	No
South America – Central America and the Caribbean	18.047 (14)	Yes

* p-value < .05

The next step involved the analysis of moderating effects but at the individual path level. Table 59 shows the outcomes of the multi-group invariance tests, specifically, for those paths reporting a statistically significant difference across groups.

[41] Multigroup analysis with three groups using the emulisrel6 correction, as referred by Byrne (2010).

Table 59. Results of the multi-group invariance analysis for the pairwise comparison of categories within the variable region for GPS

Path	Category (β)		$\Delta\chi^2$ (df)
Perform expectancy ➔ Intention to use	Brazil .268	Mexico, Central America, and the Caribbean .669	7.602 (1) *
	South America .268	Mexico, Central America, and the Caribbean .621	4.831 (1) *
Facilitating conditions ➔ use of GPS	Brazil .143	South America .326	7.391 (1) *
	South America .326	Mexico, Central America, and the Caribbean .171	4.429 (1) *

* p-value < .05

The study indicates that the intention to use GPS is predicted by PE, being the effect stronger for Mexico, Central America, and the Caribbean faculty. In this way, faculty from this subregion who identified the pedagogical benefits from teaching geography with this GST, were more likely to have intentions to use the technology, as compared to colleagues from other countries across Latin America.

The use of GPS is also driven by FC, although the effect is greater for South American faculty, meaning that is was more possible for them identify adequate administrative and organizational conditions for implementing GPS, when they have a higher use of this GST for teaching geography, as compared to the rest of faculty member form Latin America.

XI. DIGITAL GLOBES

The digital globes are the last technology subject to the analysis of the adoption of GST for teaching geography faculty at Latin American universities. This chapter addresses the outcomes of the SEM, starting with the measurement model following the findings on the structural model. The second section explored the global and individual paths, looking at the moderating effect of several variables in the faculty's adoption and use of digital globes. The chapter concludes with an explanation of intra-regional variations within Latin America, in an attempt to represent the diversity of adoption patterns across the region for this GST.

The measurement model

A CFA analysis was performed looking at the association of indicators with the PE, EE, SI, and FC factors. This procedure was conducted after confirming that the digital globes database did not have any issues related to multivariate normality and multicollinearity. In order to identify the efficiency by which the indicators measure the factors, a set of model indexes were calculated for the model (table 60). The cut-off values for the model indexes were not met, requiring further respecification by checking factor loadings and modification indexes.

Table 60. Digital globes CFA: model fit indexes

Factor model	χ^2	χ^2 / df	GFI	NFI	CFI	RMSEA	AIC	BCC	ECVI
Original	640.806	5.539	.800	.843	.889	.128	720.806	720.856	2.133
Respecified	155.697	2.780	.932	.964	.977	.073	225.697	228.741	.672

The model was respecified by 1) deleting the path from item "PE4[42]" to perform expectancy, since obtaining a raise in their jobs is not perceived as a benefit from using remote sensing for teaching geography; 2) erasing the path from item "SI4[43]" to social influence, as the geography department as an entity is not seen as influential in the decision of using remote sensing; 3) eliminating the path from "FC4[44] to facilitating conditions, as other items subsume the existence of—human—resources for implementing remote sensing in teaching geography; 4) A Correlation between items "EE2[45]", "EE3[46]", and "EE4[47]" was added in that faculty who consider that remote sensing is easy to learn may in part also use the technology without any problems, finding it easy to use.

The model fit of the data was better after model respecification[48], as model indexes (check table 60) reached an acceptable value. In addition, the comparative indexes AIC, BCC, and ECVI were found to be lower than in the original factor model,

[42] PE4 items stands for: "If I use digital globes, I will increase my chances of getting a raise".
[43] SI4 stands for: "In general, the school or department has supported the use of digital globes".
[44] FC4 stands for: "A specific person (or group) is available for assistance with digital globes difficulties".
[45] EE2 stands for: "It would be easy for me to become skillful at using digital globes".
[46] EE3 stands for: "I would find digital globes easy to use".
[47] EE4 stands for: "Learning to operate digital globes is easy for me".
[48] The respecified model graphic representation is the same as figure 4 in page 60.

confirming the good fit of data. The reliability, convergent, and discriminant validity analysis (table 61) also showed positive values for the model.

Table 61. Digital globes measurements of reliability, convergent validity, and discriminant validity

Construct	CR	AVE	MSV
Facilitating conditions	.940	.840	.643
Perform expectancy	.957	.880	.417
Effort expectancy	.979	.921	.643
Social influence	.934	.829	.343

The results confirmed that there is an internal consistency of the items with the constructs. Moreover, the items measuring each construct are related to each other, while the factors might be unrelated. These findings allowed to move into the next phase of the analysis.

The structural model

The structural model evaluated the path coefficients of PE, EE, SI as independent variables and intention to use as a dependent variable. In addition, the model checked the paths from FC and intention to use towards the use of digital globes[49].

The outcomes of the model indexes (χ^2 / df = 2.987; GFI= .917; NFI= .969; CFI = .972; RMSEA= .077) indicate an adequate fit of data with the model, meaning that no further respecifications were needed. The maximum likelihood method was used for

[49] The graphic representation of the model is shown in figure 5, page 62

calculating each of the path coefficients and variances in the model. The results of the statistical analysis are presented in figure 10 as a diagram. The following sub-sections analyze with the detail the findings from the model.

