LEGENDS, LINES, LEARNING: GIS MAP FOCUSED CURRICULUM AND ITS EFFECT ON STUDENT LEARNING AND ENGAGEMENT

by

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DEDICATION

To what brought me out to Montana. To what made me stay. To what allowed me to leave.

ACKNOWLEDGEMENTS

This would not have been possible without Erika Malo and her support of my education for the years I had the privilege of working with her. Thank you also to Elizabeth Reetz who initially collected and organized this data for another project and shared her work so I could analyze it for my capstone. Thank you to those within Project Archaeology who helped, went above and beyond, and did so in light of unforeseen disruptions.

Thank you to my grandparents for their decades-long encouragement of my passion for science—whether that was tracking sharks on an app, obsessing over turtles, collecting shells, or looking through an ancestor's microscope. Thank you for your support and help.

To my Mom, Dad, to Lucas, Will, and Claire, thank you for trusting me to know what I wanted when I was three in becoming an archaeologist. Thank you for participating in research projects, from data collection sheets to stocking the freezer with an ungodly amount of bread. Thank you all for fostering an environment where I could learn, study, ask for advice, or get pushed at a wavering point.

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ABSTRACT

Though maps have been part of classroom curricula for thousands of years, digital mapping resources are a new tool for teachers. However, how effective are digital maps, like GIS, at teaching students historical as well as science, technology, engineering, and mathematics (STEM) information? In this study, five 7th and 8th grade level classrooms in Montana and Wyoming were given a curriculum with GIS maps to pilot. The results have shown that students learn very well with GIS maps and absorbed the information. The data showed that student confidence with STEM and digital learning platforms increased. Additionally, the qualitative data from the teachers showed that ArcGIS is a user-friendly platform they enjoyed using as a teaching tool. These results indicate that digital maps, like physical maps, are valuable teaching tools from which students benefit.

CHAPTER ONE

BACKGROUND AND INTRODUCTION

Context of the Study

In the late 1900s, it was clear that looting of archaeological sites and artifacts was an increasingly severe issue that needed to be addressed. After more traditional solutions, like law enforcement, failed, archaeologists, tribal members, and government workers decided to try an education-based strategy. They taught children and young adults the importance of stewardship and archaeology, as well as ways to protect cultural heritage. These lessons caused looting rates in the United States to fall (Project Archaeology, 2019). As a result, the Bureau of Land Management (BLM) decided the educational program needed to continue in a funded and sustainable way. From this determination and interest, the organization, Project Archaeology, was created. It was clear that archaeological education was an effective means of curbing the looting problem, but more could be done to give students a comprehensive science, technology, engineering, and math (STEM) oriented understanding of the United States and its cultural heritage.

Project Archaeology realized that education, archaeology, and technology were not seen as complementary forces in the classroom. This led to the decision to write a curriculum that would help show how interconnected archaeology and technology are, as well as how maps can provide deeper understanding of the topic of migration. The curriculum was tested in five different classrooms in Montana and Wyoming. While the schools varied a great deal in size and student ability, they were all relatively schools with class sizes of less than twenty-five, and all the students were at a seventh or eighth grade level. Due to the COVID-19 pandemic, classes

used a mix of in-person and online instruction. Though some teachers were intimidated at first by the inclusion of technology, all of them grew excited about using it with their students.

Archaeology is becoming increasingly dependent on technology, especially on digital mapping resources. It is a new standard that sites be digitally mapped and rendered. While excavation is still important and useful, mapping is emerging as a new data-gathering powerhouse, slowly shifting the discipline away from gridded excavations. Technology is also an ever-present component of daily life. It is imperative that young students are exposed to technology and gain the skills to interact with it before entering the professional world or even their undergraduate education. The curriculum used in this project works to help students better understand the different types of migration, the complex history of westward expansion within the American West, and how to become good stewards of the land.

Focus Question

My focus question was, Does GIS mapping technology have a positive effect on teacher and student learning experiences, student engagement, and mastery of the curriculum material.

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Maps in Education

Maps are extremely powerful learning tools that have been used in classrooms to explain everything from geography to historic events both in early Mesopotamia thousands of years ago as well as in modern middle schools with digital mapping games (Rank, 2018). Maps are used in a variety of settings and ways to help young students learn about geography. Using maps as a teaching tool started early in children's education. In the 1700s, maps were presented to students as puzzles, teaching them critical thinking skills, problem solving skills, as well as mapping and geography skills. Maps have continued to be used in classrooms as a teaching tool to emphasize geographical and social knowledge (Olson, 2012).

Currently, modern technology has played the role of digitizing maps for students to use as educational games and study tools. Engagement with maps can enhance a students' spatial awareness and inspire curiosity. Even if maps are casually incorporated in video games, puzzles, or board games, physical and digital maps play an important role in these informal settings for student learning as the maps emphasize the ability to recognize topography and build spatial reasoning skills (Olson, 2012).

Maps have been shown to have the ability to improve learning and geography lesson retention. This is likely due to the way a map distributes information. Rather than showing information in one way like an image, maps have the unique ability to display and store visual, geographical, and historical information. Maps inherently have two types of cues that encourage recall: structure and feature. Structure refers to the layout of the map while feature refers to the

labeled attributes, like names of cities, mountains, or oceans. Both qualities help students remember and retain information because it is displayed in multiple different ways; mountains are distinguished with topographic lines and color changes as well as labels. Overall, maps are shown to be tools that enhance student learning at little to no cost to the teacher (Diana & Webb, 1997).

Though maps can easily be used in science classrooms to convey great amounts of data, they can also serve a larger function in history and social studies classrooms in addition to geography class. Maps can provide students with geographical and historical context. For example, a teacher can use a large map to reenact a historical battle or to show the economic value of trade routes, like the Silk Road, that connected the markets and cultures of Italy and China (Figure 1). When teaching about historical events or cultures, maps can provide a greater depth of knowledge by promoting inquiry. Students can use maps to better understand the true size of an area with scale. Students can also better understand why certain events happened if they can observe geographical barriers that impact events in the area. Students can even use maps to better understand more complex ideas like the transfer and traveling of new ideas, expansion, disease, and trade by watching the growth and demise of civilizations on a map (Tarr, 2016).

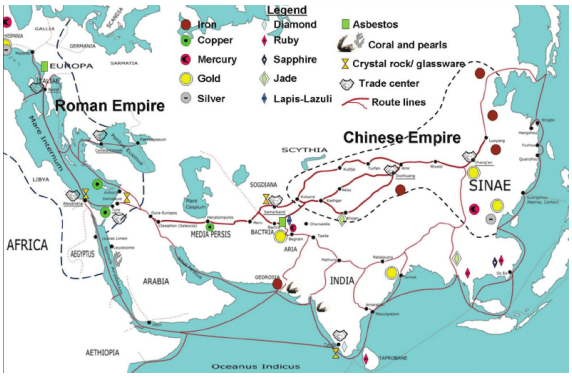

Figure 1. An informational map displaying geography and historic trade (Lopez et al., 2011).

Within the classroom today, maps have largely been reduced to tools used for basic memorization of facts, like state capitols or the location of European countries. However, the original idea of incorporating maps into classroom learning was to allow students to form their own opinions about spatial relationships, maps, and their overall importance within a wider historical context. These skills would help students foster their own understandings and reach individual conclusions. With students understanding spatial relationships and historical context, problems and conditions of an area could be clarified with geographic concepts (James, 1990). While many maps are physical print maps, digital maps like Geographic Information System maps, a modern type of digital mapping software, have become prevalent. GIS technology and digital maps can provide historical context for world events, further allowing students to better understand spatial and contextual relationships through the wider lens of geography (Fitzpatrick, 2017).

What Is a Map?

Though there are many different types of maps, the type most often used in the classroom is a topographical map, or one that displays geographic and political information like state lines, city names, and roadways (McDermott, 1969). Archaeologists have discovered that maps were present very early in human history, and some of the oldest maps ever found are over 10,000 years old. Inuit peoples carved maps into driftwood and Marshallese islanders created maps of far oceanic islands with sticks and shells (Figure 2). This suggests that the human brain has been capable of understanding geography, spatial relationships, and how to relay information through a drawing for a very long time. Maps have been used as a teaching tool for people for many thousands of years (National Geographic Society, 2012).

