AUGMENTED REALITY:

CAPTURING KNOWLEDGE IN GEOGRAPHIC EDUCATION

By

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TABLE OF CONTENTS

LIST OF FIGURES

Figure or Table   **Page**

ABSTRACT

The use of Augmented Reality provides an opportunity to introduce geospatial technologies and geographic education into the classroom, yet the technology is underutilized. At the same time, museum experiences within smaller communities have become less popular because of the lack of available resources and technology. To address these concerns, I created an interactive Augmented Reality museum tour at the Hispanic Cultural Center in San Marcos, Texas that combines oral histories with current information in the museum.

This project explores how Augmented Reality changes students' learning experiences. When touring the museum, students use Augmented Reality to engage with content and answer questions regarding Mexican migration, segregation histories, and struggles for equality. With this added layer of Augmented Reality content, I argue that students will receive and retain extra information beyond what is typically available. Working with Augmented Reality, we suspect, will also create a more dynamic and enjoyable learning experience for students.

Augmented Reality holds the potential to transform geographic education. This project is a first step to understand that potential. The Augmented Reality tour will continue at the Hispanic Cultural Center in perpetuity and be opened to the San Marcos community.

I. Introduction:

The use of Augmented Reality (AR) provides an opportunity to introduce geo-spatial technologies and geographic education into the classroom, yet the technology is underutilized. To address this paradox and to explore the potential of AR, this project analyzed how participation in an interactive AR museum tour impacts students' ability to meet geographic learning objectives, as well as their attitudes toward learning geographic concepts and geo-spatial technologies.

In order to understand how AR changes students' learning experiences, this research asks the following research questions: How can AR be used in geographical education to help students achieve learning objectives? What additional benefits does AR bring to a) students' education and b) learning experiences? What are the challenges of integrating AR into geographic education?

To answer these questions, this project designed an AR museum tour at the *Centro Cultural Hispano de San Marcos,* the Hispanic Cultural Center of San Marcos, as part of an upper-division course at Texas State University. Then used a survey evaluation tool and the class assignment to access the student's ability to meet geography learning objectives and changes in students' learning and attitudes. The students' learning objectives included learning more about the history of racial segregation in San Marcos, TX, familiarize themselves with the history of the Hispanic community, and understand the impacts of gentrification today. The research design measured knowledge and attitudes to these learning objectives at the beginning of the course before any instruction, after a conventional reading assignment and in-class lecture, and lastly, following the AR tour of the Hispanic Cultural Museum. When touring the museum, students used AR to engage with content and answer questions regarding Mexican migration to

Central Texas, San Marcos' history of segregation, and Mexican American struggles for equality. The AR tour will continue at the Hispanic Cultural Center in perpetuity and is open to the San Marcos community.

This research demonstrates that the use of AR enhanced the existing museum experience and achievement of the learning objectives and that students' attitudes toward AR and geospatial technologies became more positive throughout their assignment. Students enjoyed the ability to use their devices to listen to oral histories from members of the San Marcos past and present as well as receive additional information on practices of segregation and discrimination. AR was a tool that many students had not used before in their educational experience and many student's assignment responses detailed the personal dimension and affect that AR brought to the tour. The AR stops also provided the pacing for the tour. This flow unveiled the learning objectives in an organization that students appreciated more than attending lecture alone.

In addition to identifying these benefits of AR, this research also identifies many challenges and barriers to incorporating AR into classroom learning environments. These challenges included the reliability of the technology, the quality of the media presented through the AR, and the distribution of technology for guests whose devices were not compatible. When viewing the AR stops, many students had to restart the stops and complained about the videos not restarting from where they left off. The HP reveal application used in the AR assignment did not have this capability. There was no feedback of content not being displayed through HP Reveal, but two stops had lower audio levels depending on which brand of devices was being used. The Centro was given three tablets for facilitating the tour during scheduled hours. This was not a huge issue for the study because only three students needed the technology, but the

signing in and out of the devices for public tours added another duty to the front office that was already working to capacity.

This research contributes to the literature on geographic education that focuses on the use of geospatial technologies. The desire of our field is to find ways that improve students' knowledge acquisition. This project evidences that AR can build a bridge that connects the course content with the Hispanic heritage of our community and of many of our students at Texas State University, which is a federally recognized Hispanic-Serving Institution. Geography is a knowledge base that opens new ways of thinking about the world and AR is a tool that proved useful to help students think more geographically and improve their attitudes toward geography and learning more broadly.

Analyzing the potential for AR in the classroom has real-world implications. Students increasingly rely on electronic devices in their education and daily lives. This has changed how students learn and engage with each other and the world around them. Furthermore, the increase in online opportunities for students suggests the need to find new ways to inspire and educate students. AR has the potential to play a large role in meeting the opportunities and challenges posed by these changes. In short, I argue that AR holds the potential to transform geographic education and this project contributes to understanding that potential.

II. Background

Augmented reality (AR) is simply creating a digital layer, on top of a two-dimensional surface, that students can examine through their electronic devices such as tablets and cell phones. These "layers" can be pictures, videos, audio clips or any other form of interactive information. When a student holds their cell phone over an image or object enhanced with AR, an image, video or audio recording on their phone or tablet play. HP Reveal is a user-friendly app that allows students to create their AR material, as well as engage in premade material. These AR layers can be created in less than one minute through the HP reveal application or can become more nuanced with more time spent in the application. Responsibility of information can be shared by student and teacher.

In previous teaching environments and this research, I have used HP Reveal as the platform to bring AR to life. From 2015 to 2018, I used HP Reveal in my Advanced Placement (AP) Human Geography classroom as a tool to connect concepts and places throughout the year in preparation for students' final exam. The technology director at the American International School of Jeddah in Saudi Arabia introduced me to AR in 2014. The flexibility of my administration allowed me to create a blank canvas for exploration in a Geography classroom. This support helped me transform the walls of my classroom into an interactive global experience.

In this experience, my students both enjoyed using AR and scored above global averages on their final exam. The students' scores went from a 50% passing rate to 75% on the AP Human Geography exam. These results made me question the broader role that AR played in my students' success and the broader potential for AR in geography education. This interest led to the pursuit of a Master of Applied Geography in Geography Education at Texas State University.

After volunteering and collaborating with local K-12 classrooms, I decided to take advantage of the feasibility and opportunity to conduct my study in an upper-division Political Geography course at Texas State University. The professor of the course, Dr. Jennifer Devine had previously participated in activities offered by the *Centro Cultural Hispano de San Marcos,* the Hispanic Cultural Center.

Figure 1: Entrance to the Hispanic Cultural Center of San Marcos

Source: http://www.sanmarcoscentro.org/about.html

The Centro Cultural Hispanic of San Marcos (http://www.sanmarcoscentro.org/), locally known as, *El Centro,* is a non-profit community-serving organization that shares the story of San Marcos' Hispanic heritage through a library, museum, art gallery, and through various community events. The center is active in bringing current educational trends to the San Marcos community, including a summer STEM workshop focusing on building a love of engineering with younger students. The center has established strong ties with Texas State University through previous projects and internships. The center has a small museum on-site called *Ofelia T. Vasquez Mexican American Cultural Museum* that details the history and civil rights

achievements of the Hispanic community and the residential and educational segregation and discrimination they faced in the small town of 65,000 in central Texas. The building housing the center was the location of the segregated so-called "Mexican School" in San Marcos from 1949 to 1965. As such, it is an ideal place for students and the broader community to learn about the history of the Hispanic community and the dynamics of racial segregation more broadly.

Augmented Reality Tour Stops: San Marcos Hispanic Cultural Center	
1	History of the building
2	Greeting and information about Centro
3	Difficulties of migration from Mexico
4	The role of the Catholic Church supporting the Hispanic community
5	Struggle for equal rights
6	Segregation of neighborhoods
7	Educational inequalities in the school district
8	Cemeteries and segregation after death
9	GIS and charting of unmarked graves

Figure 2: Description of Augmented Reality Tour Stops

During the summer of 2019, I worked with Dr. Devine and the center's staff to develop the lesson for the political geography class and the AR tour. The center's AR tour is comprised of nine stops. These nine stops include issues that deal with segregation, migration, and struggles for equality. Figure 2 details the focus and content of each of the individual stops.   The tour is available to all visitors to the center, not just students from the political geography class. Following the completion of this project, the center has kept the AR tour available to its visitors, and students interning at the center from Texas State are translating the tour to Spanish and adding additional content.

III. Literature Review

<u>Augmented Reality and Education</u>

Augmented Reality (AR) is a powerful tool because it allows the digital world to enter people's everyday environment through simple, free applications on their phones. AR involves overlaying virtual objects onto real-world experiences (Azuma et al., 2001). Augmented images can be either image-based or location-based. Image-based systems use a trigger marker to display a picture, video, or 3-D image. This picture or image creates an overlay when the trigger marker is engaged. Location-based images add a layer to the existing physical world humans live in.