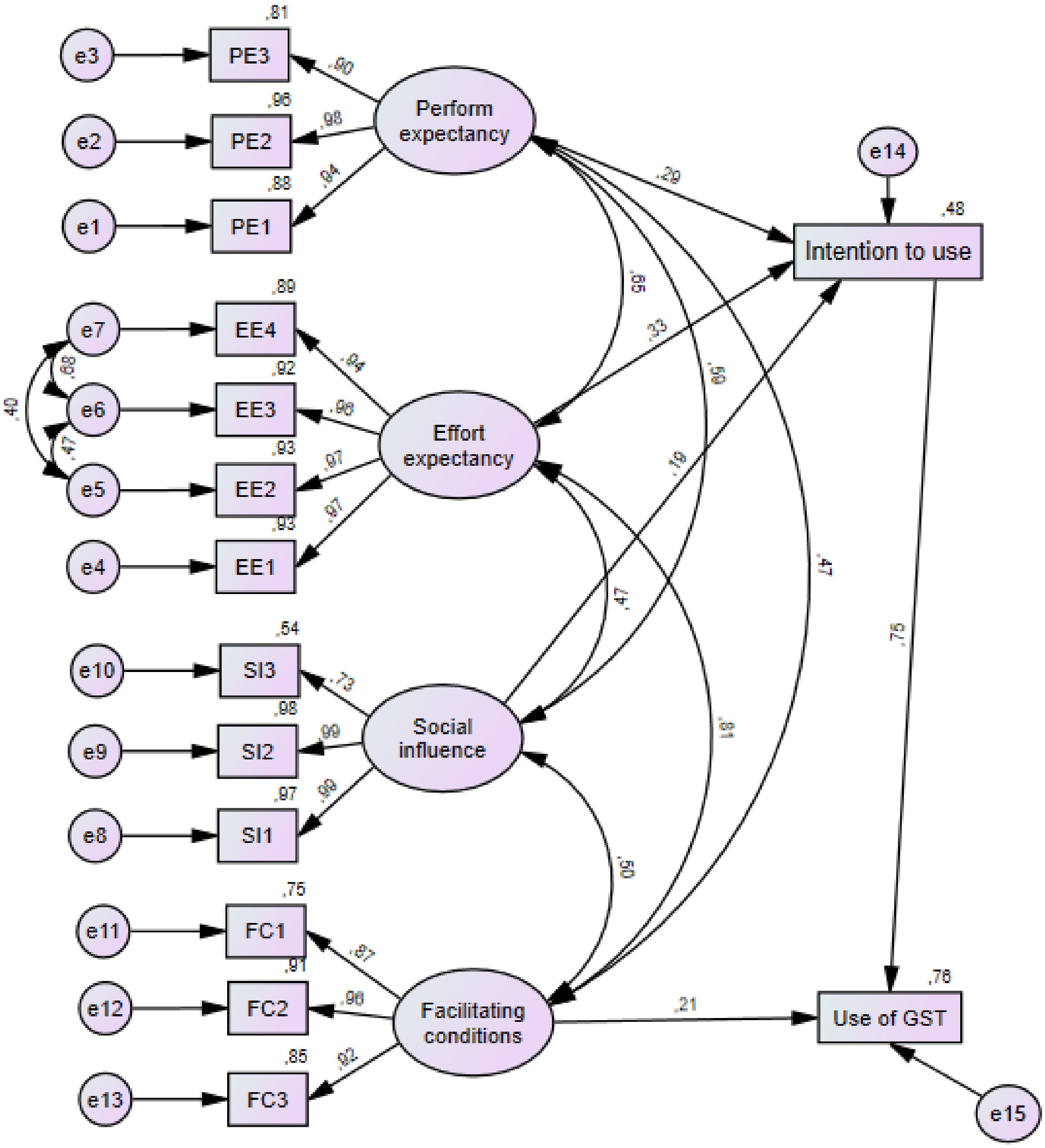

Figure 10. Digital globes structural model

The intention to use digital globes for teaching geography

The multiple regression results of the structural model (table 62) confirmed the hypothesis of the first research question, since 48 percent of the variance in intention to use digital globes is driven mainly by EE, followed by the PE, and SI.

Table. 62. Digital globes: path coefficients towards intention to use

Path	B	SE	β	p-value
Perform expectancy ➔ Intention to use	.445	.092	.291	< .001
Effort expectancy ➔ Intention to use	.450	.075	.327	< .001
Social influence ➔ Intention to use	.203	.053	.193	< .001

Another interpretation of this outcome is that faculty who perceive this GST as easier to learn and use and think that there is a pedagogical benefit of using the technology in their classroom, were more likely to have greater intentions to use GPS in the classroom. Furthermore, these faculty members also perceive as positive the opinion of people who are influential to them regarding the implementation of digital globes as part of the teaching strategies.

The average scores for the variables in the model (table 63) provide an additional context for understanding the results. Besides being EE and PE the strongest predictors of intention to use digital globes, the research findings also suggest that most of the faculty members tend to have a strongly positive perception of the benefits of including this GST as part of the teaching strategies. Furthermore, they reported lower difficulties when learning and using digital globes. On the other hand, the score for SI suggests neither a positive nor negative perception about the opinion of people for faculty members related to the relevance of using this GST for teaching purposes.

Table 63. Scores of independent and dependent variables in the digital globes model

Construct	Mean	SD
Perform expectancy	4.13	.99
Effort expectancy	4.02	1.01
Social influence	3.11	1.26
Facilitating conditions	3.73	1.19
Intention to use digital globes	3.77	1.38
Use of digital globes	3.40	1.47

The use of digital globes for teaching geography

The multiple regression analysis for the use of digital globes is presented in table 64. The research findings revealed that 76 percent of the variance accounted for the use of GST is driven mainly by the intention to use the GST for teaching geography, followed by the FC to a lesser extent. The variance outcomes are even higher than what has been projected by Venkatesh et al. (2003) for the UTAUT, confirming the efficacy of the model to predict user behavior for digital globes. Faculty who use more digital globes are more likely to have greater intentions to use them for teaching geography, and to report adequate administrative and organizational conditions for implementing the technology.

Table 64. Path coefficients towards the use of digital globes for teaching geography

Path	B	SE	β	p-value
Intention to use ➔ Use of digital globes	.784	.033	.748	< .001
Facilitating conditions ➔ Use of digital globes	.260	.041	.209	< .001

Besides being FC and intention to use predictors of the use of digital globes, the average scores of these variables (Table 63) showed that most of the Latin American faculty have a positive perception about the resources and conditions for using the technology, and more intentions to use the digital globes. These results are also framed in a context in which the majority of participants reported a positive level of use of the GST for teaching geography in the region.

The effect of the moderating variables

The multi-group invariance analysis shows the moderating effect of the variables for the structural model. The cut-off value for significance was set as .1 for the chi-square difference tests, as in the previous technologies. Table 65 displays the outcomes of the global analysis of the moderating effect among all paths of the observed and latent factors. The findings confirm that four variables do have a general effect across the model: academic degree, worktime, age, and field of expertise.

Table 65. Results of the tests for the global effect of moderating variables for digital globes model

Moderating variable	$\Delta\chi^2$ (df)	Invariant
Gender	21.028 (14)	Yes
Academic degree	29.931 (14) ***	No
Decision to use	14.245 (14)	Yes
GST research	10.507 (14)	Yes
Work time	25.321 (14) ***	No
Type of software used	12.538 (14)	Yes
Professional category	17.198 (14)	Yes
Age*	44.576 (28) ***	No
Professional experience*	19.806 (28)	Yes
Field of expertise*	68.295 (28) **	No

* Multigroup analysis of three categories using the emulisrel6 correction, suggested by Byrne (2010).
** p-value < .01
*** p-value < .05

Additional tests were performed for follow-up analysis of the moderating effect of the field of expertise and age, looking at the pairwise comparison of the three categories within each variable. Table 66 shows the outcomes of the chi-square difference tests.

Table 66. Global effect of the categories within specific fields of expertise and age in the digital globes model

Field of expertise	$\Delta\chi^2$ (df)	Invariant
Human geography – Physical geography	24.086 (14) **	No
Human geography – Geospatial technologies	49.476 (14) *	No
Physical geography – Geospatial technologies	26.241 (14) *	No
Age	**$\Delta\chi^2$ (df)**	**Invariant**
Young faculty – Middle-aged faculty	19.806 (14)	Yes
Young faculty – Senior-faculty	21.221 (14) ***	No
Middle-aged faculty – Senior faculty	25.506 (14) **	No

* p-value < .001; ** p-value < .05; *** p-value < .1

There is a global moderating effect for all categories within the field of expertise, while it is significant in the age variable only for senior faculty, as compared to young and middle-aged colleagues. The next step involved testing, as suggested by Chin et al. (2012), differences across individual paths, confirming the global results or finding new possible moderating effects for other variables that were no statistically significant in the general model. Chi-square difference tests were performed between an unconstrained model and another model were each path is constrained, one at the time. The outcomes are described in the following sub-sections.

Perform expectancy

Table 67 shows the outcomes of the multi-group invariance analysis. Field of expertise, age, gender, type of software used, and gender have a moderating effect on this path. The findings confirmed Venkatesh et al. (2003) argument of age and experience as controlling PE. However, the results are different for the latter variable, as PE did not necessarily increase with higher experience.