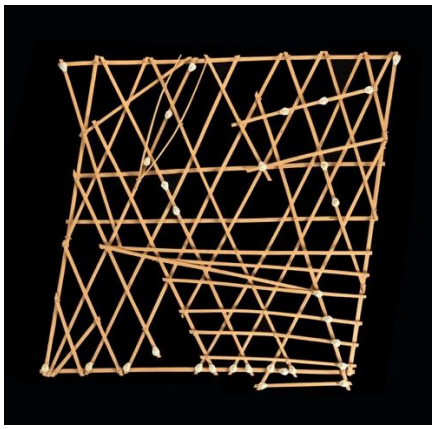

Figure 2. A Marshallese stick map from the Denver Museum of Nature and Science (*A.926.1*. (n.d.).

Today, maps have a slightly different definition from their ancient form. Archaeologists and geographers accept ancient drawings as maps when they relate in some way to the surrounding environment. These ancient maps qualify as maps even without an established scale, legend, or labeled orientation (National Geographic Society, 2012). Today, a map must have this kind of associated information in order to be used as a resource. These are necessary qualities for maps used within a classroom as well, as details about who made the map and why help students better understand geographic knowledge and gain an understanding of spatial relationships within a historical context (Van Cleef, 1948). At their core, maps are tools that can help people better understand data in a visual form and translate it into a verbal result (McDermott, 1969).

Technology in Education

As technology has advanced, geographical classroom tools have also become more complex and high-tech. Technology has been a fairly consistent addition to the classroom for many years. There is a great deal of simple technology that can make a positive difference in a student's quality of learning. For example, classroom response systems are devices that allow students to remotely answer questions, a process that gives the teacher idea of how learning is

going and break up the monotony of lectures. E-lectures are another way to help learning. Lessons can be recorded and uploaded online, helping students who could not attend class or need a refresher. Similar to the Geographic Information System (GIS), Virtual Reality (VR) is another complex and advanced form of technology that helps learners that uses devices like goggles to display realistic images in 3D, simulating a real experience. VR can be paired with maps, like Google Earth, to see ancient cityscapes (Sprenger & Schwaninger, 2021). It can also be used in science class for students to see endangered biomes or animals, like coral reefs, engendering empathy and an interest in preservation (Leeson, 2016). Certain types of technology can be simple to incorporate into the classroom, like digital lectures and classroom response systems, and are devices educators have recently embraced as teaching tools. Other more complex and complicated technologies, like virtual reality (VR), are seen by teachers as simply not being as useful and were found to be difficult to incorporate into the classroom (Sprenger & Schwaninger, 2021).

Overall, when implementing technology into classroom learning, it should not be done under the guise of keeping up with the times but rather a deliberate choice to increase the productivity of instructors and foster deeper student learning. Before implementing new technology, teachers should ensure that they have proper training. Once teachers feel trained and comfortable with the curriculum, technology needs to become part of the everyday classroom routine and scheduled to normalize its presence for students (Guzman & Nussbaum, 2009).

Using Digital GIS Maps in Education

Maps have always been helpful tools for students to learn from and engage with in the classroom. Digital maps are even better that traditional print maps because advanced GIS

technology has made more maps easily accessible and useable in the classroom. New GIS tools can be used by teachers to explain interconnectivity between multiple events with maps, allowing students and teachers to analyze an event and the location, and impact of geography (Fargher, 2019). GIS mapping technology can help students understand natural phenomena as well as the geographic context for events throughout the world (Fitzpatrick, 2017). Teachers currently using GIS in their classrooms have noted a positive effect on student learning, but these efforts must be sustained to continue having an impact. This means teachers must be supported so they can stay up to date with new technology and the training necessary to use it as a teaching tool (Fargher, 2019).

Though physical maps are wonderful teaching tools, GIS digital maps possess greater advantages for learners, such as exposure to new technologies, training in computer skills, a wider range of available maps to study as well as the technological tools to manipulate them, the ability to see how certain variables of geography impacted events or cultures, and a better understanding of spatial relationships (Figure 3). The technological capabilities interactive GIS maps allow students to use can enhance a student's critical thinking skills, ability to problem solve, and widen their world view. Ultimately, digitized maps like those on the Environmental Systems Research Institute (ESRI) give students a sense of agency, control, and power in a way that positively impacts their learning and performance. The GIS maps and curriculum also encourage a level of exploration that physical maps do not, which in turn increases motivation and inspires students. GIS maps and lessons were shown to increase student interest and productivity (Songer, 2010).

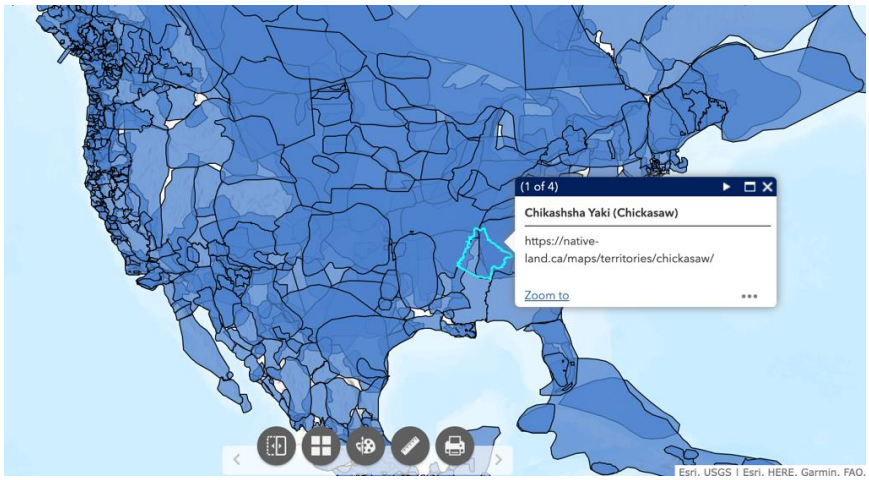

Figure 3. Online GIS map from Project Archaeology Investigating Migration displaying Native American territory boundaries (Project Archaeology, unpublished).

GIS can be an effective tool for engaging and teaching all ages. Even though it is complex technology, research shows it can be an effective teaching tool with younger audiences. GIS education is based on the idea that geographical teaching has been focused for too long on memorization of names and places rather than focusing on understanding the role history has in shaping geographic realities (Shin, 2006). GIS technology helps break this barrier and move towards what geography education should be—understanding how to analyze issues that relate to geography. GIS is a tool that encourages students to explore further. Because it has so many features and components, it inherently encourages students to want to go deeper on a topic. One issue that is shown with using GIS in classrooms is that it takes students some time to get to the point of active engagement. It is a complicated tool, so it takes a little time for students to feel comfortable with it and inspired by the information it reveals (Shin, 2006).

In addition to students needing time to get used to the new way of learning, teachers also face challenges with GIS technology. There is a lack of infrastructure to support classrooms interested in incorporating the technology. Teachers must learn the new system, familiarize themselves in order to create a new lesson, and then manage students learning with the

technology for the first time (Shin, 2006). These efforts are arguably worthwhile for several reasons. Online GIS can be user friendly after spending a little time working with it. Additionally, after figuring out a lesson, grading, and a student management system, GIS becomes like any other lesson taught in the classroom, but with the potential for bigger impacts. GIS learning can also encourage students towards careers in Science, Technology, Engineering, and Math (STEM) (Beshay, 2019).

CHAPTER THREE

METHODOLOGY

Demographics

This project collected data from five different classrooms in Montana and Wyoming. Each teacher and classroom had different sizes, ranging from four students to twenty students. The classrooms were in different locations. Some schools were in very remote locations while others were in bigger cities, like Casper, Wyoming or Bozeman, Montana. There was a total of 82 students who participated in the project and five teachers as the treatment group. While a total of 82 students participated, due to issues with students being out sick or quarantined with

COIVD-19 or other interruptions, only 33 students fully completed the Learning Migration Though Maps Pre and Posttest. One final classroom in Bozeman served as a non-treatment group and participated in the pre and posttests without being taught the curriculum.