Many people's first interaction with location-based AR may have been with the recent Pokémon Go game. Zsila et al. 2018 report that there were 100 million users from over 30 different countries that downloaded the app in the first few weeks. This game created millions of people trying to capture location-based images that had been created in physical landscapes.

Within the last three years, the popularity of AR has increased with the creation of free applications like HP reveal, Orb, and Meta Verse. When working with today's students, educators can leverage students' technological competence and teach them ways to use their phone as a tool for learning. The trade journal Horizon Reports forecasts that AR will be a promising technology in the long term and that AR will have a significant impact and garner attention in the short term (Johnson et al.,2006). Educators need to tap into this hybrid digital-physical world and create a classroom setting that embraces technology.

AR is being used in K-12 learning environments (Chaing et al. 2014b). AR has been implemented by teachers and is spreading into classrooms more quickly with improvements in

cellular phone capabilities. Teachers are using AR to bring books to life by having interactive 3-D characters pop off the page through 2-D trigger images on the page (Dunser et al. 2010). The advantage of AR is its "unique ability to create immersive hybrid learning environments that combine digital and physical objects, thereby facilitating the development of processing skills such as critical thinking, problem-solving, and communicating through interdependent collaborative exercises." (Dunleavy, Dede, and Mitchell 2009, p. 20).

AR is also being used in higher education (Ferrer-Rorregrosa et al. 2015). Students can have interactive opportunities for exploration created through AR (Dede 2009). For example, the City View AR application allows students to see a superimposed, undamaged building in the place of the devastation caused by an earthquake. This can help engineering students get a view into the past and work toward a possible restoration of the building in the future.

The 2010 Horizon Report stated that students' wireless mobile technologies will be a more powerful tool for students in the future and they will not need to be tied down to desktop computers (Johnson et al., 2010). When trying to teach students about geography there is no better way to learn about a place than experiencing it firsthand. Students are all experiencing patterns and processes in their everyday life through their physical environment.

Some of the concerns with AR by teachers is the reliability of the hardware or software during a lesson. Technology plays an essential role in AR instruction (Wu et al. 2013), and the different platforms options to display AR is a concern for teachers. Technology continues to improve in AR, making it a more reliable tool to be implemented into class on a more regular basis.

Augmented Reality and Geographic Education

As geographer teachers, we want to want to make our students more spatially aware of the world that they live in. The focus within our discipline is to improve the acquisition of conceptual knowledge in geography. Students within our classes have four different types of learning styles that educators must understand and adapt lessons around (Healy et al., 2005). Many times, teachers do not have a background in geography or have not been trained to make geography an engaging topic. GIS and AR are tools that can work together to help teachers bring geography effectively into the classroom.

Geography teachers need a tool that can capture the student's interest and foster positive attitudes toward geographic education. The concept of "geo-capabilities" is highly relevant to preparing our students for the challenges presented to them after graduation (Walkingtion et al., 2018). Geocapabilities examine the capabilities necessary for a single human to pursue well-being as a person and member of their community (Uhlenwinkel et al.,2017). Applications like HP reveal provide personalization to content through their phones and can be used as a tool to connect the principles of geo-capabilities with our students. The experience of watching a video clip of a cultural dance or ceremony is a much better tool than reading a page while looking at a stagnant picture. Today, geography students are living in a hybrid world where their cellular technology is an everyday companion that links them to the ever-changing technoscapes. When students are involved in location-based AR, they become more immersed and engaged in the learning process (Chiang et al.,2014), as it transforms the world around them creating an exploratory attitude.

Geographic Information Technologies is an emerging field in geographic education (Carrera & Bermejo 2017). AR is an essential part of the emerging field. Google Earth provides

teachers with lessons for latitude and longitude and pictures from around the world (Demirci et al., 2013). This technology helped teachers connect different places where teachers had a platform for students to explore.

GIS has been at the forefront of GIT at the university level but is struggling to gain implementation into K-12. The struggles are due to the lack of teachers experience with this new technology despite support from the National Geographic Research and Exploration, which argues, "The Geography for Life Standards have conceptualized GIS as a crucial integrative technology that teachers and students will or should be trained to use" (NGRE 1994).

The infrastructure needed for GIS to be successful was not in place to be implemented at a large scale. The use of collaborative GIS requires an advanced database, and internet technologies, not readily available in many educational circles (Baker and White, 2003). GIS has made progress in classrooms despite the slow start. "Geographic information systems (GIS) education is at a crossroads in the United States. Since its inception in the early 1990s, GIS has diffused slowly into select groups of K-12 classrooms through the efforts of geography and environmental educators" (Bednarz, 2004).

Innovations within GIS are being created to make the experience more user friendly to inspire teachers to learn this new tool and see the worth of implementing it in their class. There are many free sources online now that do not require expensive hardware or the user to download software. There has also been a proposal put forth to create an Advanced Placement class to teach high school students how to work with GIS and gain college credit upon completion. With all these positive developments, there should continue to be growth in GIS use and engagement in K-12 programs nationwide.

This project confirms the growing consensus in the geography education literature that GIT is underutilized by powerful means to improve education at K-16 levels. However, this research suggests that AR may be more accessible than GIS, maybe more user friendly than GIS, and less expensive to implement in the classroom. When looking at implementing AR into classrooms we can look at how it can be coupled with GIS. AR is an interactive map layer for GIS, displaying an interactive and thought-provoking level of information that teachers can create. There are both image-based and location-based types of AR in classrooms today. Both are being used at K-12 and college-level classes. For example, when looking at a topographical map student found examining a 3D mountain helped them understand spatial concepts about the mountain better than a 2D map (Carbonell & Bermejo 2017). When looking at technologies that have been implemented into geography, AR has the potential to be easily adapted into classrooms because the level of technological availability as simplicity has advanced so quickly in recent years. AR can be used to help students gain a better understanding of spatial awareness with many different scales. There can be models created to analyze transportation in large urban areas or soil erosion on a small rural farm. AR allows for endless possibilities to recreate space and scenarios to teach geographic concepts.

The limited number of educational AR studies has steadily increased over time, indicating more interest in its research and teaching possibilities (Akçayır and Akçayır 2017). This engagement of the application has led educators to study the effect that AR could have in their classrooms. By 2015, only 68 research articles have been published on AR that examines educational use in K-12 and higher education (Akçayır and Akçayır 2017). This research has been conducted primarily since 2012 with 57 of the 68 articles being published during those three years. Since 2015, AR has become more widespread throughout education, in a large part

due to the improved cell phone and the limited cost of applications that create and display these interactive possibilities. Lu and Lui 2015 state that students in their study had a positive attitude toward AR-enhanced learning activities. Research also suggests that location-based also leads to increased collaboration skills among students (Bressler & Bodzin 2013). For example, a study was a college in Turkey that recreated lessons on topography into a three-dimensional AR for a physical geography lab (Akçayır and Akçayır 2017).

My mixed-method approach followed prior educational AR studies by (Turan 2018), and (Adedokun-Shittu 2020). Carrera & Bermejo (2017) used a Likert scale to ask a question about the intrinsic motivation that AR created for students. The results showed that the students enjoyed using the new technology and would like to use it regularly. Carrera & Bermejo (2017) also used a topographic map assessment exercise with 18 items that tested their understanding of the topographic relief interpretation, to gather quantitative data compared to a control group that did not use AR. The results showed students using AR had scored better relief interpretation than the control group. I have yet to find a study that shows the results on students creating their AR for projects. Student's creating AR as a part of the project-based study is how I have used AR in my classroom the past three years. Students created an interactive classroom that combined place and concepts throughout the year.

I believe that a mixed-method research approach will show teachers that AR holds merit and provides learning opportunities for students in their classrooms. However, more research needs to be done to evaluate these platforms in the field of geography and the context of the classroom. For teachers who invest time and effort into developing AR content for their geography course, research needs to show that it will improve future educational practices to the benefit of students. This project contributes to this goal by illustrating and providing quantitative

12

and qualitative evidence that AR improved student's learning outcomes and attitudes toward the

study topic and geo-spatial technologies more broadly.

IV. Research Methods

When developing a lesson for an upper-division political geography class, the course professor and I used a location that would help students connect with the community and would allow me to transform an area using augmented reality (AR). The *Centro Cultural Hispano de San Marcos* is a center point of Hispanic culture in San Marcos and actively works with Texas State University. Director Dr. Ricardo Espinoza and the center's staff agreed to let me create an interactive AR museum for Dr. Devine's political geography class that would be open to the public after my research was conducted.

The project answers the following questions through evaluation of an AR assignment in Dr. Devine's Political Geography class during the Fall semester of 2019: How can AR be used in geographical education to help students achieve learning objectives? What additional benefits does AR bring to a) students' education and b) learning experiences? What are the challenges of integrating AR into geographic education?