Table 67. The moderating effects in the digital globes perform expectancy path

Moderating variable	**Category (β)**		**$\Delta\chi^2$ (df)**
Field of expertise	Human geography .286	Geospatial technologies .609	5.314 (1) *
	Physical geography .121	Geospatial technologies .609	8.763 (1) *
Gender	Male .463	Female .118	6.192 (1) *

Table 67 continued

Type of software used	Licensed .080	Open-sourced .393	4.716 (1) *
Work time	Full-time .261	Partial time .581	6.559 (1) *
Professional experience	Moderate .447	High .062	3.338 (1) **
Age	Young faculty .286	Senior faculty -.035	4.910 (1) *
	Middle-aged faculty .327	Senior faculty -.035	3.448 (1) **

* p-value < .05; p-value < .1

The intention to use digital globes for teaching geography is driven by faculty's identification of the benefits of using digital globes in a pedagogical sense, being this effect stronger among GST faculty and males. Furthermore, the moderating is greater in young and middle-aged faculty—when compared to senior faculty—, for those working part-time, with a moderate level of teaching experience, and using mostly open-sourced digital globes software.

Effort expectancy

The statistical analysis for the EE path indicated that only field of expertise ($\Delta\chi2 = 2.818$, df = 1, p =.048) and gender ($\Delta\chi2 = 12.160$, df = 1, p =.093) were reported as having a moderating effect on EE. The intention to use is mainly driven by the faculty's opinion that digital globes are relatively easy to use and learn. This effect is stronger among physical geography faculty (β =.522) as compared to human geographers (β= .265) and among female (β=.431) than male faculty (β=.201). The results aligned with

Venkatesh et al. (2003) proposition of gender as a moderator, but not in the case of professional experience.

Social influence

The analysis of the path showed that only field of expertise ($\Delta\chi2 = 3.526$, df = 1, p =.041) and professional experience ($\Delta\chi2 = 4.163$, df = 1, p =.060) had a moderating effect on SI. The intention to use digital globes is driven by the faculty's positive perception of the ideas that people who are influential to them have about the use of technology for teaching purposes. This effect is stronger for faculty working in human geography (β=. 206) as compared to GST (β= -.059) and those with a higher level of teaching experience (β=.314) as compared only to moderate experience faculty (β=.064). None of the variables that Venkatesh et al. (2003) indicated having an effect in SI were found to be statistically significant in this analysis.

Facilitating conditions

Table 68 represents the outcomes of the multi-group invariance tests. Field of expertise, gender, age, and professional experience have a moderating effect on the FC path. The use of digital globes for teaching geography is driven in part by the faculty's recognition of acceptable administrative and organizational conditions for implementing the GST in the classroom. This effect is greater for middle-aged faculty and females. Furthermore, the effect of FC is stronger for faculty with a moderate level of experience, as compared to low-experience faculty and those working in human geography, compared to physical geographers.

Table 68. The moderating effects in the digital globes facilitating conditions path

Moderating variable	**Category (β)**		**Δχ² (df)**
Age	Young faculty .083	Middle-aged faculty .296	14.218 (1) **
	Middle-aged faculty .296	Senior faculty .194	7.397 (1) *
Gender	Male .122	Female .311	4.671 (1) **
Professional experience	Low .125	Moderate .298	3.010 (1) ***
Field of expertise	Human geography .772	Physical geography .326	3.071 (1) **

* p-value < .001; ** p-value < .05; *** p-value < .1

Intention to use digital globes

Table 69 shows the outcomes of the statistical analysis for this path, in which four variables have a statistically significant moderating effect: field of expertise, age, gender, and professional experience.

Table 69. The moderating effects in the digital globes intention to use path

Moderating variable	**Category (β)**		**Δχ² (df)**
Professional experience	Low .833	Moderate .595	2.928 (1) **
Gender	Male .812	Female .670	6.081 (1) *

Table 69 continued

Field of expertise	Human geography .718	Physical geography .793	5.251 (1) *
	Human geography .718	Geospatial technologies .796	9.537 (1) *
Age	Young faculty .827	Middle-aged faculty .593	10.558 (1) *
	Young faculty .827	Senior faculty .769	7.042 (1) *

* p-value < .001; ** p-value < .05

The use of digital globes is mainly driven by the faculty's intention to use the technology for teaching geography. This effect is stronger among those working GST and physical geography as well as male faculty, young respondents and those who have a low level of experience (as compared to moderately experienced faculty).

A synthesized interpretation of the moderating variables

The results of the statistical analysis for the path coefficients showed the existence of six variables reporting a moderating effect. It is relevant to notice that the field of expertise had a global effect but also all individual paths show differences across groups for this variable. The professional experience, gender, and age were also reported as being moderators in some paths, followed by type of software used and work time who had a more limited effect.

The GST faculty that identified the pedagogical benefits of using the technology for teaching geography were likely to have more intentions to use digital globes, as compared to human and physical geographers. Furthermore, physical geographers with indicating a relatively easy use of technology were likely to have greater intentions to use digital globes when compared to human geographers, however, no statistical significance was reported related to GST faculty.

On the other hand, human geographers with a better perspective about the opinion of other people who are influential to them about the use of digital globes for teaching geography, were more likely to have greater intentions to use the technology, as compared to GST faculty. This finding might suggest the effect that peer pressure is having on human geography faculty for introducing the technology as part of their pedagogical practices, which is not the same as GST faculty. No statistically significant differences were found for physical geographers.

The multi-group invariance analysis also pointed out that human geographers who report better organizational and administrative conditions for teaching geography with the technology were more likely to have a more frequent use of digital globes, as compared to physical geographers. No statistically significant differences were found with GST faculty. On the other hand, human geography faculty were less likely to have intentions to use digital globes, as compared to physical geographers and GST faculty, who instead reported more intentions to do so.

The analysis of gender as a moderator in the UTAUT model suggest that male faculty that were prone to identify the pedagogical benefits of using this technology for teaching geography, were likely to have more intentions to use digital globes. However, they were less likely to consider the technology easy to use and learn, as compared to female colleagues, who reported an opposite perspective on PE and EE. Furthermore, the female faculty that consider having adequate administrative and organizational resources for teaching geography were more likely to have a frequent use of digital globes in the classroom. Nonetheless, this groups also exhibited a lower intention to use the GST as a predictor of the use of digital globes, as compared to their male colleagues.

The results about age differences in the model suggest that young and middle-aged faculty with better intentions to use digital globes were more likely to have a positive perception of the pedagogical benefits of teaching geography with this GST, as compared to senior faculty. In this case, the study suggests more interesting of younger scholars for using the technology in the classroom.

The research findings also revealed that young faculty who reported greater intentions to use the technology, were more likely to have a more frequent use of digital globes in the classroom, as compared to middle-aged and senior colleagues, confirming the enthusiasm of younger faculty with this GST. However, it is the middle-aged faculty who are more prone to report adequate organizational and administrative conditions for implementing the technology, compared to young and senior colleagues.

The analysis of professional experience that moderately experienced faculty who report the benefits using the technology for teaching purposes, were more likely to have intentions to use digital globes in the classroom. However, they were less likely to have a positive view of the ideas from people important to them about digital globes influence their intention to use the GST, when compared with high-experienced faculty, who indeed were more prone to experience the peer pressure effect for using the technology, as a predictor of intention to use. Furthermore, low experienced faculty who indicated more intentions to use the technology were likely to have a frequent use of GPS, however, they were also less prone to report good administrative and organizational conditions, as compared to moderate experience faculty.

The type of software used, and work time had a moderating effect only for the PE path. In this case, faculty using more open-sourced software that perceive the benefits of using digital globes for teaching geography, were likely to have more intentions to use the technology, compared to faculty who used mostly licensed products. A possible explanation is the prevalence of open-sourced digital globes software, free and easy to install in different devices. In addition, it would be worthy of exploring in further research the fact that faculty working partial time having more intentions to use the technology were more likely to report more performance expectations of the technology for teaching geography, as compared to full-time faculty.