The data collection was completed with the piloting of the curriculum. I wrote the curriculum and collaborated with five different teachers who implemented the same curriculum in their classrooms. This curriculum was written in stages, and I wrote the mapping and final sections, edited and/or rewrote the first four lessons, and worked with the other stakeholders and authors—Courtney Agenten, Jeanne Moe, and Erika Malo—to do final edits of the lessons. The maps were created for Project Archaeology by independent contractor, Samantha Kirkley, and. later redone by SEARCH, Inc. a private archaeology firm. To secure parental permission of the students, I created pre and posttests that were blind with educational consultant, Elizabeth Reetz, along with editing input from Courtney Agnenten, Jeanne Moe, and Erika Malo. With blind pre and posttests, I learned no personal information about the students. The students gave themselves anonymous codes at the beginning of the pre and posttest based on answers to questions like, "How many pets do you have?" and "Write the first two letters of your teacher's last name." Since the data collection was done during the piloting of a curriculum in classrooms that I did not teach in, Project Archaeology hired an independent contractor, Elizabeth Reetz, to help collect and organize data to ensure it was collected blind. Once this data was collected and organized, Elizabeth Reetz shared the data so I could independently evaluate it for this project.

Though the classroom sizes and locations were different, all of the classrooms were at either a 7th or 8th grade level. One classroom was technically in 9th grade, but the teacher assessed the students at a 7th or 8th grade level. The teacher explained the students were severely behind due to the delays the COVID-19 pandemic brought on the school and individual students. All the

classrooms used were history classes, though some had different specific focuses. This project's curriculum on Migration and the Overland Trail matched well with the overall planned lessons from the teachers.

Students took the Learning Migration Though Maps Pre and Posttest either with Google forms or written on paper directly before the teacher taught the full curriculum (Appendix B). The treatment included the full instruction of *Project Archaeology: Investigating the Overland Trail* with two accompanying online GIS maps (Agenten & Hodge, unpublished). The treatment ended when students took the Learning Migration Though Maps Posttest after they had finished the curriculum's final assessment (Appendix B).

Project Archaeology: Investigating Migration is a curriculum written for 7th and 8th grade on the topic of migration. Students first learn what migration is and how it can look different based on the time and people. Then, the curriculum discusses what archaeology is and how archaeologists use digital tools like maps. The curriculum uses the Overland Trail and two online GIS maps to further investigate migration. Students end by learning proper stewardship practice and with a debate. The curriculum was written in stages with the bulk written by myself and early drafts written by Courtney Agenten with editing and help from Erika Malo and Jeanne Moe. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Data Collection Instruments

The Learning Migration Though Maps Pre and Posttest used a combination of question types. Many of the questions were open-ended, so students could write answers that provided

information on what they did and did not know. The questions were written to gain an understanding of a student's knowledge about migration, Native American history, archaeology, their general level of comfort with maps, and their understanding of ArcGIS. The test consisted of 18 questions containing prompts about history, mapping skills, and archaeology. There were two Likert style questions, the first asking students to rate how comfortable they were reading maps and the second on how comfortable they were making maps. There were also two multiple choice questions. One of these was a yes or no question asking if they had made a map before. The second asked students if the relationship between settlers and Native Americans was positive, negative, or both. These four questions were analyzed separately. The remaining 14 questions were short answer. These short answer questions were coded on a scale of zero to four.

The Learning Migration Through Maps Pre and Posttests answers were scored with five different codes. A code of zero was given for non-existent answers, such as a blank answer or when a student answered "idk" or "I don't know." A code of one was given for answers that were "under-developed," meaning the answer was completely inaccurate, incorrect, but was not blank or "I don't know." For example, an answer that got a score of one was "Europeans/Americna settlers migrated or imigrated to the U.S. becoming the fist or native americans." This answer is completely inaccurate, minimally developed, and did not answer the question fully.

A code of two was given for answers that were minimally developed, meaning the answer was partly accurate or answered a part of the question. For example, an answer that got a two code was "books, websites" for a question asking for two examples of primary sources. This answer received a two because it was minimally developed. Though the student answered the

question and books and websites can be primary sources, it was not clear that the student understood what a primary source was.

A code of three was given for answers that were well-developed, meaning the student fully answered accurately and did so well. For example, an answer that got a three was “Take a picture of the place to be able to show archaeologist, and put a pinpoint on a map where the location is so that archaeologist can go back and collect more data.” The question asked what to do if you find an archaeological site. The student fully answered the question with an accurate and fully developed answer, earning a code of three.

A code of four was given for answers that were highly developed or outstanding. For example, an answer that got a four was “Migration has impacted the united states in many ways. It has become a political debate with some wanted to such everyone out and others who want to let people in. The now former president campaigned on building a wall to keep the immigrants out, and had a ban on immigration. The current president; however, is expected to reserve these things.” The question asked how immigrated impacted the U.S., and the answer earned a four because it was well developed, accurate, and went above and beyond in terms of answering the question. The treatment pre and posttests were coded by four individuals to create standardization. The nontreatment pre and posttest were coded by two individuals due to scheduling difficulties. The averages of these scores were what contractor shared and were used in this project.

These short answer—or open-ended—questions were analyzed after their code had been assigned. Basic analysis was done with the mean, median, and mode. The median, or average, was this most important for this study since it highlighted the average growth from pre to posttest as well as individual student improvement and question improvement. These pre and posttests

could have a score of between a minimum of zero and a maximum of four, so average improvement is reported within these boundaries.

In addition to looking at mean, median, and mode, the normalized gain was also calculated, as well as the average of gain and the gain of averages. However, due to the small sample size, the effect size was the most telling calculation (Hake, 1998). In addition to regular bar graphs to display data, box and whisker plots were also used to show normalized gain (Appendix B).

These were all the ways the coded, short-answer data was analyzed. The Treatment group was taught the full *Project Archaeology: Investigating Migration* curriculum over a period of weeks, taking the pretest prior to the curriculum and the posttest after the final assessment was completed. A total of 33 students were in the treatment group. The nontreatment group took the pretest, waited two weeks, and then took the posttest with no curriculum. The nontreatment group was comprised of 20 students from one classroom in Bozeman, and they were in a class learning about U.S. history at the time. These factors may influence the pre and posttest results.

The Likert-style questions were analyzed by calculating the mean and mode. The multiple-choice questions were analyzed by calculating the mean, mode, and displayed in stacked bar graphs. These methods were done for both treatment and nontreatment groups.

The Teacher Roundtable Questionnaire gathered qualitative data from the teachers who were interviewed together as a discussion during a roundtable meeting. This meeting was recorded and transcribed. This interview data was organized into similar categories and then given different descriptive codes. This feedback helped provide qualitative data on how students interacted with the maps, and how they as educators felt about a map's ability as a teaching tool (Appendix C). The transcript was analyzed and sorted. Every time a teacher mentioned a code in

the transcript as well as who mentioned it was recorded and displayed on a stacked bar chart. This data was then broken down for each question to better understand teacher and student experience.

Triangulation Matrix

Table 1. Data Triangulation Matrix.

Research Question	Source 1	Source 2	Source 3
Does GIS mapping technology have a positive effect on teacher and student learning experiences?	Teacher Roundtable Questionnaire and Discussion	Learning Migration Through Maps Pre and Posttests (with treatment)	Learning Migration Through Maps Pre and Posttests (without treatment)
Does GIS mapping technology have a positive effect on student mastery of the curriculum material.	Learning Migration Through Maps Pre and Posttests (with treatment)	Learning Migration Through Maps Pre and Posttests (without treatment)	Teacher Roundtable Questionnaire and Discussion

CHAPTER 4

DATA ANALYSIS

Results

The analysis of the Learning Migration Through Maps Pre and Posttest data with treatment indicated that 90% of students improved from their Learning Migration Through Maps Pretest to their Posttest scores (*N*=33). Of those students, 53% improved by between 0 and .5, 30% improved by between 0.5 and 1, and 13% improved by more than one. The maximum score on a question was a code of four and the minimum score was a zero. The non-treatment Learning Migration Through Maps Pre and Posttest Data showed that 75% of students improved between their Learning Migration Through Maps Pretest and their Learning Migration Through Maps Posttest assessment (*N*=20). Of those students, 65% improved by between 0 and .5, 10% improved by between .5 and 1, and 0% improved by more than one.