To answer these questions, the project was executed in three phases:
1) Development of a pilot Augmented Reality lesson
2) Students participate in the Augmented Reality exercise
3) Evaluation the benefits, limitation and challenges of using Augmented Reality in the classroom

Phase 1: Develop Pilot AR Lesson

During the Summer term of 2019, I spent 50 hours at The Centro Cultural Hispano de San Marcos gathering information about the Hispanic migrant population that was used to develop the pilot lesson for the upper-division political geography class and the AR tour. To

accomplish this goal, I worked with the course professor, Dr. Jennifer Devine, to identify the learning objectives of the lesson. This included touring the center's existing museum and examining archival materials and information that could be used as topics and themes to develop the learning objectives.

The information I used to develop the AR stops included oral histories from Hispanic residents in San Marcos. We also used excerpts from the book, *Sueños y Recuerdos del Pasado* (Dreams and Memories from the Past) (Davis 2000), published by the center that details the town's history of Mexican migration, segregation, and struggles for equality. With the collected materials, I used HP Reveal to design the augmented stops called "auras" that would appear when students held their devices over the trigger image. Throughout the summer I constructed the AR tour. When curating content, I selected material that would help reflect the importance of the stop and connect the students to the information. The oral histories connected the students with the existing information in the museum. I created a self-guided tour of the Centro building and museum using AR to teach students about the history of the Latino community in San Marcos and the city's history of racial segregation and migration. The only technology that I used for the project was provided from the applications iMovie, Otter and HP reveal. This information was provided by the center and had not been made available to the public before this study.
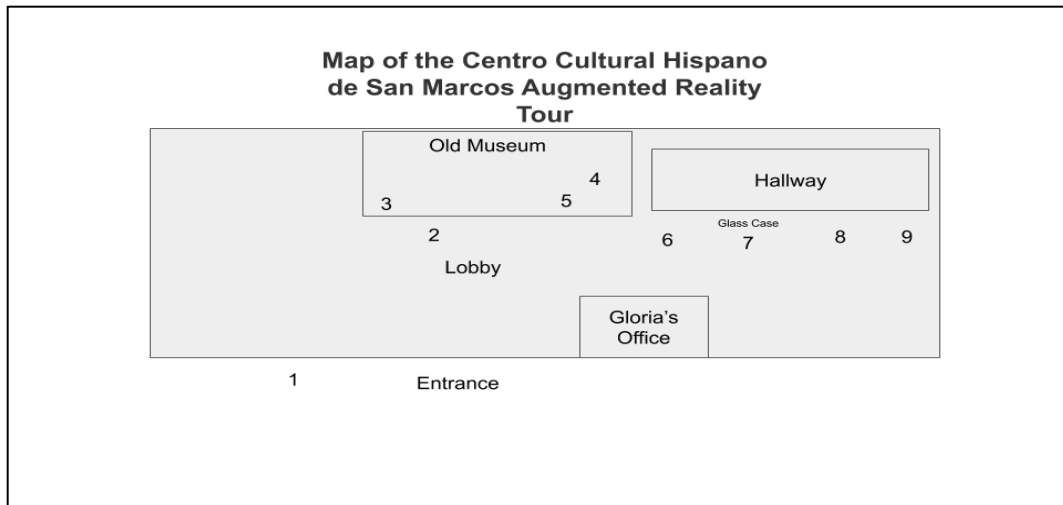
Figure 3: Map of Museum Tour

In tandem with tour development, Dr. Devine and I created the assignment that the students would be required to complete. The assignment consisted of visiting nine AR stations identified by trigger images placed throughout the Centro's building and museum (see Figure 3). Students answered questions at each station, and following the completion of the tour, they wrote a reflection piece on their experience. While students visited these nine stops, they recorded their responses to questions from the current information found in the museum and the additional information revealed through the augmented content. Three of the stops are in the existing Ofelia T. Vasquez Mexican American Cultural Museum and the other six stops are in the entrance and the hallways of the center. The students were given a map to be able to follow the nine stops in order. The students were also given readings before they visited the museum. Before participating in the tour at the center, student excerpts from the book *Sueños y Recuerdos* and attended an in-class lecture on the reading. Upon completing their short answers in the museum, students responded to the reflective questions about the overarching learning objectives and their experience and attitude to AR.

After speaking with the center's director, Dr. Espinoza, I discovered there was an interest in creating an interactive AR exhibit that would be open to the community at large. As such, we partnered with the Hispanic Cultural Center to create an interactive exhibit for the public that displayed the key events, historical information, and founders of the San Marcos Hispanic Community. The display included transcripts and documents previously not released to the public. The purpose of this exhibit was to tell the historical and political landscape of San Marcos through the eyes of the Latino past.

Phase II: Implementation and Student Participation - Data Collection

Data collection comes from an evaluation form given three times to students and their AR tour assignment. We evaluated students' knowledge of racial segregation and gentrification in San Marcos and the US more broadly as well as their attitudes toward AR and geo-spatial technologies 1) before any class introduction on the topic, 2) after the in-class reading assignment and lecture, and 3) after the students had made their visit to the AR museum (see appendix B. Examples of these questions include, "The use of augmented reality in classrooms enhances student learning" and "I like to use new technology in the classroom". A Likert scale of strongly disagree to strongly agree was used for question responses.

Dr Devine's political geography class had sixty students enrolled and students were asked to participate in my directed research using IRB protocols for the protection of human subjects. Thirty-seven of those sixty students signed the consent form and completed all three evaluations and the AR assignment. The data collected is reflective of those thirty-seven students' responses and evaluations. The first survey was given with the consent form on my initial visit. All three

evaluations were held in Dr. Devine's office until the completion of the semester and were not evaluated until after the grades were recorded for the students.

The first evaluation was given before the assignment and was to gauge the students' experience with AR and their knowledge of San Marcos, and about the Hispanic community. The second survey was given after students read a passage from a book created by the museum to gauge student responses to a traditional assignment before they toured the AR museum. The final survey was given after the completion of the AR experience. Students completed the assignment on their own time within five weeks during the semester. Students signed a class roster at the Centro reception to assure full participation. Two tablets were available for students without cell phones, along with headphones. All the evaluations were done by paper in class. Upon the completion of the semester, the responses were recorded digitally on an Excel spreadsheet and Google Forms to see the trends within the data.

Phase III: Data Analysis

After collecting all three evaluations, I imputed the responses into a google form to calculate the percentage change by response between the first, second and third evaluation. After calculating the responses, I was able to see the change between the three evaluations of the student's attitude. To condense the data, I grouped the Strongly Agree and Agree responses into positive attitudes and have analyzed these changes in attitude between the three evaluations. Using google forms enabled me to conduct line and pie graphs to display the change in the results section.

To analyze the open-ended responses of the assignment, I used a semi-structured coding method (Cope 2010) to develop themes, insights, and final arguments regarding the benefits, challenges, and limitations of the students' AR tour and assignment experience. The semi-structured coding allowed me to see trends in the student responses and better understand the attitudes represented in the surveys.

Limitations:

When examining the limitations during this research I believe the most limiting factor was having to rely on HP Reveal as the platform to display the AR stops. HP Reveal ended up going out of service a few months after the study, which as I describe in my analysis, is a challenge to integrating AR into classroom settings. Some of the challenges that we faced dealt with the audio content. Students had trouble hearing some of the stops and the variation of the audio between the stops. When using the HP Reveal application, students complained about having to restart the stops from the beginning. If the student moved the phone too much, they would lose connection to the trigger image and would have to restart from the beginning. Another limitation was them being able to record their responses while holding the phone to look at the augmented stops. One student screen recorded the stop so that they could view them later to be able to answer the questions. While this is a solution, it does not improve the experience or capabilities of the application. There should be a way in which the videos continue at the point in which they stopped if the students are not on the trigger images for the entire stop. Another limitation was my lack of technical knowledge to be able to code or create graphics that would have provided a more wow factor to the displayed content. The AR museum experience was

created using the app HP reveal and iMovie maker and additional funding would have enabled more ample use of technology and enhanced the experience.

Another limitation that we ran into was the students all having different devices to use at the museum experience. Three of the sixty students that toured the museum needed my assistance to gain access to HP Reveal. I had to work with them on a one to one basis but ended up having them use the tablets provided at the museum for their tours. Another limitation that occurred was having all students complete the three evaluations and give their consent. The majority of the students gave their consent, but only 37 of the 60 gave their consent, along with completing all three evaluations.

Another limitation that occurred dealt with the students' tight schedules and the limited hours of operation at the museum for them to complete their assignment. Students need an hour and a half to tour the museum and complete their assignment and the window for them to be able to do this was four hours in the afternoon, which may not have been conducive to their work schedules. A challenge we had with the tablets at the center was the process of checking out fully charged tablets for all students that needed them. There was a limited amount of space for charging, and the receptionist had to be on duty to check-out these tablets for the museum experience. Another hurdle I ran into while creating the AR stops was finding people within the community that were related to or had a connection to the people of the oral histories. I believe that the stops would have been more authentic if read by an extended family member, or at least someone within the community that has close ties to this person or family. I believe using voices from the community would have provided a more engaging experience.