Intraregional differences in the adoption and use of digital globes

The last part of the analysis explored possible variations of the UTAUT model for different subregions in Latin America. For this purpose, a multi-group invariance analysis was performed, establishing a p-value .1 for reaching statistical significance. The result of the chi-square difference test ($\Delta\chi 2 = 47.686$, $df = 28$, $p =.006$) indicates that there is a global effect of the variable region across the paths in the model.

A follow-up pairwise comparison was performed for the three categories within the variable region. The results of the chi-square difference tests are shown in table 70, being possible to identify a global effect for the South American faculty, compared to the rest of colleagues across Latin America.

Table 70. Global effect of the categories within the variable region for digital globes

Subregion	$\Delta\chi^2$ (df)	Invariant
Brazil – South America	28.568 (14) *	No
Brazil – Mexico, Central America and the Caribbean	19.561 (14)	No
South America – Mexico, Central America, and the Caribbean	22.452 (14) *	Yes

* p-value < .05

The next step looked into the statistically significant moderator effect of these categories for each specific coefficient path in the model. Thus, multiple chi-square difference tests were performed between an unconstrained model and another where each path is set to be constrained, one at the time. Table 71 shows moderating effects on PE, FC, and intention to use paths.

Table 71. Results of the multi-group invariance analysis for the pairwise comparison of categories within the variable region for digital globes

Path	Category (β)		$\Delta\chi^2$ (df)
Perform expectancy ➔ Intention to use	Brazil .232	South America .546	5.713 (1) *
Facilitating conditions ➔ use of digital globes	Brazil .232	Mexico, Central America, and the Caribbean .004	3.963 (1) *
	South America .300	Mexico, Central America, and the Caribbean .004	6.358 (1) *
Intention to use ➔ use of digital globes	Brazil .730	Mexico, Central America, and the Caribbean .905	2.758 (1) **
	South America .660	Mexico, Central America, and the Caribbean .905	3.419 (1) **

* p-value < .05; ** p-value < .1

The results confirmed that South American faculty who had a more positive perspective about the value of including this GST as part of the teaching practices, were more likely to have greater intentions to use digital globes in the classroom, compared to Brazilian faculty, but not to Mexico, Central America, and the Caribbean colleagues.

On the other hand, the research findings revealed that Mexico, Central America, and the Caribbean faculty reporting adequate administrative and infrastructure conditions along with greater intentions to use the GST for teaching geography, were more likely to have a frequent use of the digital globes in the classroom, as compared to their colleagues from other Latin American countries.

XII. CONCLUSIONS

The study identified the existence of adoption trends shared for the five GST by Latin America geography faculty. At the same time, the research findings suggest variations on the level of adoption when considering the differences in the faculty's profile. This final chapter offers an integrative view of these trends, with the purpose of obtaining an integrated perspective about the GST adoption in the region.

The research revealed a relatively low use of GST by faculty members, which contrasts with the positive intention to introduce them as part of the teaching practices (table 72). In a context where GST has become an important component of geographic learning, and a requirement for professionals looking for jobs[50], it is to a certain extent worrisome that faculty members do not frequent the use of GST for teaching geography in Latin America.

Table 72. Summary of intention to use and use of GST by Latin American faculty

Technology	Intention to use	Use of GST
Desktop GIS	3.6	3.02
Web-based GIS	3.41	2.75
Remote sensing	3.02	2.62
GPS	3.33	2.89
Digital globes	3.77	3.40

[50] For a more detailed argument, check the introduction on page 1

Although no comparative data exist for other world regions across the Planet, the research findings suggest the need for increasing the adoption rate of GST by faculty members, with the purpose of transforming the way students learn geography.

In this way, the understanding of the factors explaining why faculty members tend to have more intentions and use of the GST, represent a powerful and valuable knowledge. The results could be interpreted as a framework for geography departments and universities who are interested in developing strategies for increasing GST adoption for teaching geography.

A shared perspective on the intention to use GST

The research findings suggest that Venkatesh et al. (2003) UTAUT is an efficient model for understanding the adoption of GST. In each of the technologies, the proportion of variance accounted by the intention to use a GST had a medium effect size, being this effect stronger for remote sensing, followed by desktop GIS, web-based GIS, GPS, and digital globes.

There is a trend in the UTAUT model across all technologies. The PE, EE, and SI are predictors of faculty's intention to use GST—with the exception of SI for desktop GIS—, meaning that the faculty is be more willing to adopt a technology when they foresee that the GST will help them to teach geography in a better way, when the technology is easy to use, and when people who are influential to them believe the use of the GST is important.

The PE was the strongest predictor for desktop GIS and remote sensing, but it was also an important predictor for the other three technologies. These findings suggest the importance that some faculty members have placed on the role of technology as part of their teaching practices. The faculty had more interest in adopting the GST when they recognize the relevance of using the technology for improving student's learning. Thus, geography departments might think in technological-pedagogical training as a way to increase the potential adoption of GST by faculty members.

The EE was the greatest predictor of intention to use in web-based GIS, GPS, and digital globes, but it was also relevant for desktop GIS and remote sensing. These results indicate the importance for faculty of having a solid GST preparation, as a way to enhance their use as part of their teaching practices. It would be important for geography departments who want to increase faculty's adoption rates, to think in training programs that will increase the knowledge and skills of specific GST, as a way to facilitate their inclusion in the classroom. The intention of using a GST would be limited in Latin American if no GST preparation is required or given to their faculty.

The SI was a statistically significant predictor of intentions to use for all GST, with the exception of desktop GIS. Faculty with greater intentions to use the other four technologies were also more likely to appreciate what people who matter to them believe about the importance of using GST. These outcomes point out that peer pressure is a significant factor in the faculty's attitudes towards including technology in their teaching practices. Geography departments that would like to improve interest in adopting a technology should consider the influence that faculty members might have on each other. The creation of an environment where colleagues have a positive attitude towards technology can spark the potential implementation of GST in the classroom in Latin America.

A shared perspective on the use of GST for teaching geography

The second research question asked to what extent intention to use and FC can explain the faculty's use of GST for teaching geography. The research findings confirmed that the use of these technologies is driven by the intention to use and FC. This means that the faculty's implementation of GST in the classroom increases when the geography departments have adequate administrative and organizational conditions, but mostly when faculty members are motivated to use the technology.

The UTAUT model has been efficient to describe this process, as the amount of variance explained by the use of all GST had a large effect size, being greater for remote sensing, then followed by digital globes, GPS, desktop GIS, and web-based GIS. There is a clear trend for understanding the use of GST. Faculty members with frequent use of any GST were more likely to perceive acceptable administrative and organizational resources to implement them in the classroom. These research findings point out the relevance that faculty placed on the infrastructure as a requirement for teaching geography in higher education. Thus, departments who might want to increase the faculty's use of these technologies should consider in reviewing and enhancing resources available, with the purpose of satisfying the faculty's needs for including the GST as part of their courses.

At last, faculty members who use GST frequently were likely to report more intentions to use them for teaching geography. The research findings confirmed that having motivated faculty is fundamental for increasing student's opportunities for learning geography by using technology. Thus, the awareness of the pedagogical benefits of using GST for teaching, the development of strategies to strengthen the knowledge and skills of faculty members, and the creation of a positive environment where colleagues have a positive attitude towards technologies become relevant for increasing the adoption of the GST. In this way, Latin American geography departments can have a clear notion of what does motivate faculty to use GST, but also to recognize the route for increasing their use in the classroom, especially among colleagues who are more reluctant to do so.