The success of the curriculum is further emphasized by qualitative data from the Teacher Roundtable Questionnaire, with teachers saying things like, “I… really love the technology piece, I love the story[maps]. I love using the ArcGIS system with them.” One hundred percent of responding teachers, one teacher was late, said that the curriculum met their needs (*n*=3) and 100% said that they would teach the curriculum again with one commenting, “Yes, I would like to continue using this curriculum in the future, especially for the intended age group…” (*N*=4).

The Learning Migration Through Maps Pre and Posttest was made up of 18 questions. However, only 14 questions were short-answer and could be coded (Table 2).

Table 2. Learning migration through maps pre and posttest short answer questions.

#	Question	Treatment Pretest Score	Treatment Posttest Score	Avg. Improvement	Nontreatment Pretest Score	Nontreatment Posttest Score	Avg. Improvement
1	What reasons might people migrate (move) from one country or place to another?	2.34	2.91	0.57	2.75	2.75	0.00
2	Give one example of people migrating in the 1800s.	1.9	2.71	0.81	2.2	2.55	0.35
3	Give one example of people migrating today (in the present day).	2.16	2.35	0.19	2.4	2.5	0.1
4	How has migration impacted the United States?	2.04	2.52	0.48	2.55	2.5	-0.05
5	Name two types of primary sources we could use to learn about people’s	1.61	2.36	0.75	1.7	2.25	0.55

	migration experiences.						
6	Why? Please explain your answer to the previous question.	1.92	2.4	0.48	2.75	2.7	-0.05
7	List three types of information a map could provide:	2.42	2.98	0.56	2.9	3.05	0.15
8	How can a map tell a story or help to solve a problem?	1.89	2.44	0.55	2.5	2.4	-0.1
9	What is the main job of archaeologists and why is this job important?	1.84	2.26	0.42	2.05	2.2	0.15
10	Archaeologists collect data while investigating archaeological sites. How might an archaeologist use this data with modern mapping technology to learn even more about the past?	1.54	2.33	0.79	1.1	2.2	1.1
11	Name 2 things you think people should do if they find or visit an archaeological site and explain why people should do these things.	1.57	2.14	0.57	1.65	2.15	0.5
12	Name 2 things you think people should not do if they find or visit an archaeological site and explain why people should not do them.	1.8	2.09	0.29	1.65	2.35	0.7

13	How does learning about past people and cultures benefit us today or in the future?	1.98	2.33	0.35	1.6	1.75	0.15
14	Explain the relationship between the following words: human migration, maps, archaeology.	1.23	1.99	0.76	0.9	1.7	0.8

The average treatment pretest score was 1.64 while the average treatment posttest score was 2.11. This showed an improvement of .54 in the treatment group while there was an improvement of .27 in the non-treatment group (Figure 4).

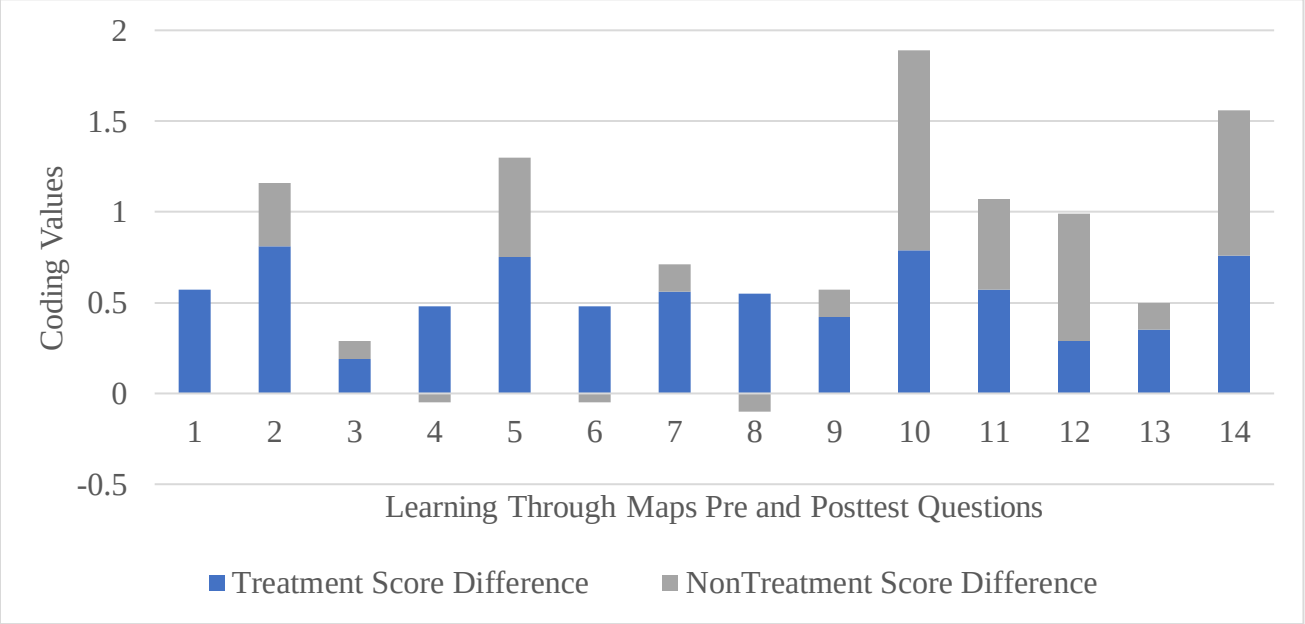

Figure 4. Treatment vs Nontreatment pre and posttest average score difference, (*N*=53). Question 1: What reasons might people migration (move) from one country or place to another? Question 2: Give one example of people migrating in the 1880s. Question 3: Give one example of people migrating today (in the present day). Question 4: How has migration impacted the United States? Question 5: Name two types of primary sources we could use to learn about people's migration experiences. Question 6: Why? Please explain your answer to question #6. Question 7: List three types of information a map could provide. Question 8: How can a map tell a story or help to solve a problem? Question 9: What is the main job of archaeologists and why is this job important? Question 10: Archaeologists collect data while investigating archaeological sites. How might an archaeologist use this data with modern mapping technology to learn even

more about the past? Question 11: Name 2 things you think people should do if they find or visit an archaeological site and explain why people should do these things. Question 12: Name 2 things you think people should not do if they find or visit an archaeological site and explain why people should do these things. Question 13: How does learning about past people and cultures benefit us today or in the future? Question 14: Explain the relationship between the following words: human migration, maps, archaeology.

The Gain of Averages and Average of Gains for the treatment group were calculated to be .20 and .18, respectively. While these values show only a small impact, the effect size was calculated to be .96, which is a value well over the large impact range (Madsen, et al., 2016). This normalized gain can be visualized with Figure 5 in a box and whisker plot as well. The box and whisker plot shows the overall improvement from pre to posttest and highlights the success and value the qualitative data expressed as well. For example, one teacher explained how she liked the curriculum's interdisciplinary focus: "I think the value is great…I love the technology piece within it. The story map is awesome. I love connecting it to the modern, you know, clashes with landowners and the wind farm."