V. Results and Discussion

Section V.1 of this chapter presents the results of the knowledge and attitude evaluations. The first evaluation the students completed was given to them before beginning the assignment to gauge their initial interest in aspects of political geography and augmented reality (AR). The second evaluation was given to students after they had completed a reading assignment and attended a lecture regarding the history of the Hispanic populations' struggle of migration and equality in San Marcos. The final evaluation was delivered after the students had toured the AR museum, recorded the questions at each stop, and had the time to complete the reflective responses about the entire experience. Within this section, I examine the changes in attitude across the three evaluations and track the percentage of change from the Likert scale on the evaluation.

Section V.2 presents the analysis of the assignment where students reflect on the assignment's AR aspects of the museum looking at the benefits and limitations of their tour. Also, students were asked how AR can be used in the future to teach subjects related to their majors and any additional comments they wanted to add about their experience. These reflective questions allow the student to express the attitudes on the evaluations into responses. I have coded the student responses into themes to analyze and discuss the role of AR in future of geographic education.

Section V.3 details to my recommendations for improving classroom assignments using AR and future research projects based on information from the data and my experience.

V.1. Analysis of Longitudinal Change: Knowledge and Attitude Evaluations
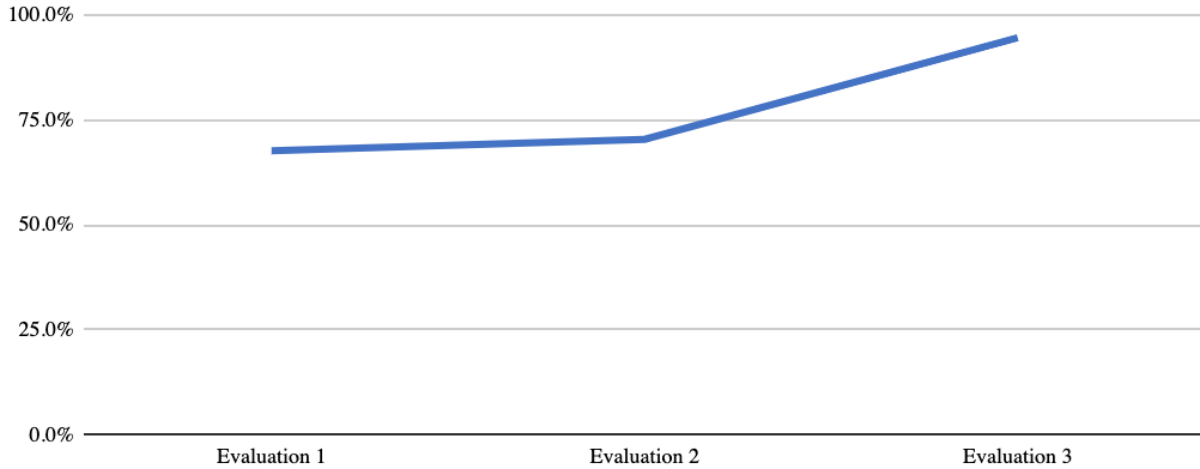

Figure 4: Familiarity with the history of the Mexican American Community in San Marcos

Regarding the first question about student familiarity with the history of the Mexican American community, the results indicate a dramatic increase from the first to third evaluation, which indicate their familiarity before the lesson, then measured again after completing course reading and lecture, and then measured once more. Interestingly, before the assignment, 67% of students claimed familiarity with Hispanic history, and that number rose to 70%, a three-point increase. Meaning that the reading alone and the lecture only increased their familiarity by three percent. However, following the AR tour that number jumps significantly to 94.5% (see Figure 5 below).
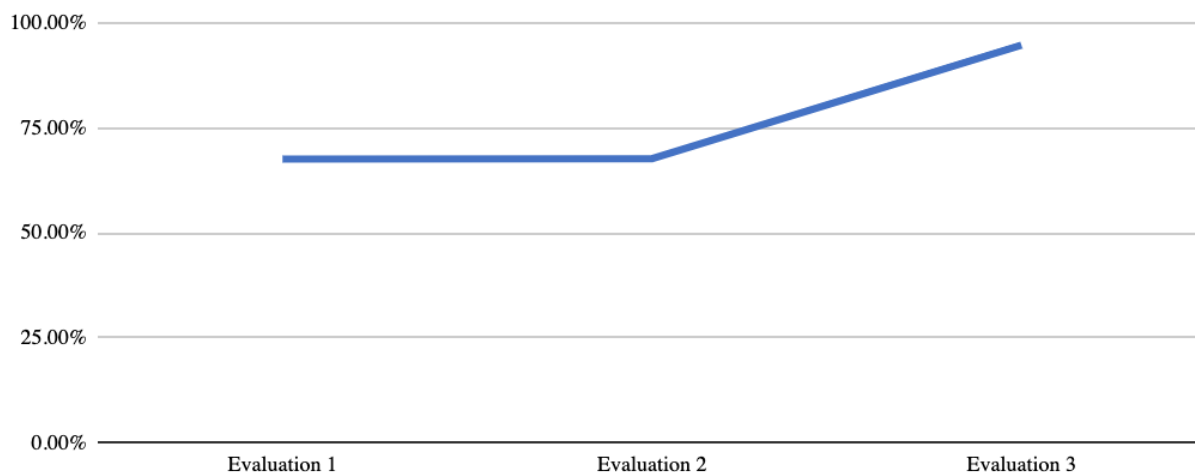
Figure 5: Familiarity with the racial discrimination against Mexican Americans in
San Marcos

The second question asks if students are familiar with the history of racial discrimination in San Marcos. The figure above indicates a similarity with question one. There seems to be a direct correlation, as students better understand past events in San Marcos, they can also understand the discrimination the has occurred. The positive attitudes of understanding this discrimination went from 67% to 94.5% showing substantial growth (see Figure 5).

The third question asks if contemporary residential segregation contributes to segregation in American schools and the students' agreement ranged from 89% to 97% with the least positive attitude occurring during the second evaluation, following the reading and instruction. These attitudes were compared to the course objectives and with the first six questions.

Question four has an overwhelming 100% agreement by students on the first and third evaluation that racism is a problem in the United States. On the second evaluation, there was one student that responded as neutral, meaning that no one disagreed with this topic throughout the entire study.

The fifth question saw a large increase from evaluation 1 to evaluation 2. There is a 19% increase of positive attitude, from 81% to 100% when it came to the perception of gentrification being a concern in American cities, especially in historic neighborhoods of color. Every student expressed concern about this question besides one outlier being neutral in the third evaluation. This question can also be tied to the local scale of gentrification in historic districts of San Marcos, as students became more aware of their local community their attitude also changed on gentrification at a national level.

Question six also had a 100% positive attitude that learning about past practices of racial discrimination is important to understand society today, besides one neutral response in the second evaluation. Questions three through six did not have a lot of changes, which is encouraging that students responded so positively that they care about these issues. Perhaps, however, the questions are too broad to capture the changes in attitude.
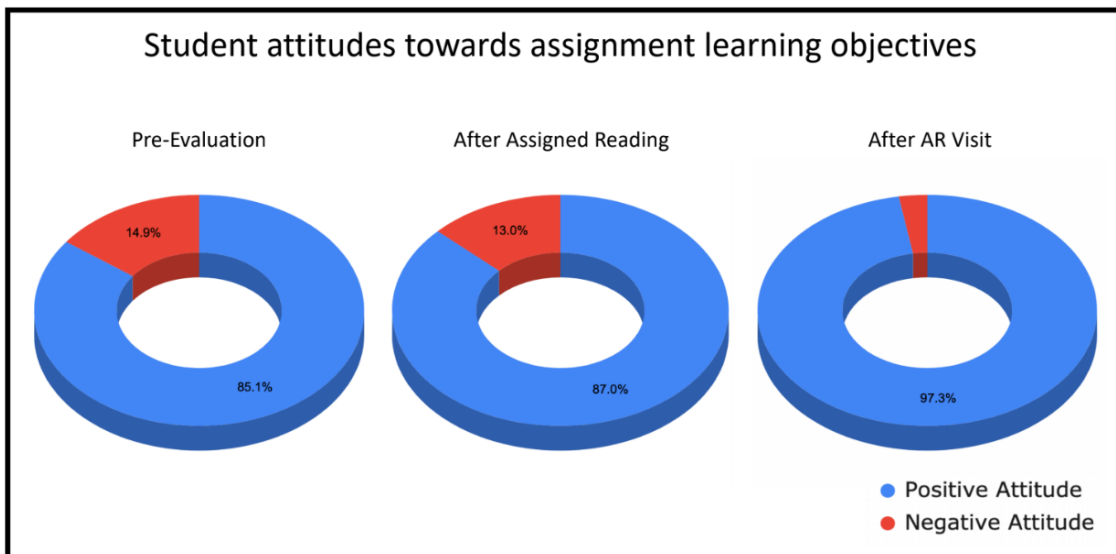

Figure 6: Attitudes toward Assignment Learning Objectives

Figure 6 summarizes the percentage change in positive attitudes for the first 6 questions from the three evaluations. I averaged the 6 responses to show the change in the classes overall attitude toward the learning objectives. The graph above helps us examine the following research question. How can AR be used in geographical education to help students achieve learning objectives? The positive trend in attitude shows students felt increased confidence in their understanding of the learning objectives. There is a 2% increase after the students completed the reading assignment and a 10% jump after completing their AR tour. The raise of positive attitude shows that the students enjoyed the assignment and were more confident in the objectives they were assigned to learn.