The results provide valuable information for considering programs for faculty in geography departments. In fact, future areas of research can be developed based from the results of this study. First, the findings on the factors that explain intention to use and use of each GST can be used as a base for developing faculty professional development programs, taking into account the importance of the pedagogical, technological, and pedagogical-technological knowledge, as part of the training process, since it would probably increase the further adoption and implementation of the GST in the classroom. Small scale research can also provide valuable insights on how the large-scale results of this study work in specific teaching environments in higher education, along with the role of the faculty's profile.

At last, the research can provide future researchers guidelines for thinking on strategies and possibilities for including new emerging technologies into the context of higher education geography. The study suggested that the adoption of a technology is driven by several factors. Therefore, when other technologies are thought to be included in geography departments (e.gs., drones, GPS enable devices, virtual reality, augmented reality, etc.), they should complemented with the social, pedagogical, and technical perspectives that are important to improve the success in the implementation for teaching purposes.

The role of moderating variables among GST

The research showed the statistically significant effect that PE, EE, and SI have in the intention to use GST—except SI for desktop GIS—and intention to use and FC in the use of behavior. Nonetheless, the analysis of the moderating variables showed that these effects are not the same across all faculty members. This means that when looking at their profile, it is important to place attention on what kind of faculty member exhibited greater adoption patterns. The research emphasizes that there is not a unique explanation for understanding the role of each variable in the UTAUT models.

The field of expertise was the variable having the most visible moderating effect across all technologies, but not on all the paths. There was not a consistent stronger effect for GST, physical geography, or human geography faculty in the adoption and use patterns across all the technologies. Instead, what the research findings suggest is that some specialists would show greater PE, EE, SI, FC, or intentions to use depending on the technology under analysis.

For instance, GST faculty with more frequent use of web-based and remote sensing, and digital globes were more likely to have more intentions to use the technology, as compared to human geographers. However, this effect is the opposite of GPS, while it was no statistically significant for desktop GIS. Another example is that the physical geographers using remote sensing, GPS, and digital globes were more likely to have more intentions to use the technologies, as compared to human geographers, but not in the case of web-based GIS.

Human geographers were less prone to have intentions to use these technologies, with the exception of GPS, which indicates the diversity of adoption and use of technologies by faculty members. These examples reflect the fact that differences in the adoption of GST vary according to the faculty profile, being not possible to classify all faculty in a unique pattern.

Another variable that had a clear moderating effect in several GST was the professional experience—differences across groups were detected in 9 paths—. However, it had a moderating effect only in desktop GIS, web-based GIS, and digital globes, but not in the same paths across these technologies. This is another example of why it is not possible to represent a unique perspective of professional experience for all GST, each of them should be treated separately, as it was presented in the past chapters. A similar perspective occurs with age, who had a moderating effect in seven different paths in desktop GIS, web-based GIS, and digital globes, but no presence on GPS, and a limited role in remote sensing.

Besides these three variables, most of the moderating effects of other variables—gender, decision to use, professional category, type of software used, work time, and academic degree—were limited to one or two technologies and to a specific path. The interpretation of their effect should be limited to the context of each GST, as they do not offer an overall view to explain the adoption and use patterns of all technologies as a whole.

In this way, the third research question addressing the role of moderating effects on the model might be answered by stating that the effects are specific to each technology, explained in previous chapters, being the field of expertise the only variable that had an effect in all the technologies. Thus, not all the moderating variables have a moderating effect. Furthermore, not all of them contribute to explain differences in the paths. Only a small group of variables represented most of the differences existing among Latin American faculty about the adoption of GST, being the field of expertise the most relevant of all of them.

Subregional variations of GST in Latin America

Since the variable region was treated as another moderator variable in the UTAUT model, it is possible to say that along with the field of expertise, it was the variable explaining more differences in the adoption of GST among faculty in Latin America. There were statistically significant effects across all GST, but not necessarily on all paths. The results should be interpreted with caution, as subregional differences exist for each GST and paths.

In the case of the PE path, Mexico. Central America, and the Caribbean faculty who had more intentions to use remote sensing, web-based GIS, and GPS were likely to identify the pedagogical benefits of using such technologies for teaching geography, as compared to colleagues in the rest of the Region. South American faculty were also more prone to identify positive PE but compared to Brazilian faculty for the case of desktop

GIS and digital globes. In general terms, Brazilians were less likely to have reported a better PE when thinking about using these technologies.

There was a regional moderating effect on EE for desktop GIS, but for other technologies. The effect was greater for South American faculty, compared to the rest of colleagues in the region. On the other hand, the variable also had a moderating effect on SI only for web-based GIS and remote sensing. The research revealed that Mexico, Central America, and the Caribbean faculty have a negative perception of other people who are influential to them regarding the importance of suing such GST in the classroom, as compared to colleagues from other countries of Latin America.

In general terms, faculty members from South America tend to report better FC when using remote sensing, GPS and digital globes, being this a similar case for Brazilian faculty when using remote sensing and digital globes as well. In this case, the FC effect on the use of GST was weaker for Mexico, Central America, and the Caribbean faculty.

At last, the research findings suggest differences across technologies and subregions when looking at the intention to use GST. The findings suggest that Mexico, Central America, and the Caribbean faculty who use digital globes and desktop GIS were more likely to have more intentions to include them as part of their teaching practices, compared to the rest of Latin American countries. However, this result is the opposite when talking about remote sensing, whereas there is not statistically significant for web-based GIS and GPS.

APPENDIX SECTION

Appendix 1

Number of faculty by university and country

Country	University name	Number of faculty
Argentina	Universidad Nacional del Nordeste	39
	Universidad Nacional del Sur	33
	Universidad de Buenos Aires	30
	Universidad Nacional del Centro de la Provincia de Buenos Aires	26
	Universidad Nacional de La Plata	24
	Universidad Nacional de Mar de Plata	17
	Universidad Nacional de Cuyo	15
	Universidad Nacional de la Pampa	13
	Universidad Nacional del Litoral	4
	Universidad Nacional de la Patagonia Austral	3
	Universidad El Salvador	2
Bolivia	Universidad Mayor de San Andrés	12
Brazil	Universidade Federal de Goiás	66
	Universidade Estadual "Júlio de Mesquita Filho"	66
	Universidade Estadual de Goais	64
	Universidade de São Paulo	58
	Universidade Federal Fluminense	48
	Universidade Federal do Rio Grande do Sul	46
	Universidade Federal da Paraná	46
	Universidade Federal de Sergipe	44
	Universidade Estadual do Oeste do Paraná	40

	Universidade Federal Matto Grosso do Sul	41
	Universidade Federal do Rio Grande do Norte	41
	Universidad do Estado do Amazonas	39
	Universidade Federal de Minas Gerais	39
	Universidade Federal do Rio de Janeiro	38
	Universidade Estadual do Centro-Oeste	37
	Universidade Estadual de Londrina	35
	Universidade do Estado da Bahia	32
	Universidade Estadual de Maringá	32
	Universidade Estadual de Feira de Santana	31
	Universidade Estadual de Ponta Grossa	30
	Universidade do Estado do Rio Grande do Norte	29
	Universidade Estadual de Ceará	28
	Universidade Federal de Pernambuco	28
	Universidade Federal da Bahia	27
	Universidade Federal Rural do Rio de Janeiro	27
	Pontifícia Universidade Católica do Rio de Janeiro	26
	Universidade Estadual Do Sudoeste da Bahia	26
	Universidade Federal de Santa Catarina	26
	Universidade Federal de Alagoas	25
	Universidade Federal de Uberlândia	24
	Universidade de Brasília	24
	Universidade Estadual do Norte do Paraná	23
	Universidade Federal do Espiritu Santo	23
	Universidade Federal Do Pará	23
	Universidade Estadual de Campinas	23
	Universidade Estadual Vale Do Acaraú	22