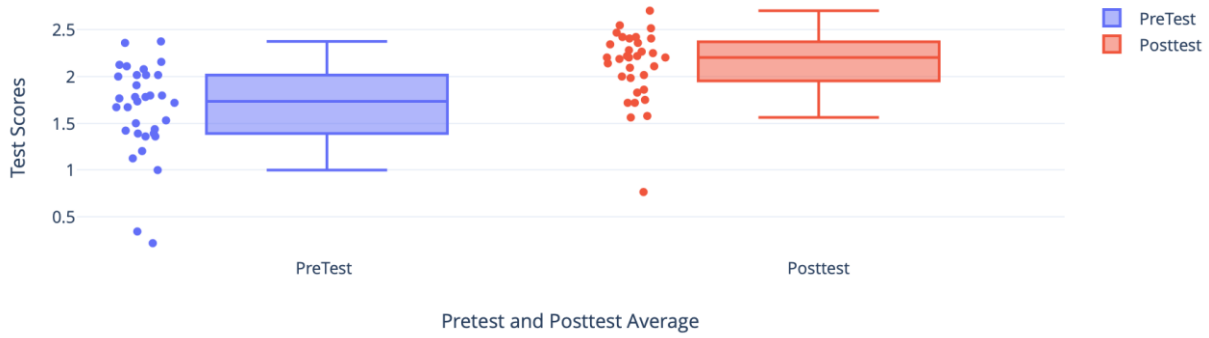

Figure 5. Box and whisker plot of the Learning Migration Through Maps Pre and Posttest, (*N*=33).

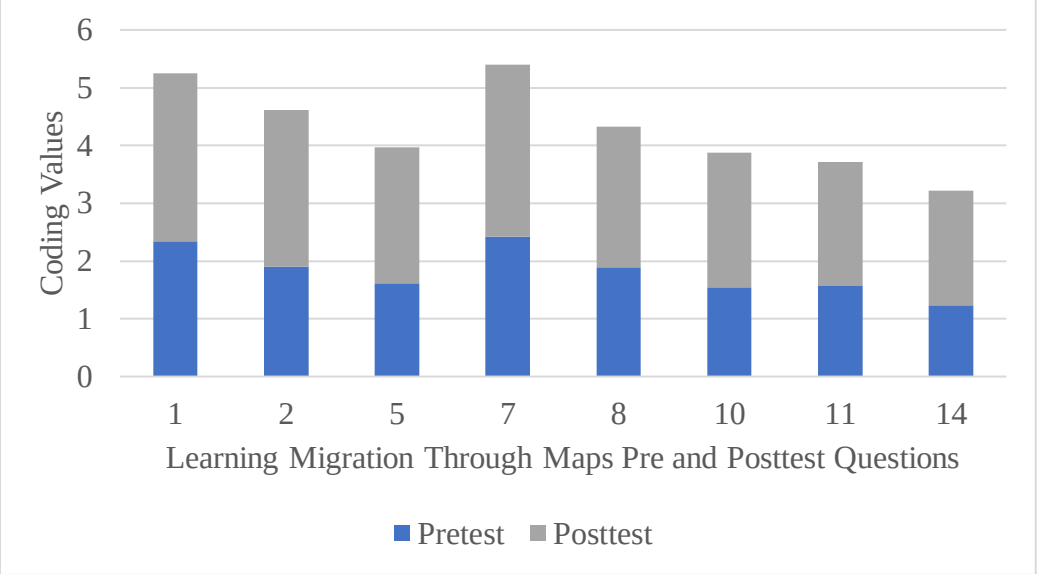

Figure 6. Pre and posttest questions that had an above average level of improvement, (*N*=33). Question 1: What reasons might people migration (move) from one country or place to another? Question 2: Give one example of people migrating in the 1880s. Question 5: Name two types of primary sources we could use to learn about people's migration experiences. Question 7: List three types of information a map could provide. Question 8: How can a map tell a story or help to solve a problem? Question 10: Archaeologists collect data while investigating archaeological sites. How might an archaeologist use this data with modern mapping technology to learn even more about the past? Question 11: Name 2 things you think people should do if they find or visit an archaeological site and explain why people should do these things. Question 14: Explain the relationship between the following words: human migration, maps, archaeology.

The overall level of improvement in the treatment group was .54, but there were seven questions that had an above average amount of improvement. Of these seven questions, five of the questions, or 71%, were GIS related (Figure 6). This means that there were five questions that specifically tested for GIS knowledge, skills, or information that only the StoryMap provided. For example, one non-mapping question asked what students thought people should do or should not do upon finding an archaeological site (Appendix B). This question was not about mapping. The non-treatment group showed above average improvement on six questions, and only two were GIS related. Qualitative data from teachers can explain this above-average improvement on the mapping questions with comments like, "I kind of lose a couple of them in

the history sometimes, but I think the map stuff was so hands on that they really enjoyed it" and "And yeah. I mean, overall, it was a really, really good set of lessons that I think do the job that they want to do."

Students were asked to give an example of people migrating in the 1800s. The students that have no apparent posttest score earned a score of zero. The Learning Migration Through Maps Posttest results show consistently higher values (Figure 7). The average score for the pretest was 1.9 while the posttest average score was a 2.7. Student answers on the posttest also indicate they are remembering content from the digital mapping resources, such as, "the Overland trail" and "Homesteaders moving to the west in the US."

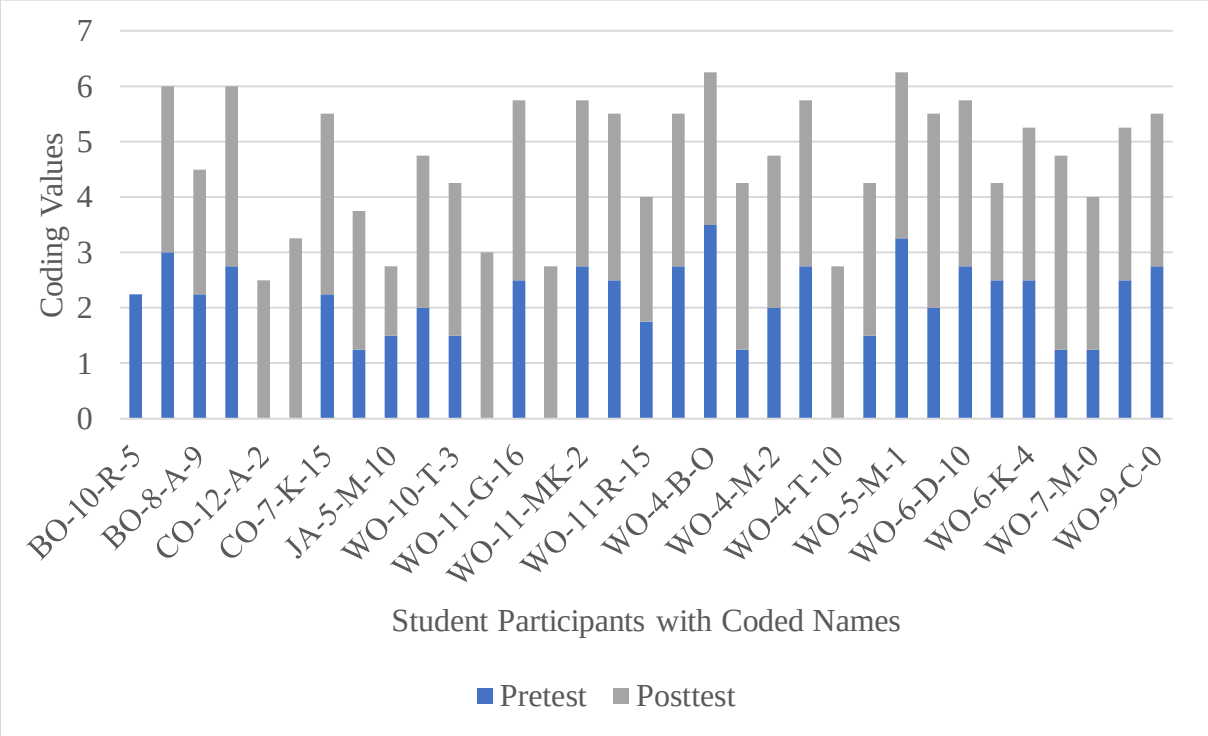

Figure 7. Learning Migration Through Maps Pre and Posttest student scores on Question Two, (*N*=33). Question Two: Give an example of people migrating the 1800s.