When asked about their concern with the gentrification of historic districts in San Marcos there was a significant change (see Figure 7). This may be because the students' concern over rising apartment prices in the future or Centro's proximity to these gentrifying areas while they visited the tour.
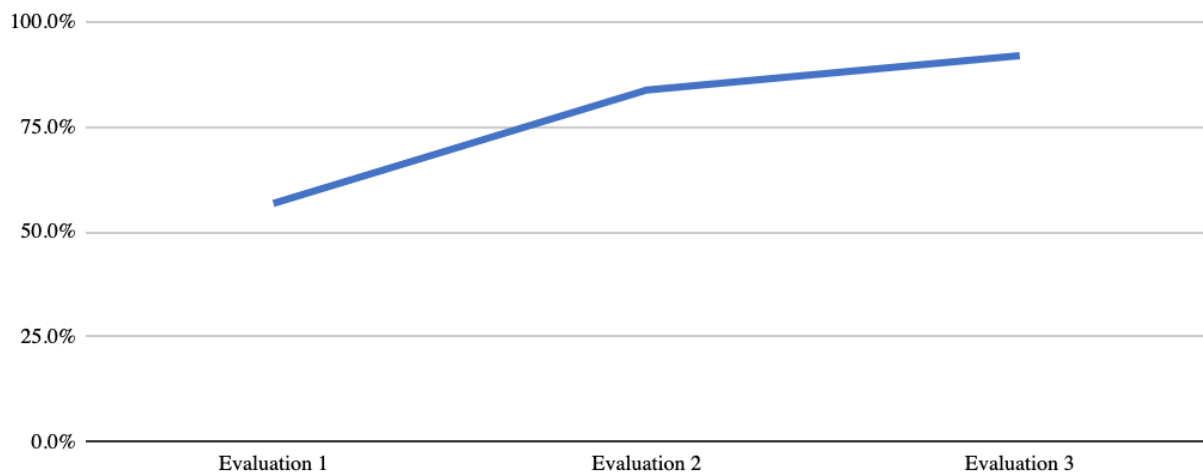

Figure 7. Concern over Gentrification of Historic Districts in San Marcos

The response given by a student helps clarify this change in attitude: "Gentrification has pressured locals to quickly develop the area without considering those who cannot afford the change. Forcing the poor to move to the outer limits of the city. It is also affecting areas of rich culture and history with the threat of total gentrification." This change in attitude was also seen in the students' view of this issue on a national level. This is exciting to see because the students will transfer this attitude to the community they decide to work in after graduation.

Question eight, ask students if they want to be more involved in the larger San Marcos community. It was the only question that saw no change in response results that were not 100% positive. 73% of students showed a positive attitude toward becoming more involved in the larger San Marcos community across all three evaluations. This lack of change may be a result of many students not being from the San Marcos area, and not having community ties to drive them to be more involved. The area that surrounds San Marcos does not have an abundance of jobs for college graduates, making students look elsewhere upon completion of their degree.

Question nine inspects the students' attitude of museums and cultural centers being important places to support multiculturalism and respect for diverse cultures in our communities. Besides one neutral response in evaluation two and three, there was a 100% positive attitude towards this claim. This finding helps support the fact that museums are viable areas for people to learn. Museums should be used to combine cultural aspects found within the community to better understand each other's background.

Question 10 ponders whether visiting a museum is a valuable learning experience. The students responded with a unanimous 100% positive attitude across all three evaluations. This attitude reflects the positive experiences that students have had before and during the study.

Museums will be a place that people visit for learning experiences and we must look at new ways to continue this positive attitude.

Question 11 inspects if students have a positive attitude toward using new technology in the classroom. The positive attitude declined from 89% to 81% from evaluation 1 to 3. There was only one that responded negative and that was recorded in the third evaluation. This student could have shown a negative attitude because of technical issues or a dislike for the AR tool used at the museum. The other responses were recorded in the neutral category, accounting for the decline.

Reflections on Augmented Reality and Geo-Spatial Technologies

The following section summarizes students' attitudes to AR and geospatial technologies and how these attitudes have changed before and after the assignment and AR tour. Based on the results of this study most of the students had a positive attitude toward using AR as a part of their assignment. When looking at students' responses to the evaluations, many make indications of positive attitudes towards AR before their museum experience (see Figure 8).
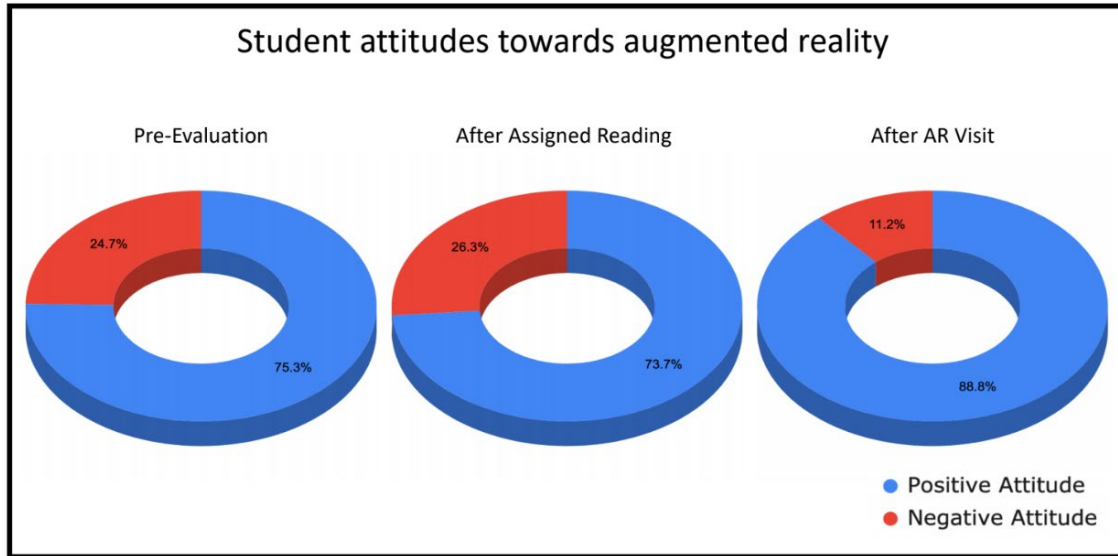
Figure 8. Students' attitudes toward using Augmented Reality

One student responded, "I thoroughly enjoyed being able to experience the usage of AR. It was very fun and cool to see the little note cards come to life with pre-recorded messages. I did not think I would ever be able to experience something like that." There is a wow factor associated with this technology. Educators must determine if it is a fad or can be added to the teaching toolkit to improve students' education. After completing the assignment one student responded, "AR was very beneficial because it is a more interactive way of learning and acquiring knowledge to what it is displayed." This is a very strong testimonial to what AR can accomplish as an educational tool.
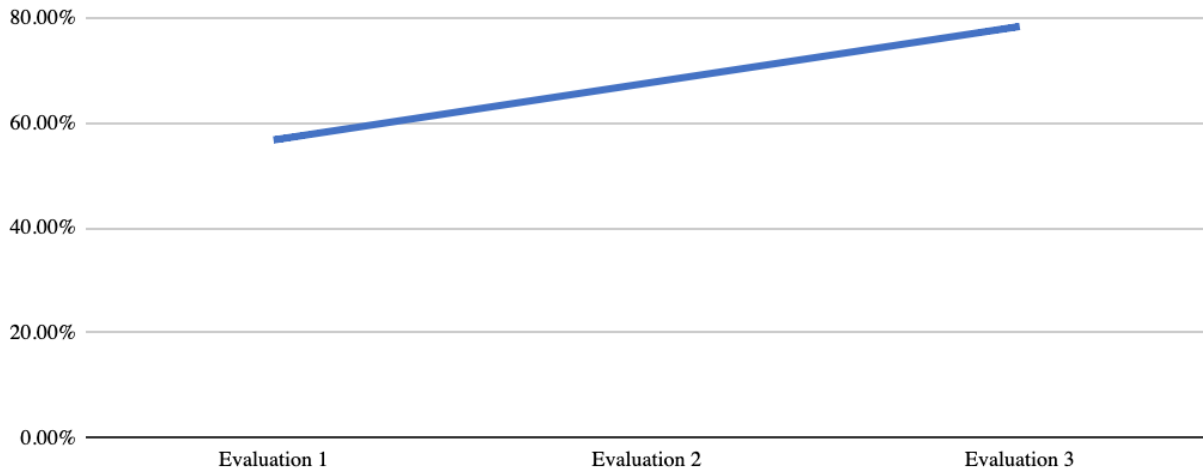
Figure 9. Augmented Reality Enhances Student Learning