	Universidade Federal de Grande Dourados	22
	Universidade Federal do Ceará	21
	Universidade Federal Juiz de Fora	21
	Universidade Federal de Santa Maria	20
	Universidade Federal do Maranhão	20
	Universidade Federal da Fronteira Sul	20
	Universidade Federal do Amazonas	19
	Universidade Federal do Rio Grande	19
	Universidade Estadual do Maranhão	18
	Universidade Federal de Roraima	17
	Universidade Federal de Rondônia	16
	Universidade Regional do Cariri	16
	Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte	16
	Universidad Federal do Piauí	15
	Pontifícia Universidade Católica de Minas Gerais	15
	Universidade do Estado de Santa Catarina	15
	Universidade do Estado do Rio de Janeiro	15
	Universidade do Estado do Mato Grosso	14
	Universidade Estadual de Alagoas	14
	Universidade Federal do Tocantins	14
	Faculdade de Ciências Humanas e Sociais	13
	Universidade Federal do Oeste da Bahia	13
	Universidade Federal do Triângulo Mineiro	12
	Universidade Federal Dos Vales do Jequitinhonha e Mucuri	12
	Universidade Estadual de Santa Cruz	12
	Universidade Federal da Integração Latino-Americana	11
	Universidade Federal da Paraíba	11

	Universidade Federal do Sul E Sudeste do Pará	11
	Instituto Federal de Educação, Ciência e Tecnologia da Bahia	10
	Universidade Estadual da Paraiba	10
	Universidade Federal de Viçosa	10
	Universidade Estadual do Parana	9
	Universidade Federal do Vale do São Francisco	9
	Universidade Federal de Alfenas	8
	Universidade Federal do Acre	8
	Universidade Estadual de Roraima	8
	Instituto Federal de Educação, Ciência e Tecnologia do Pará	8
	Universidade Estadual de Montes Claros	7
	Universidade Federal do Oeste do Pará	7
	Pontifícia Universidade Católica do Rio Grande do Sul	6
	Universidade Metropolitana de Santos	6
	Pontifícia Universidade Católica de Goiás	6
	Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerai	5
	Instituto Federal de Educação, Ciência e Tecnologia de Pernambuco	4
	Instituto Federal de Educação, Ciência e Tecnologia Fluminense	4
	Pontifícia Universidade Católica de Campinas	4
	Universidade do Extremo Sul Catarinense	4
	Universidade do Vale do Paraíba	4
	Universidade de Passo Fundo	4
	Centro Universitário Campos de Andrade	3
	Universidade Católica do Salvador	3
	Universidade Caxias do Sul	3
	Universidade da Amazônia	3

	Universidade Luterana do Brasil	3
	Faculdade de Jandaia do Sul	1
	Faculdade Santa Marcelina Muriaé	1
	Faculdades Integradas da Upis	1
	Centro Universitário Fundação Santo André	1
	Faculdade de Ciências Humanas do Sertão Central	1
Chile	Pontificia Universidad Católica de Chile	23
	Universidad de Chile	19
	Universidad Academia de Humanismo Cristiano	17
	Pontificia Universidad Católica de Valparaíso	16
	Universidad de Santiago de Chile	15
	Universidad de Concepción	13
	Universidad de Playa Ancha	11
	Universidad Católica de Temuco	7
	Universidad Alberto Hurtado	7
	Universidad de La Serena	6
	Universidad de La Frontera	5
	Universidad de Los Lagos	5
	Universidad de Talca	4
	Universidad Metropolitana de Ciencias de la Educación	3
	Universidad de Bio Bio	3
	Universidad Católica de la Santísima Concepción	3
	Universidad Autónoma	2
	Universidad Católica Silva Henríquez	2
	Universidad de Tarapacá	2
Colombia	Universidad de Córdoba	14
	Universidad del Valle	14

	Universidad Nacional de Colombia	13
	Universidad de Ciencias Aplicadas y Ambientales	8
	Universidad del Cauca	7
	Universidad de los Andes Bogotá	3
Costa Rica	Universidad Nacional	16
	Universidad de Costa Rica	21
Ecuador	Universidad San Francisco de Quito	5
	Pontificia Universidad Católica del Ecuador	6
Honduras	Universidad Autónoma de Honduras	14
Jamaica	The University of West Indies	2
Mexico	Universidad Nacional Autónoma de México	112
	Universidad de Guadalajara	43
	Universidad Autónoma del Estado de México	16
	Universidad Veracruzana	15
	Colegio de Michoacán	9
	Universidad Autónoma de San Luis Potosí	6
	Universidad de Quintana Roo	6
	Universidad Autónoma de Ciudad Juárez	6
	Universidad Autónoma Metropolitana	6
Nicaragua	Universidad Autónoma Nacional de Nicaragua	7
Peru	Universidad Nacional Federico Villarreal	44
	Universidad Nacional Mayor de San Marcos	22
	Pontifica Universidad Católica de Perú	21
Puerto Rico	Universidad de Puerto Rico	4
Dominican Republic	Universidad Autónoma de Santo Domingo	6
Trinidad & Tobago	University of West Indies at Saint Agustine	6
Uruguay	Universidad de la República	13

Venezuela	Universidad Central de Venezuela	22
	Universidad de Los Andes	19

Appendix 2

List of Latin American Universities and their offer of undergraduate and graduate geography programs (2018)

Country	University name	Undergraduate		Graduate	
		Bachelor program	Licentiate program[51]	Master program	Doctoral program
Argentina	Universidad Nacional del Nordeste		X		X
	Universidad Nacional del Sur		X	X	X
	Universidad de Buenos Aires		X		X
	Universidad Nacional del Centro de la Provincia de Buenos Aires		X		
	Universidad Nacional de La Plata		X		X
	Universidad Nacional de Mar de Plata		X	X	
	Universidad Nacional de Cuyo		X		X
	Universidad Nacional de la Pampa		X		
	Universidad Nacional del Litoral		X		
	Universidad Nacional de la Patagonia Austral		X		
	Universidad El Salvador				X
Bolivia	Universidad Mayor de San Andrés		X		
Brazil	Universidade Federal de Goiás	X	X	X	X

[51] This degree consists of an additional fifth year in the undergraduate program. However, in Brazil the licentiate program represents a 4-year program which prepares future geography teachers, which is different from the rest of Latin America.