The non-treatment group also showed improvement, when asked to give an example of people migration in the 1800s. The Learning Migration Through Maps Pretest had a score of 2.2

and the Learning Migration Through Maps Posttest had a score of 2.55, yielding an improvement of .35 (Figure 8).

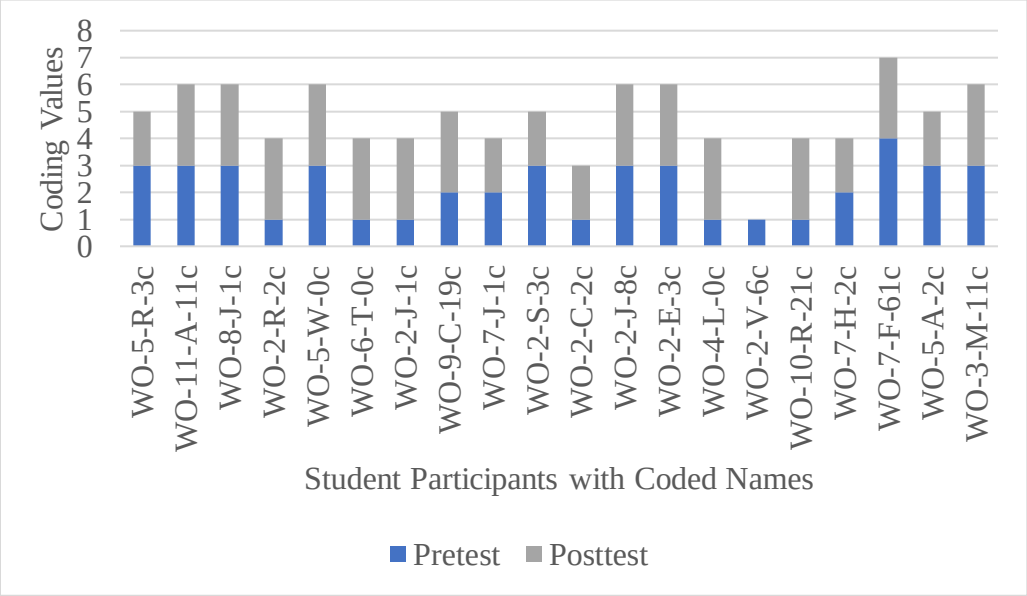

Figure 8. Learning Migration Through Maps Pre and Posttest non-treatment student scores on Question 2, (*N*=20). Question Two: Give an example of people migrating the 1800s.

Students were asked to use the Likert scale to rate their level of comfort with reading and using maps; one was the least comfortable and five was the most comfortable (Appendix B). The Learning Migration Through Maps Pretest treatment average was 2.4 while the Learning Migration Through Maps Posttest treatment average was 2.9. Students increased their level of confidence by .5 after using the maps in the curriculum and building their own at the end as an assessment (Figure 9).

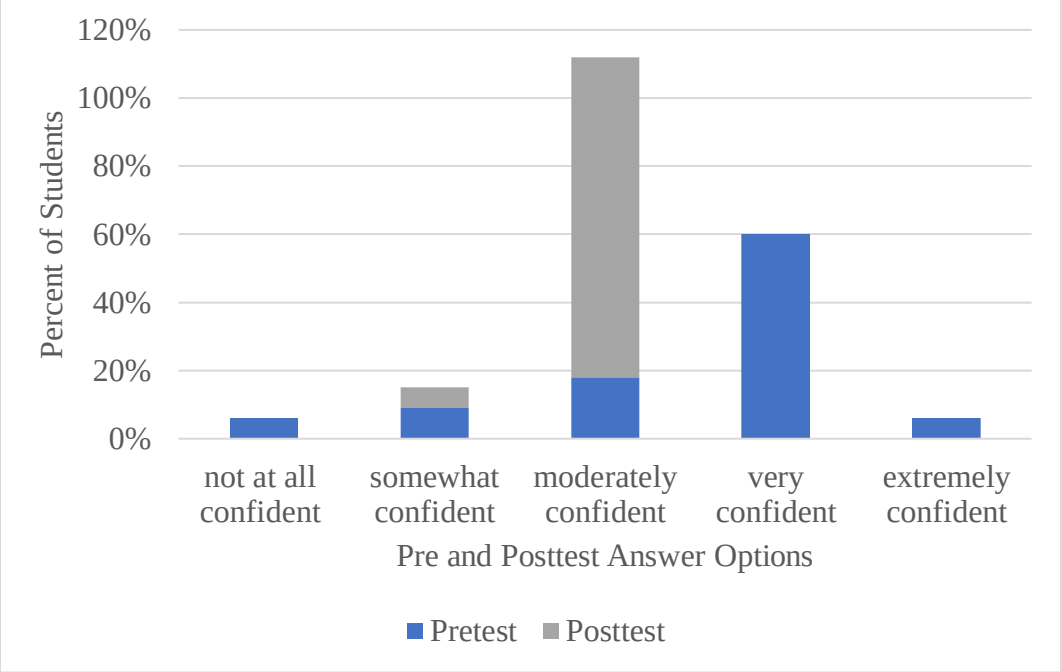

Figure 9. Student confidence increasing on mapping abilities and familiarity from pretest to posttest, (*N*=33). Questions 10: Have you ever created your own map using a digital resource (like a website, mobile app, GIS, or software)? (yes or no) Question 11: If you answers YES to question #10, rate yourself on this scale: How confident are you with your digital map-making skills?

The Learning Migration Through Maps Posttest treatment scores had 0% of students rate themselves at a one, or not at all confident (Figure 9). The students in the Learning Migration Through Maps Pretest rated themselves at a higher level of confidence before the treatment.

Prior to the treatment, students provided answers like “north, south, east, and west” on the Learning Migration Through Maps Pretest. After the curriculum, students provided more specific, GIS-themed answers on the Learning Migration Through Maps Posttest, referencing information that was only present on the maps. For example, some answers included “It could show migration trails, it could show highways, and buildings” and “migration patterns, directions, artifact locations.” The average treatment Learning Migration Through Maps Pretest

was a score of 1.9 while after the curriculum the Learning Migration Through Maps Posttest showed an average of 2.4, showing that students increased by .5 (Figure 10).

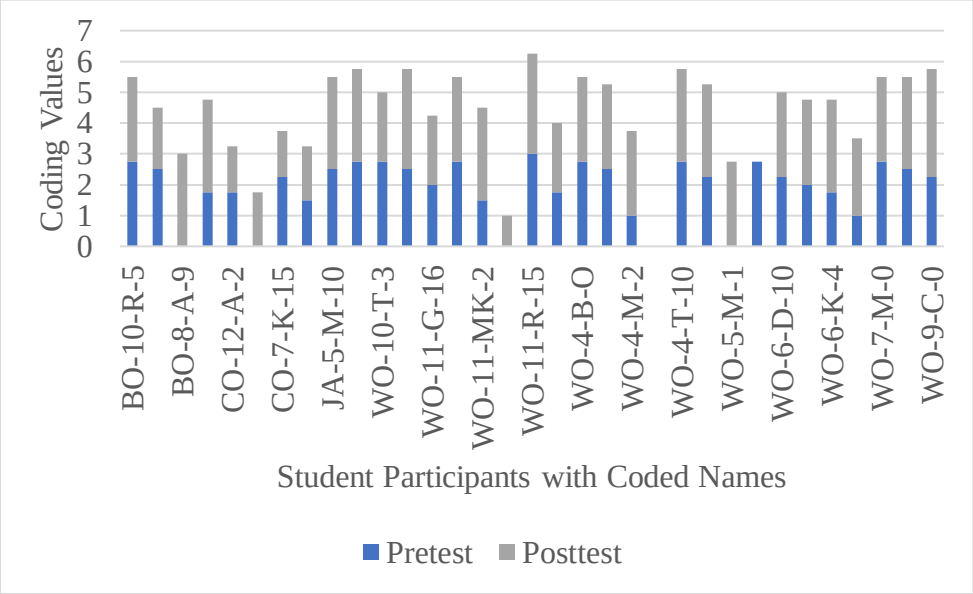

Figure 10. Student pre- vs. posttest scores on the different components of a map, (*N*=33). Question 9: List three types of information a map could provide.