Question 12 responses delve into the attitude of students. Is learning enhanced by using geospatial technologies in the classroom? The results have been charted in Figure 9 (see above). The percentage of positive attitudes increased from 56.7% to 78.3% over the three evaluations showing a 21.6% increase in a positive attitude. This increase shows that students viewed AR as a geospatial technology that enhanced their learning experience as no other geospatial technology was used during the study.
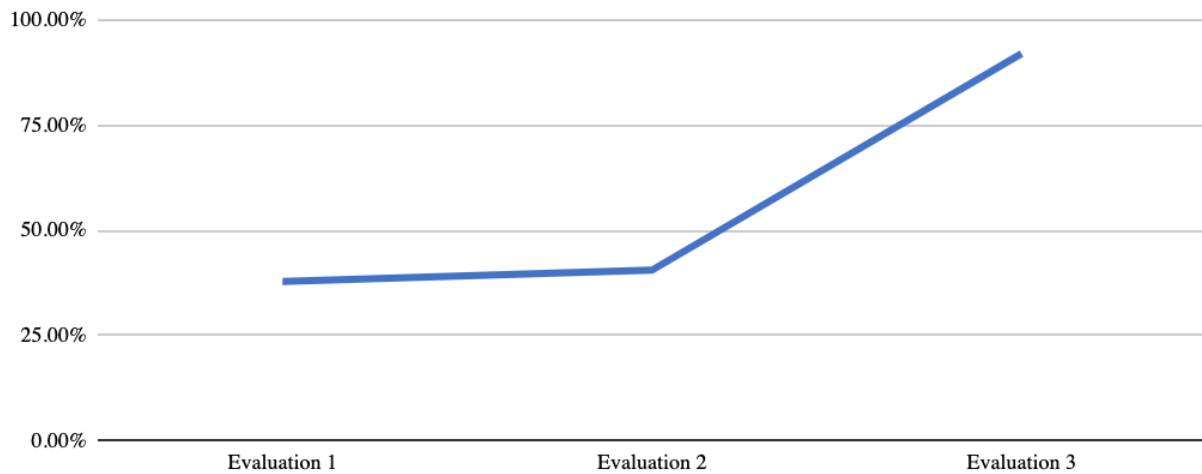
Figure 10. Students familiarity with Augmented Reality

Question 13 probes the attitude of students with being familiar with AR technology. After touring the AR museum there was a dramatic increase with the students' familiarity with AR technologies. There was a 51.5 % increase (see figure 10 above). This finding shows that a majority of students had little knowledge about AR before the study and now have an improved understanding of the technology. After gaining this knowledge I read many enthusiastic comments about how students would like to use this technology within their majors, which I detail in section V.2.
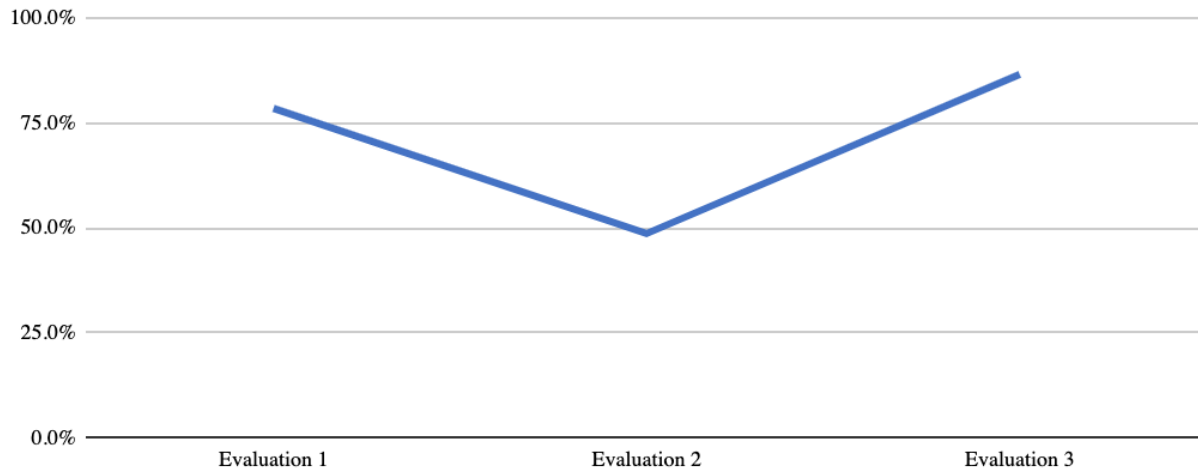
Figure 11. The use of Augmented Reality in the Classroom Enhances Student Learning

In question 14 students' positive attitude of AR significantly dropped after reading the book assignment and completing Evaluation 2 to less than half positive that AR would enhance student learning. This could have been because some students felt they had learned enough about the topic through the readings, or the reluctance of having to take time out of their schedule to tour the museum. After completing the tour and Evaluation 3 the students had an 87% positive attitude toward using AR in their learning experience. This 38% increase was the largest shift in attitude in the surveys, besides students becoming more familiar AR in general.

V. 2. Analysis of the AR Tour Assignment

This section presents the analysis of four open-ended questions that were part of the students' assignment that accompanied their AR tour of the Hispanic Cultural Center. These questions include: 1) How did the use of AR change your museum experience? 2) Would the tour experience be different without the use of AR? If so, how? 3) How do you think AR can be used

in the future to teach subjects related to your major (please state your major)? 4) What additional comments would you like to add regarding your experience?

On examining the first question of how the use of AR changed the museum experience finds the students' enjoyment of a personalized tour in which they got to use their device. When stopping at the first stop and seeing Professor Devine pop onto their screen students expressed that it felt like a true extension from the class. Many students have never experienced anything like this before and they portrayed excitement with this new experience. Many of their positive attitudes from the evaluation were reflected within their short answers. Students excitement was shown in short answers responses. One student said, "The augmented reality was very beneficial because it is a more interactive way of learning, interacting and acquiring knowledge to what was displayed" and another stated, "augmented reality made static displays come to life and made me more engaged to the information being presented". The students repeated that the information was coming to life and their attention constantly being grabbed with the subsequent stops. They were impressed by the amount of information that was comprised within a small area and the depth that was added to the existing space through oral histories

The second thing that I saw from the student responses was how interactive the experience was for them. They were impressed with the personal feel of primary accounts that helped them have a deeper understanding of the past. Many students expressed how they were immersed within the museum, and how the content came alive. One student responded, "Hearing life-stories personalized the historical content and felt the most effective in learning. The social aspect of having a face comfortably conversate also assists in the understandability of information presented. I also noticed that simply by causing me to be slower traversing through the museum, I took the time to view and enjoy more of the information provided than just what

was required of me." The students enjoyed the scavenger hunt aspect of finding the stops around the museum, with the help of a map that was provided with the packet. Even shy students found comfort by AR stops instead of having to ask people at the front desk for help or information. One student expressed, "And for me, a person with dyslexia, it was much easier to understand the information being presented to me." Further research could be conducted on other learning disabilities, and what effect that AR has on aiding students with disabilities.

The final theme I saw from this question was a connection to the community. Students expressed that this experience was like going back in time. Within the confines of the building that housed the original Hispanic school, the students heard the voices of past migrants and participants felt a connection to the Hispanic population. Students that consider San Marcos home express a great appreciation for better understanding the struggles for equality through first-hand accounts and students who were new to this city appreciated understanding the past, and how current issues are causing continued hardship.

For question two on how the tour would have been different without the use of AR the students said that there would be a lack of connection that they felt while using augmented reality. There would have been a drastically different feel that would be the same as a customary museum. They expressed that they would have lost focus having to read everything off the boards. A student explained, "It would take out a level of immersion which I believe to be necessary when researching things like this." There was a resounding response that students would have been bored and not engaged as they would have with AR complementing the existing museum.

The second aspect that students would have said was missing was the lack of direction the augmented stops provided. The students enjoyed going from stop to stop and would have

found the assignment more difficult finding all the information on placards. The placards are located throughout the building making it difficult to find the information for the assignment by themselves. The additional information would have needed to be displayed as well, which would have led to a lack of organization. One student stated, "I would not have retained as much information if I had walked through myself." The voices that were triggered at different stops almost worked as a guide around the museum with different personalities at each stop.

The final concern the students voiced is the issue of availability. It would be difficult to have large numbers of students that show up to the museum for a tour with the limited number of tour guides. Students would not have been accommodated. The students would be missing the self-paced aspect that made it convenient to tour on their schedule. Tour guides would have needed to be trained and that would take time from the busy schedule of running the front office. Existing information from Centro could have been used for the assignment but any additional oral histories or new information would have been difficult to portray.