	Universidade Estadual "Júlio de Mesquita Filho"	X	X	X	X
	Universidade Estadual de Goais		X		
	Universidade de São Paulo	X	X	X	X
	Universidade Federal Fluminense	X	X	X	X
	Universidade Federal do Rio Grande do Sul	X	X	X	X
	Universidade Federal da Paraná	X	X	X	X
	Universidade Federal de Sergipe	X	X	X	X
	Universidade Estadual do Oeste do Paraná	X	X	X	X
	Universidade Federal Matto Grosso do Sul	X	X	X	
	Universidade Federal do Rio Grande do Norte	X	X	X	X
	Universidad do Estado do Amazonas		X		
	Universidade Federal de Minas Gerais	X	X	X	X
	Universidade Federal do Rio de Janeiro	X	X	X	X
	Universidade Estadual do Centro-Oeste	X	X	X	X
	Universidade Estadual de Londrina	X	X	X	X
	Universidade do Estado da Bahia	X	X		
	Universidade Estadual de Maringá	X	X	X	X
	Universidade Estadual de Feira de Santana	X	X		
	Universidade Estadual de Ponta Grossa	X	X	X	X
	Universidade do Estado do Rio Grande do Norte		X	X	X
	Universidade Estadual de Ceará		X	X	X

	Universidade Federal de Pernambuco	X	X	X	X
	Universidade Federal da Bahia	X	X	X	X
	Universidade Federal Rural do Rio de Janeiro	X	X	X	
	Pontifícia Universidade Católica do Rio de Janeiro	X	X	X	X
	Universidade Estadual Do Sudoeste da Bahia		X	X	
	Universidade Federal de Santa Catarina	X	X	X	X
	Universidade Federal de Alagoas	X	X	X	
	Universidade Federal de Uberlândia	X	X	X	X
	Universidade de Brasília	X	X	X	X
	Universidade Estadual do Norte do Paraná		X		
	Universidade Federal do Espiritu Santo	X	X	X	X
	Universidade Federal Do Pará	X	X	X	X
	Universidade Estadual de Campinas	X	X	X	X
	Universidade Estadual Vale Do Acaraú		X	X	
	Universidade Federal de Grande Dourados	X	X	X	X
	Universidade Federal do Ceará	X	X	X	X
	Universidade Federal Juiz de Fora	X	X	X	
	Universidade Federal de Santa Maria	X	X	X	X
	Universidade Federal do Maranhão	X	X		
	Universidade Federal da Fronteira Sul		X		
	Universidade Federal do Amazonas	X	X	X	

	Universidade Federal do Rio Grande	X	X	X	
	Universidade Estadual do Maranhão		X	X	
	Universidade Federal de Roraima		X	X	
	Universidade Federal de Rondônia	X	X	X	X
	Universidade Regional do Cariri		X	X	X
	Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte		X		
	Universidad Federal do Piauí		X	X	
	Pontifícia Universidade Católica de Minas Gerais	X	X	X	X
	Universidade do Estado de Santa Catarina		X	X	
	Universidade do Estado do Rio de Janeiro	X	X	X	
	Universidade do Estado do Mato Grosso		X	X	
	Universidade Estadual de Alagoas		X		
	Universidade Federal do Tocantins	X	X	X	
	Faculdade de Ciências Humanas e Sociais		X		
	Universidade Federal do Oeste da Bahia	X	X		
	Universidade Federal do Triângulo Mineiro		X		
	Universidade Federal Dos Vales do Jequitinhonha e Mucuri		X		
	Universidade Estadual de Santa Cruz	X	X		
	Universidade Federal da Integração Latino-Americana	X	X		

	Universidade Federal da Paraíba	X	X	X	X
	Universidade Federal do Sul e Sudeste do Pará	X	X		
	Instituto Federal de Educação, Ciência e Tecnologia da Bahia		X		
	Universidade Estadual da Paraiba		X		
	Universidade Federal de Viçosa		X		
	Universidade Estadual do Parana		X		
	Universidade Federal do Vale do São Francisco		X		
	Universidade Federal de Alfenas	X	X		
	Universidade Federal do Acre	X	X		
	Universidade Estadual de Roraima		X		X
	Instituto Federal de Educação, Ciência e Tecnologia do Pará		X		
	Universidade Estadual de Montes Claros		X		
	Universidade Federal do Oeste do Pará		X		
	Pontifícia Universidade Católica do Rio Grande do Sul	X	X		
	Universidade Metropolitana de Santos		X		
	Pontifícia Universidade Católica de Goiás		X		
	Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerais		X		
	Instituto Federal de Educação, Ciência e Tecnologia de Pernambuco		X		

	Instituto Federal de Educação, Ciência e Tecnologia Fluminense		X		
	Pontifícia Universidade Católica de Campinas	X	X		
	Universidade do Extremo Sul Catarinense		X		
	Universidade do Vale do Paraíba		X		
	Universidade de Passo Fundo		X		
	Centro Universitário Campos de Andrade		X		
	Universidade Católica do Salvador	X			
	Universidade Caxias do Sul		X		
	Universidade da Amazônia		X		
	Universidade Luterana do Brasil		X		
	Faculdade de Jandaia do Sul		X		
	Faculdade Santa Marcelina Muriaé		X		
	Faculdades Integradas da Upis		X		
	Centro Universitário Fundação Santo André		X		
	Faculdade de Ciências Humanas do Sertão Central		X		
Chile	Pontificia Universidad Católica de Chile		X	X	X
	Universidad de Chile		X	X	
	Universidad Academia de Humanismo Cristiano		X	X	
	Pontificia Universidad Católica de Valparaíso		X		

	Universidad de Santiago de Chile		X	X	
	Universidad de Concepción		X	X	
	Universidad de Playa Ancha		X		
	Universidad Católica de Temuco		X		
	Universidad Alberto Hurtado		X	X	
	Universidad de La Serena		X		
	Universidad de La Frontera		X		
	Universidad de Los Lagos		X		
	Universidad de Talca		X		
	Universidad Metropolitana de Ciencias de la Educación		X		
	Universidad de Bio Bio		X		
	Universidad Católica de la Santísima Concepción		X		
	Universidad Autónoma		X		
	Universidad Católica Silva Henríquez		X		
	Universidad de Tarapacá		X		
Colombia	Universidad de Córdoba		X	X	
	Universidad del Valle		X		
	Universidad Nacional de Colombia	X		X	X
	Universidad de Ciencias Aplicadas y Ambientales		X		
	Universidad del Cauca		X		

	Universidad de los Andes Bogotá			X	
Costa Rica	Universidad Nacional	X	X	X	
	Universidad de Costa Rica	X	X	X	
Ecuador	Universidad San Francisco de Quito			X	
	Pontificia Universidad Católica de Ecuador		X		
Honduras	Universidad Autónoma de Honduras		X		
Jamaica	The University of West Indies	X		X	X
Mexico	Universidad Nacional Autónoma de México	X	X	X	X
	Universidad de Guadalajara		X	X	
	Universidad Autónoma del Estado de México		X	X	X
	Universidad Veracruzana		X		
	Colegio de Michoacán			X	
	Universidad Autónoma de San Luis Potosí		X		
	Universidad de Quintana Roo				X
	Universidad Autónoma de Ciudad Juárez		X		
	Universidad Autónoma Metropolitana		X		
Nicaragua	Universidad Autónoma Nacional de Nicaragua		X		
Peru	Universidad Nacional Federico Villarreal		X		
	Universidad Nacional Mayor de San Marcos		X	X	
	Pontifica Universidad Católica de Perú	X	X		
Puerto Rico	Universidad de Puerto Rico	X			

Dominican Republic	Universidad Autónoma de Santo Domingo		X		
Trinidad & Tobago	University of West Indies at Saint Agustine	X		X	X
Uruguay	Universidad de la República		X		
Venezuela	Universidad Central de Venezuela		X		
	Universidad de Los Andes		X		

Appendix 3

Online Survey: Adoption of Geospatial Technologies for Teaching Geography

The survey's purpose is to collect information for the doctoral research project titled "Adoption of geospatial technologies for teaching geography in Latin American universities".

The information provided is anonymous and confidential. Thus, personal data that violates privacy is not asked. The data will be used for academic purposes exclusively, and in will treated as a whole, not individually. By completing the following online survey, the participant acknowledges its consent for participating in the project. Thanks for your contribution and time.