The last GIS question asked students to explain the relationship between human migration, maps, and archaeology. The average pretest score in the treatment group was 1.23. Thirty percent of treatment students in the Learning Migration Through Maps Pretest left the answer blank or answered, "I don't know," resulting in a coding score of zero (Figure 11). The Learning Migration Through Maps Posttest showed clear improvement with an average score of two, a .77 increase. Some posttest answers include "They are all connected because, human migration is the study on the word archaeology which we can find the migration passes on a map," "The relationship between migration and maps is that migration can change the land, and archaeology is related to that because archaeologists use maps to find out history," and "Humans migrated and archaeologists can study maps to see the patterns of how people traveled." This

question showed the largest amount of improvement of all the questions on the Learning Migration Through Maps Pre and Posttest (Figure 11).

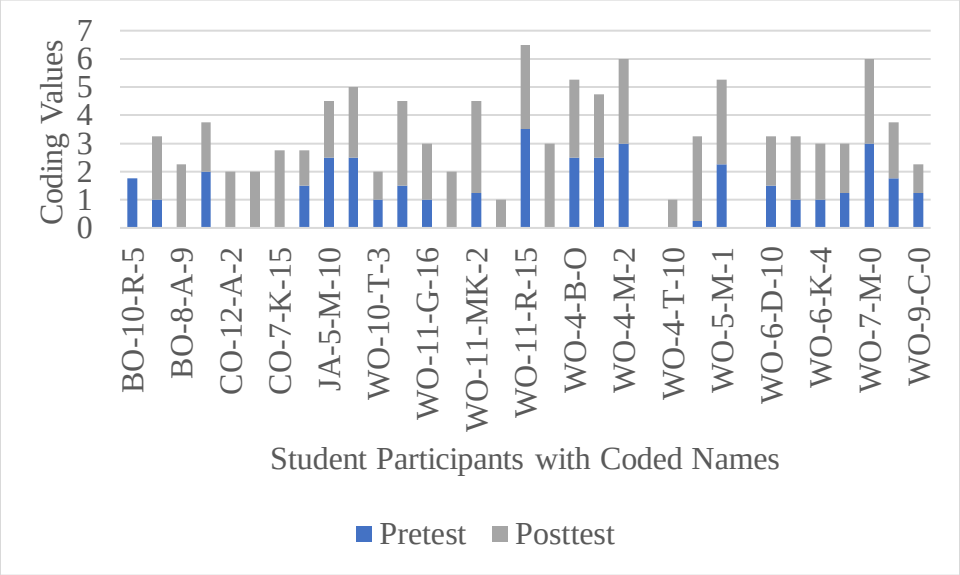

Figure 11. Pre vs posttest scores for the question showing treatment student improvement after the curriculum, (*N*=33). Question 18: Explain the relationship between the following words: human migration, maps, and archaeology.

The non-treatment group also showed improvement of .8 on this final question (Figure 12). The Learning Migration Through Maps Pretest score was .9. The Learning Migration Through Maps Posttest score was 1.7 (*N*=20).

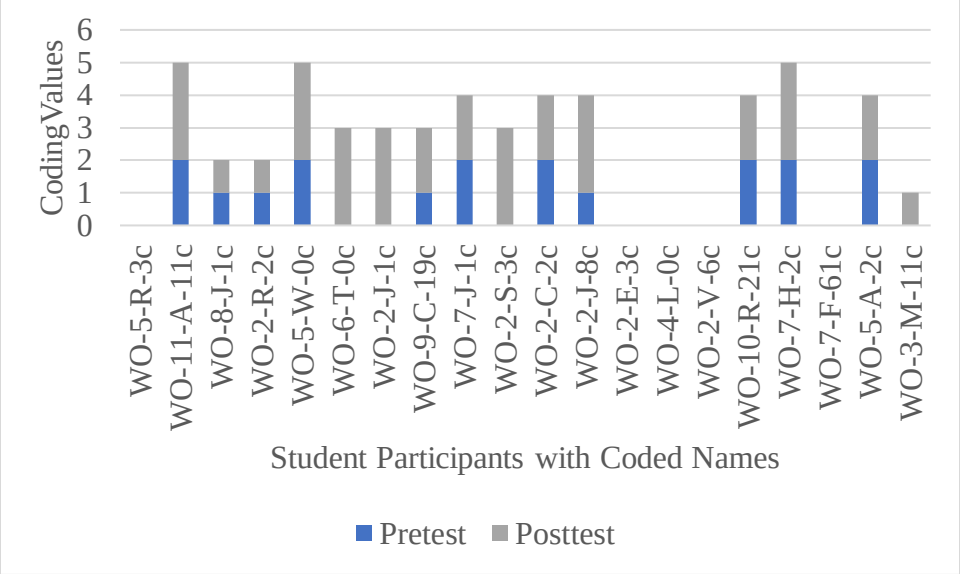

Figure 12. Pre vs posttest scores for the question showing nontreatment student improvement after the curriculum, (*N*=20). Question 18: Explain the relationship between the following words: human migration, maps, and archaeology.

In addition to the Learning Migration Through Maps Pre and Posttest quantitative data, qualitative data was also collected through the Teacher Roundtable Questionnaire. One hundred percent of teachers said they would teach the curriculum again. For example, one teacher commented, “Yeah, I think it's really valuable. I really enjoyed it.” The Roundtable discussion transcript was given qualitative codes, so how many times something was mentioned and who mentioned it could be recorded (Figure 13).

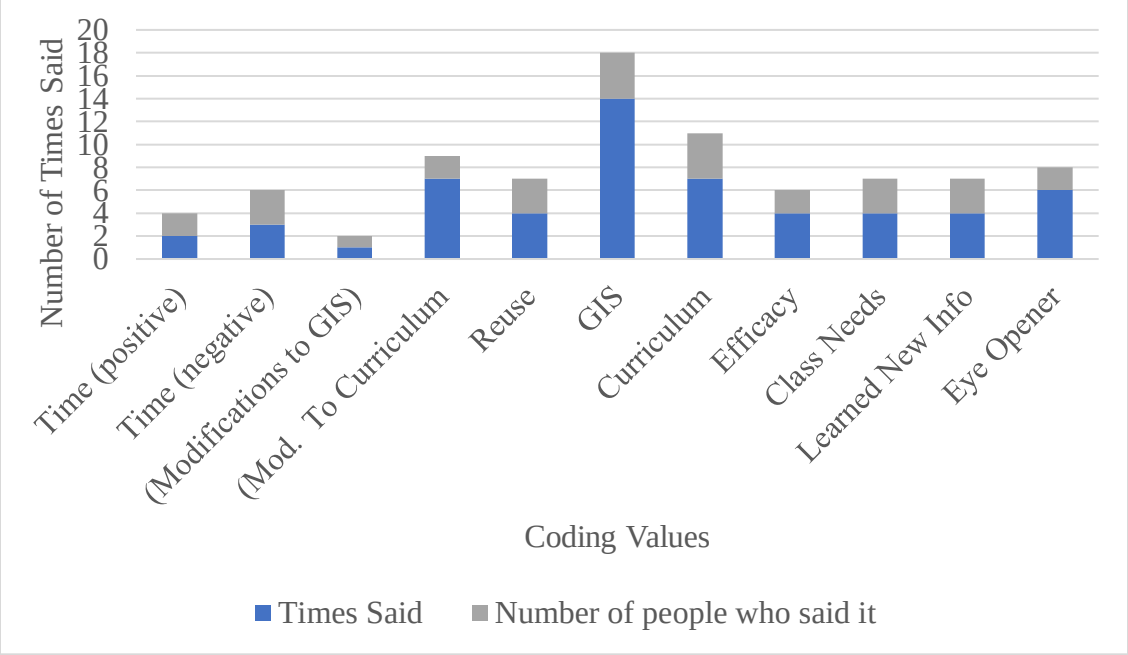

Figure 13. Overall feedback from teachers, (*N*=4).