When looking at question three on how students think AR could be used in future to teach subjects relative to their major there were a variety of answers coming from multiple disciplines. The aspect that students enjoyed, and that could be relatable to their majors, was the versatility of AR and using it for a deeper view that can provide a better perspective and understanding of their disciplines. A student studying geography stated that "Augmented reality could be used to highlight daily norms for those in poverty or unjust environments as well as comparing the daily norms of the privileged could motivate people to work towards equality and demand environmental awareness." Many students answered the question as it related to their future careers. One political science responded, "You could use AR to recreated major court cases and political speeches to put people in the moment." Examining the business students'

responses, they thought that it could be used to help with different training for workers within corporations. Future teachers thought that this technology could be used to bring classrooms alive and help provide resources to virtual classrooms around the world. Art majors that have toured many museums said that AR could help artists connect their art through interviews and explanations.

A theme that students presented was wanting to recreate traditional collegiate learning spaces by using AR, in the place of lectures. Psychology students thought about creating different hallways to frame different experiments from psychologists and to display famous theories along with examples. They brainstormed developing a model of a human brain that would be triggered to teach you about different parts and functions as a study tool for exams. An International Studies major said, "I think that AR can achieve to bring more visuals into the classrooms making lessons more memorable than only through reading about a subject. The information can be consumed at a different location more than only the museum." Political Science majors talked about recreating famous court cases and displaying at different political speeches throughout time.

The Geography majors' suggestion centered around recreating a sense of place with the power of augmented reality. They want to display human experiences from different perspectives that highlight daily norms around the world, focusing on inequalities. A physical geographer envisioned AR helping to recreate a place that would show the plants that used to grow within that area before some pesticide or deforestation had destroyed them. World language students talked about creating an immersive room that would display whatever language they were trying to learn. They pointed out a way to truly learn a language is to be immersed by the language, and AR could be a tool to help create this immersion in a nonconventional way.

When looking through the additional comments that the students expressed in the fourth question that was purposefully broad to allow the students to openly reflect on their experience students reiterated their positive attitude towards their experience on the AR tour. They enjoyed engaging with the community and seeing a different side of San Marcos. One student said, "I adored going to the museum, so much so I have gone three times and I am planning to take my mother. They have it set up in such a way that feels so comforting and homely with accurate historical information and beautiful Hispanic arts. I frequently lost myself in appreciation of the true beauty of culture." The students that were from San Marcos were appreciative that the Hispanic population was highlighted. Outside of the enjoyable experience, most comments dealt with the technical difficulties that the students dealt with, while on the tour. Some were annoyed with the HP reveal app and wished that there was an improvement in technology that would better the experience. Many students were frustrated having to re-watch the videos and thought that there should be more time spent developing the tour for future classes. Many students expressed that with the right funding, this technology could change education, and make people excited about learning through their phones. Many graduating seniors expressed that they were very excited to have this experience using this technology before graduating.

V.3 Recommendations for improving the effectiveness of Augmented Reality in Geographic Education

This section concludes this chapter by reflecting on how AR in geography education could be improved for the future. I argue that there are four key areas for improvement: 1) To have stakeholders facilitate the creation of an application that could be utilized worldwide by geographic education teachers. 2) To conduct more research focusing on how AR can be used as

a geographic tool in the classroom. 3) To consult with a range of teaching professionals to determine how this technology should be implemented. 4) To work with computer programming experts to produce world-class educational products.

First, geographers need to examine the creation of a geographic education application that could be utilized worldwide by teachers. After spending many hours creating the AR Museum at the Hispanic Cultural Center, HP Reveal discontinued the application, making the AR tour of the museum obsolete. When first introduced in 2011 Aurasma, later rebranded as HP reveal, was touted to teachers as a free educational resource provided by the company Hewlett-Packard. The application was funded by ambitious marketing projects such as a campaign for the JJ Abrams film Super 8 (Daw, 2011). In 2019 HP decided to retire the application, leaving teachers in a scramble to transfer their units onto a new platform. In the world of educational technology, application retirement is commonplace for technologies tied to big companies such as HP, Apple, and Google. The users of HP Reveal, iTunes U, and Picasa are left to recreate their resources on alternative applications.   Perhaps if an educational application was created and maintained by grants and donations, it would prevent this service interruption to future projects. One application could be created to serve as a collaborative global tool for all geographers. The app would be cost-effective for teachers and schools, AR products could be created with zero printing cost and interactive maps could be displayed by projection and can be operated by a single smart device.

Second AR is an exciting new tool, but geographers more research is needed to examine how AR can be used as a geographic tool in the classroom. This can be done by collecting the different AR practices currently used in the classroom. We could ask big thinkers in educational technology to come up with additional extensions. The results could be posted as a resource for all teachers to expand and extend their practice. Additionally, we need a conversation between

geography stakeholders focusing on deciding what the layers of information should be presented and what questions we want to ask our students to answer. Most importantly geography teachers need to be adaptable to any upcoming changes. There will be an endless amount of possibilities for growth as this technology progresses to display information to our students about the world, but we have yet to see how this technology will evolve.

Third, we need to consult with teaching professionals at all levels to determine how this technology should be implemented. Teachers know what is best for their students and we must have vertical and horizontal collaboration to create effective tools for students at all levels. Discussions need to be held to see if separate apps need to be made for primary and secondary teachers. Efforts need to be made to make sure that all teachers are embarking from a level starting point. Often lack of professional development, access to resources and varying skillsets alienate teachers from adapting new to technologies.   Any new application must be tested and reevaluated regularly using information directly from the students and teachers who are interacting with the program.

Fourth, Centro's AR experience was produced using my iPhone, and its applications. The result was functional but very amateur. With the correct combination of features on one application, a teacher would quickly be able to produce high-quality products for their students. Creating high-quality how-to video guides could also facilitate the creative process. Many new applications hit the market only to fail, due to crashing errors and lack of usability. To prevent the creation of this kind of application geographic educators must consult with experts in computer programming to produce world-class educational products.

VI. Conclusion

Augmented reality (AR) can become an effective tool to bridge the digital gap between teachers and students. AR can simply be a way to display content through an image-based system to show how concepts and places are interconnected, or as complex as a location-based system of adding layers to our physical world. The purpose of this directed research is to examine the attitudes students had towards using AR and their learning experience. To achieve this aim, this project posed and answered the following questions: How can AR be used in geographical education to help students achieve learning objectives? What additional benefits does AR bring to students' a) education and b) learning experiences? What are the challenges of integrating AR into geographic education?

To answer these questions, I created an AR museum tour at Hispanic Cultural Center in San Marcos, Texas, that unveiled the struggles for equality by the Latin population of San Marcos through oral histories and archival material. I surveyed students' attitudes in a Political Geography course at Texas State University before the assignment was introduced, during a conventional reading assignment and in-class lecture, and after their educational experience with AR. The students' learning objectives were created with the course instructor to learn more about the racial segregation in San Marcos, TX, familiarize themselves with the history of the Hispanic community, and understand the impacts of gentrification today.

The results of this research demonstrate that the use of AR for the student's assignment increased their knowledge acquisition and improved the quality of their learning experience. There are four main identified benefits of AR emerging from this research for geographic education. First, the personalization of oral histories being used for the overlay allowed students

39

to connect with the stops as if the person was present. Second, the accessibility of the students and the public to view the tour with their own devices brought convenience to visitors and reduced the cost of the project. Third, AR versatility allowed me to create different types of stops and can be applied to many other subject areas. Fourth, the AR transformed a traditional learning space with new content provided by Centro.

The data demonstrates that students' attitudes were increasingly positive in using this new tool, growing 13 per cent from the experience. Additionally, the students' positive attitudes for their learning grew 12 percent and their attuites towards the history of the Hispanic population of San Marcos grew 27.5%. From these results, we can conclude that AR had a positive experience in the learning and attitudes of the students. AR is an exciting new educational tool that is just starting to be used by educators to connect with the modern-day digital learners. The benefits are clear, and more courses should be inclined to include portions of AR in their curriculum in the future.

This study also identified several challenges and barriers to implementing AR in geography education. These include the reliability of the HP Reveal to stream the AR content without interruption and participants having to restart from the beginning if there was an issue. Another technical issue dealt with the audio of two of the stops, they had a lower sound volume of some of the devices. HP reveal discontinued its service following the project's completion which will require the museum finding a new platform to display the AR content.

These insights contribute to the existing literature on GIT in geographic education by showing that AR can more cost-effective and have lower tech barriers than GIS. Albeit the initial cost and upkeep of developing a standalone geographic education application would be substantial, the long-term benefit of engaging students in technology that they are already using

daily will far outweigh the costs. This study is one of the few mixed-method studies focusing on

AR in geographic education. Future studies are needed that focus on best learning practices for

implementing AR in classroom settings. This implementation could focus on long-term project-

based pedagogy or used in daily classroom activities. AR has the potential to change the

landscape of the geographic community in the same way as GIS. Both technologies help students

visualize the world around them. However, the ease of accessibility could allow AR to become

more accessible to the general public. To use the GIS system a student needs to be formally

trained to produce high-quality results. AR is more intuitive and can be used by students from

primary to collegiate levels. At this point, AR warrants a closer look by teachers as a tool for the

future of education.