Part I: Personal and academic information:

1. What is your gender?

( ) Male ( ) Female

2. What is your age?

________________________.

3. In which country do you currently work?

_________________________.

4. How many years of teaching in higher education do you have?

________________________.

5. What is your professional category as a faculty?

( ) Tenure.
( ) Associate
( ) Adjunct
( ) Assistant or lecturer
( ) Other, specify: _______________________.

6. Which of the following areas of Geography is your main field of expertise?
(   ) Human Geography
(   ) Physical Geography
(   ) Geospatial Technologies
(   ) Other, please specify: _______________

7. What is your last academic degree obtained?
(   ) Bachelor or licentiate
(   ) Master
(   ) Doctoral
(   ) Post-doctoral work

8. In your opinion, would you say that your department use more open source or licensed GST?
(   ) Open-sourced   (   ) Licensed

9. Is it the use of geospatial technologies for teaching geography mandatory in your program's curriculum?
(   ) Yes   (   ) No

10. Have you done research using geospatial technologies in Geography?

(   ) Yes   (   ) No

11. Do you work full-time or part-time in your department?

(   ) Full-time   (   ) Part-time

Part II, section A

Questions about desktop GIS adoption

In this section, desktop GIS refers to the geographic information system software that could be operated only by being installed in a computer. Please select the option that you consider best fit your personal opinion.

Item	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I would find desktop GIS useful in my job as faculty					
Using desktop GIS enables me to accomplish tasks more quickly					
Using desktop GIS increases my productivity					
If I use desktop GIS, I will increase my chances of getting a raise					
My interaction with desktop GIS would be clear and understandable					
It would be easy for me to become skillful at using desktop GIS					
I would find desktop GIS easy to use					
Learning to operate desktop GIS is easy for me					
People who influence my behavior think that I should use desktop GIS					
People who are important to me think that I should use desktop GIS					
The chair of the department has been helpful in the use of desktop GIS					
In general, the school or department has supported the use of desktop GIS					
I have the resources necessary to use desktop GIS					
I have the knowledge necessary to use desktop GIS					
Desktop GIS is not compatible with other technologies I use					
A specific person (or group) is available for assistance with desktop GIS difficulties					

	Very likely	Likely	I might or might not	Unlikely	Very unlikely
I intend to use desktop GIS the next 6 months for teaching geography					
I predict I would use desktop GIS in the 6 months for teaching geography					
I plan to use desktop GIS in the next 6 months for teaching geography					
	Very frequently	Frequently	Occasionally	Rarely	Never
I have use desktop GIS in the last academic year while teaching geography.					

Part II, section B

Questions about web-based GIS adoption

In this section, web-based GIS refers to the geographic information systems that can be used only by accessing any apps or websites that exist on the internet for this purpose. Please select the option that you consider best fit your personal opinion.

Item	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I would find web-based GIS useful in my job as faculty					
Using web-based GIS enables me to accomplish tasks more quickly					
Using web-based GIS increases my productivity					
If I use web-based GIS, I will increase my chances of getting a raise					
My interaction with web-based GIS would be clear and understandable					
It would be easy for me to become skillful at using web-based GIS					
I would find web-based GIS easy to use					
Learning to operate web-based GIS is easy for me					
People who influence my behavior think that I should use web-based GIS					

People who are important to me think that I should use web-based GIS					
The chair of the department has been helpful in the use of web-based GIS					
In general, the school or department has supported the use of web-based GIS					
I have the resources necessary to use web-based GIS					
I have the knowledge necessary to use web-based GIS					
Web-based GIS is not compatible with other technologies I use					
A specific person (or group) is available for assistance with web-based GIS difficulties					
	Very likely	Likely	I might or might not	Unlikely	Very unlikely
I intend to use web-based GIS the next 6 months for teaching geography					
I predict I would use web-based GIS in the 6 months for teaching geography					
I plan to use web-based GIS in the next 6 months for teaching geography					
	Very frequently	Frequently	Occasionally	Rarely	Never
I have use web-based GIS in the last academic year while teaching geography.					

Part II, section C

Questions about Global Positioning Systems (GPS)

Item	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I would find GPS useful in my job as faculty					
Using GPS enables me to accomplish tasks more quickly					
Using GPS increases my productivity					
If I use GPS, I will increase my chances of getting a raise					
My interaction with GPS would be clear and understandable					

It would be easy for me to become skillful at using GPS					
I would find GPS easy to use					
Learning to operate GPS is easy for me					
People who influence my behavior think that I should use GPS					
People who are important to me think that I should use GPS					
The chair of the department has been helpful in the use of GPS					
In general, the school or department has supported the use of GPS					
I have the resources necessary to use GPS					
I have the knowledge necessary to use GPS					
GPS is not compatible with other technologies I use					
A specific person (or group) is available for assistance with GPS difficulties					
	Very likely	Likely	I might or might not	Unlikely	Very unlikely
I intend to use GPS the next 6 months for teaching geography					
I predict I would use GPS in the 6 months for teaching geography					
I plan to use GPS in the next 6 months for teaching geography					
	Very frequently	Frequently	Occasionally	Rarely	Never
I have used GPS in the last academic year while teaching geography.					

Part II, section D

Questions about digital globes

Digital globes refer to a special kind of geospatial technology such as Google Earth.

Item	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I would find digital globes useful in my job as faculty					
Using digital globes enables me to accomplish tasks more quickly					

Using digital globes increases my productivity					
If I use digital globes, I will increase my chances of getting a raise					
My interaction with digital globes would be clear and understandable					
It would be easy for me to become skillful at using digital globes					
I would find digital globes easy to use					
learning to operate digital globes is easy for me					
People who influence my behavior think that I should use digital globes					
People who are important to me think that I should use digital globes					
The chair of the department has been helpful in the use of digital globes					
In general, the school or department has supported the use of digital globes					
I have the resources necessary to use digital globes					
I have the knowledge necessary to use digital globes					
Digital globes are not compatible with other technologies I use					
A specific person (or group) is available for assistance with digital globes difficulties					
	Very likely	Likely	I might or might not	Unlikely	Very unlikely
I intend to use digital globes in the next 6 months for teaching geography					
I predict I would use digital globes in the 6 months for teaching geography					
I plan to use digital globes in the next 6 months for teaching geography					
	Very frequently	Frequently	Occasionally	Rarely	Never
I have use digital globes in the last academic year while teaching geography.					

Part II, section E

Questions about remote sensing.

Item	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I would find remote sensing useful in my job as faculty					
Using remote sensing enables me to accomplish tasks more quickly					
Using remote sensing increases my productivity					
If I use remote sensing, I will increase my chances of getting a raise					
My interaction with remote sensing would be clear and understandable					
It would be easy for me to become skillful at using remote sensing					
I would find remote sensing easy to use					
Learning to operate remote sensing is easy for me					
People who influence my behavior think that I should use remote sensing					
People who are important to me think that I should use remote sensing					
The chair of the department has been helpful in the use of remote sensing					
In general, the school or department has supported the use of remote sensing					
I have the resources necessary to use remote sensing					
I have the knowledge necessary to use remote sensing					
Remote sensing is not compatible with other technologies I use					
A specific person (or group) is available for assistance with remote sensing difficulties					
	Very likely	Likely	I might or might not	Unlikely	Very unlikely
I intend to use remote sensing the next 6 months for teaching geography					
I predict I would use remote sensing in the 6 months for teaching geography					
I plan to use remote sensing in the next 6 -months for teaching geography					

	Very frequently	Frequently	Occasionally	Rarely	Never
I have use remote sensing in the last academic year while teaching geography.					

Thanks for your participation, your opinion is very important for my research.

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