VII.   Appendix Section

Appendix A: Augmented Reality Tour Assignment

Political Geography 3400: Understanding the racial geographies and histories of racial segregation of San Marcos through Augmented Reality

This assignment consists of a museum visit *to El Centro Cultural Hispano de San Marcos* (San Marcos Hispanic Cultural Center) and taking the Augmented Reality (AR) tour. The tour discusses the history of Mexican Americans in San Marcos and their contributions to the city. The goal of this assignment is to connect you with the history of the city of San Marcos as a way of understanding past and contemporary race relations in America, racial inequality, and challenges posed by development and growth.

Learning Objectives:

During this assignment you will learn about the historical origins of the Hispanic community in San Marcos, their struggles against segregation, and successful campaigns for integration and social justice. Schools in San Marcos were segregated, dividing the African American, Hispanic, and white populations. While completing this assignment you will familiarize yourself with the impacts and legacies of discrimination. You will analyze the difference between *de jure* and *de facto* segregation policies in San Marcos, and how past segregation impacts contemporary development of the city. While touring *El Centro Cultural Hispano de San Marcos* you will learn about the role Hispanic culture, music, and holidays that have been diffused in the community. A part of the tour will examine the role GIS played in addressing racial injustices. During the tour you will be responsible for reading all displays and interacting with the augmented reality stops with your smartphone or tablet.

This assignment is comprised of various steps:

1. Visit the *Centro Cultural* between October 7th – November 8th and complete the Centro AR Tour Assignment. The tour will be comprised of 10 stops. At each stop, students will read the information on the display board, engage with the AR material and answer a question or two based on the material presented.
2. After completing the tour, complete the reflection part of the assignment by November. This reflection assignment contains open ended questions.
3. Upload the Tour Assignment and the Reflection assignment to TRACS by November 8th.

How to use Augmented Reality in the Museum:

1. Download HP Reveal from the App Store to your phone *before going to the museum*.
2. Bring a set of headphones to take the tour. There are limited headphones available at the Hispanic Cultural Center to borrow.
3. **When arriving to the museum, YOU MUST SIGN IN at "Gloria's Office."**
4. If you do not have a smart phone, you can borrow a tablet at the Center starting October 8 if you bring your ID and give it to Gloria or whoever is working in the office.
5. If you have any issues with HP Reveal on your phone, restart the app.

1. OPEN HP REVEAL APP

2. SCAN THE QR CODE

3. FOLLOW CENTRO AR MUSEUM
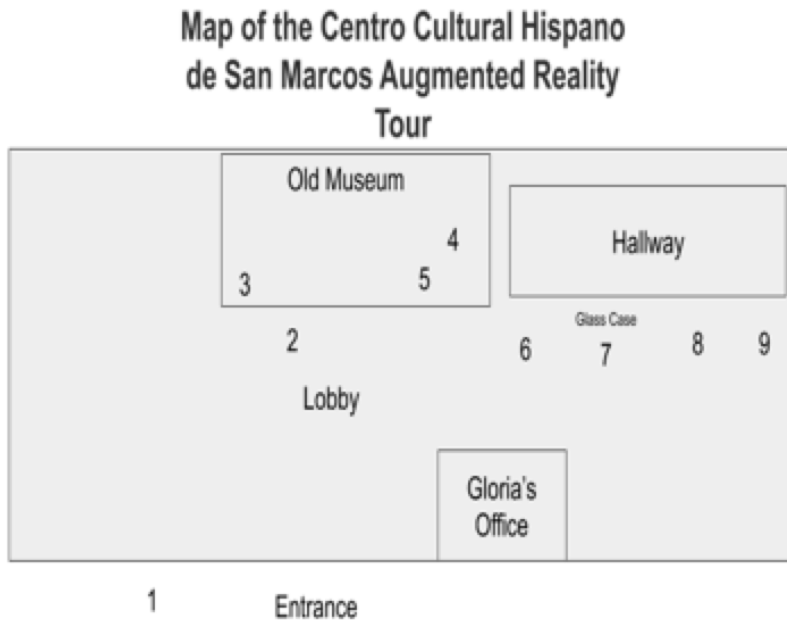   *(Best to follow in app)*

SCAN ME

Use blue button in HP Reveal to scan.

GETTING CONNECTED EASY AS 1 2 3!

Location of Augmented Reality Stops in the Center:

Map of the Centro Cultural Hispano de San Marcos Augmented Reality Tour

Old Museum

3   5   4

Hallway

2

Glass Case

6   7   8   9

Lobby

Gloria's Office

1   Entrance

Questions to answer during the Museum Visit:
Answers should be approximately 50 – 100 words long.

Stop 1: Historical Introduction (Sign Outside of the Building)

1. Were schools in San Marcos segregated? If so, how and until what year? Where were "the Mexican School" and the "Negro Schools" located?

Stop 2: "Welcome to the Centro" Sign (Green and Orange Sign in the lobby)

2. What are the goals of the *Centro*? Why was it founded? What programs does it offer the community?

Stop 3: "Migration Histories" (Inside the museum to the left)

3. When and from where did many of San Marcos' Hispanic populations immigrate from? What dynamics prompted their migration?

Stop 4: Claretian Mission History (Inside the museum)

4. What are Claretian missions? What role did the mission play in the establishment of the Hispanic community? What is the name and location of the original Hispanic Catholic Church?

Stop 5: Religious Practices (Last stop inside the museum)

5. How were religious organizations in San Marcos segregated by gender and ethnicity? How did this differ between Catholic and Evangelical churches?

Stop 6: The "Mexican Barrios" (Near the Glass case, left when you exit the museum)

6. What led to the establishment of the *barrios* in San Marcos and what was lasting effect of these neighborhoods? Which neighborhoods in San Marcos were segregated?

Stop 7: Discrimination in the School System (Glass Case)

7. What qualifications did Felipe Reyna have as an educator and what ban on school grounds did he fight against?

Stop 8: Segregated Cemeteries (Continue down the hall on the left)

8. How were African Americans and Mexican Americans labeled in society? How did segregation continue even after death?

Stop 9: GIS and Social Justice (Last placard on the left wall)

9. How was the cemetery's history preserved by using GIS?

Stop 10: Conclusion Stop

Part II: POST TOUR REFLECTION (to be completed after leaving the Centro)
Answers should be approximately 50 – 100 words long.

1. Which aspects of San Marcos life were segregated for Hispanics? Give three examples of *de jure* and *de facto* segregation.

2. Why is important to remember a) the history of segregation in San Marcos and b) the hard-won rights of Mexican Americans in our community?

3. How does the history presented in the museum explain the racial landscape (location and distribution of different racial/ethnic groups) of San Marcos today? (Find San Marcos on this map to understand the racial geography of the town today: https://demographics.virginia.edu/DotMap/)

4. How are current pressures for development (gentrification) impacting residential patterns of different communities in San Marcos?

5. What benefits and limitations did you experience using Augmented Reality (AR) in your tour?

6. How did the use of AR change your museum experience?

7. Would the tour experience be different without the use of AR? If so, how?

8. How do you think AR can be used in the future to teach subjects related to your major (please state your major)?

9. What additional comments would you like to add regarding your experience?

Appendix B: Student Evaluation: Learning Attitudes and Outcomes

Directions: [Check/Tick] your reaction to each statement. Please reply to all items; there are no "right" or "wrong" answers. Choose whether you: Strongly Agree — Moderately Agree — are Neutral or have No Opinion — Moderately Disagree — or Strongly Disagree to each statement.

	Strongly Agree	Moderately Agree	Neutral/ No Opinion	Moderately Disagree	Strongly Disagree
1. I am familiar with the history of the Mexican American community in San Marcos, Texas.	☐	☐	☐	☐	☐
2. I am familiar with the history of racial discrimination against Mexican Americans in San Marcos.	☐	☐	☐	☐	☐
3. Contemporary residential segregation contributes to segregation in American schools.	☐	☐	☐	☐	☐
4. Racism is a problem in the United States.	☐	☐	☐	☐	☐
5. Gentrification is a concern in American cities, especially in historic neighborhoods of communities of color.	☐	☐	☐	☐	☐
6. Learning about past practices of racial discrimination is important to understand society today.	☐	☐	☐	☐	☐
7. I am concerned about gentrification of historic districts in San Marcos.	☐	☐	☐	☐	☐
8. I want to be more involved in the larger San Marcos community	☐	☐	☐	☐	☐
9. Museums and cultural centers are important places to support multiculturalism.	☐	☐	☐	☐	☐
9. Visiting museums is a valuable learning experience.	☐	☐	☐	☐	☐
11. I like to use new technology in the classroom.	☐	☐	☐	☐	☐
12. Using geospatial in the classroom enhances my learning.	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

13. I am familiar with Augmented Reality technology. ☐ ☐ ☐ ☐ ☐

14. Augmented Reality should be used <u>in classrooms</u> to enhance student learning. ☐ ☐ ☐ ☐ ☐

15. Augmented Reality should be used to enhance <u>museum</u> learning and engagement. ☐ ☐ ☐ ☐ ☐

VIII. References

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