One hundred percent of teachers expressed that the curriculum content met their curricular and classroom needs. One teacher expressed that it was easy to use, even in difficult teaching situations, saying, “The curriculum content did meet my curricular and classroom needs...this curriculum was easily transferable onto our district wide platform, Canvas, and easy for me to share and incorporate over zoom during designated meeting times when students were required to stay at home.” Another teacher spoke to how well the curriculum fit with her year-long plan: “it fits so nicely with the U.S. history curriculum… It was pretty awesome because we had just come off a homesteading unit and, you know, we're going into immigration and the urban society. So it's like this was perfect…” Not only were teachers satisfied that the curriculum met their classroom needs, but they also thought it excelled at teaching the material and appreciated the cross-curricular components.

Only one teacher directly answered a question asking how the curriculum impacted their understanding of GIS and StoryMaps as teaching tools. She said, “The curriculum impacted my

understanding of GIS and StoryMaps as teaching tools by acting as a catalyst for familiarization to otherwise intimidating technology. I especially enjoyed the Story Maps aspect as a tool, using layers to explain a situation. It reminded me of Spence Rogers techniques, such as incorporating "telephone" into lessons."

An important component of the Teacher Roundtable Questionnaire was to gather feedback on all aspects of the curriculum and maps as teaching tools. Question Five did this by asking what feedback teachers had regarding curriculum content, lesson procedures, timing, length, materials, assessment, and use of technology. Half the teachers touched on the reusability of the curriculum as well as its ability to satisfy the needs of their classroom. Two of the teachers also used this question to voice recommended changes they had. However, one hundred percent of the feedback on modifications concerned the written curriculum, not the digital mapping portion. Teachers referenced small frustrations with page organization resulting in longer preparation times.

When providing general GIS feedback, one teacher said, "But in general I really, really liked it. I mean, I love the story mapping with all the different layers in the map and being able to change everything. I wish my kids could have been able to use it separately…" Additionally, the negative feedback, such as with timing, modifications, and feelings of being overwhelmed was only about the curriculum and not the mapping component.

The Teacher Roundtable Questionnaire also asked specifically about the GIS and mapping component in the first part of Question 13, asking teachers to summarize their thoughts on how well students used GIS and how well they understood StoryMaps (Figure 14). Overall, the only negative comment was from one teacher whose students felt overwhelmed. These

students were learning in an extremely small, rural school with little to no technology education. One teacher said,

> It was actually, I think one of the parts that most of them were the most engaged on. And it was, for my students, fairly easy to pick up on and do what they needed to do and follow the directions… it worked pretty well for us. That part was pretty seamless, the whole GeoDig part. And I like that part. For sure.

The final question asked in the Teacher Roundtable Questionnaire was whether teachers found there was value in the curriculum. This question was not originally included in the Teacher Roundtable Questionnaire, but it came up organically during the discussion and teachers wanted to answer it as they had with the offical questions (Appendix C). Teachers answered strongly "yes." They found there was value in the curriculum, citing the GIS components the most, the eye-opening moments that the GIS mapping imagery brought on, as well as the curriculum overall (Figure 14). Most of the teachers talked about how valuable the connections were between the subjects of science, history, and technology. One teacher explained it by saying,

> I think that the more history, the more math, more writing that you bring into science that create it-- for them to recognize that everything is all connected together, the more important it is. So, yeah, I found adding--I found me adding science to this curriculum somewhat in the reverse to make it even more cross-curricular.

Another teacher answered the final question by speaking about eye opening moments experienced in the classroom because of different connections the GIS materials made clear. They said,

> … I've been very down on my students for not being super open minded, but they had some amazing discussions and it definitely, like, opened their eyes a little bit more. And I think bringing in the history into the science and, you know, stuff like that where I don't think a lot of kids think of archaeology as being science in school, it's very-- I felt it was very applicable and the flow of it was very natural.

Finally, other teachers specifically mentioned the value of the GIS and mapping. She said,

I like that they had to research places that when they were taking their trip, where would they want to stop and what would they want to learn about …I think that was really interesting… It's a bigger picture. And I think showing them that bigger picture at this age is really important because some of them haven't even been out of the state of Montana. So showing them how much they can impact some of these lives or how much their lives have already been impacted by something that's happened to them. That's priceless.

CHAPTER FIVE

CLAIM, EVIDENCE, REASONING

Claims From the Study

Maps have been used for centuries and millennia as teaching tools, and they are known to be effective because of their unique ability to show several different types of information at once. For example, a physical map could show the names of countries, their borders, their World War II (WWII) alliances, and battle fronts all at the same time. However, what physical maps cannot do is layer information or show change through time, but ArcGIS digital maps can.

Thanks to modern technology, ArcGIS can show more information in a more user-friendly and customizable way. For example, a digital map could show countries, borders, WWII alliances, battle fronts, as well as how borders fluctuated with time due to different victories, the impact of American or Japanese involvement, bombing patters, and more. The ability to show change allows students to direct their own learning, engage more directly, and fosters deeper inquiry by giving them the freedom and power to explore. The Treatment group showed not only general improvement, but also retention of the information the learned from that same type of learning engagement and exploration with digital maps. Posttest answers repeated information directly from the maps, cited mapping examples, and teachers spoke to the mapping sections of the curriculum being the most engaging and fun for the students.

This study began with questioning whether digital maps were effective teaching tools. The goal was to see if digital mapping resources, like ArcGIS and StoryMaps, were engaging for students, easy for teachers to learn how to use as well as integrate within their classrooms, and if students could learn the material by using digital mapping resources without getting distracted by the technology. This study piloted a curriculum about migration with traditional, pen-and-paper worksheets as well as ArcGIS and StoryMaps for learning and assessment in five different classrooms across Montana and Wyoming. Data was collected with pre and posttests on

treatment and nontreatment groups as well as a teacher roundtable discussion that was recorded, transcribed, and coded for qualitative analysis.

All of this collected data showed students improved more and learned more on the questions involving the ArcGIS and StoryMap resources. Teacher roundtable discussion qualitative data reflected instructor eagerness to use the curriculum again, voiced no recommended changes to the mapping component of the curriculum, and shared stories of students experiencing eye-opening and "aha" moments when using the GIS and StoryMaps because it presented information in a new way and allowed students to make new connections.

The data showed that students learned and retained more information by using digital mapping resources, like ArcGIS and StoryMaps, than with traditional curricula and lecture-based teaching techniques. This data came from analyzing the pre and posttest scores from the treatment group. There was an average improvement of .54 on the posttests. Five of the seven questions that had above-average improvement were mapping-related questions while only one of the above-average improvement questions with the non-treatment group was map-related. This shows the GIS and StoryMap curriculum had a positive impact on student learning. The treatment group of students showed above average levels of improvement on mapping questions than they did with questions from the non-mapping portion of the curriculum. This increased improvement observed in the quantitative data was further emphasized by the qualitative data. The teachers empathically expressed an appreciation and liking for the digital mapping resources because of their impact on the students. Teachers spoke of students learning more deeply, turning in higher-quality work, and even experiencing aha or eye-opening movements thanks to the tools digital maps allowed them to use that regular maps cannot do, such as layering information or showing change through time. Another teacher cited that his

students were able to make connections between many different types and pieces of information that would have otherwise been impossible thanks to the digital maps putting everything in one spot for students to experience.

This project started with a three-part focus question. The first part asked if GIS maps had a positive impact on teacher and student learning experiences. The Treatment Pre and Posttest data reflects average improvement of student performance as well as above average improvement on mapping questions. Teachers during their interviewed answered that the curriculum met their needs, was easy to use, and that they would all use it again in the future.

The second part of the focus question asked if there was a positive effect on student engagement. Teachers cited students enjoying the mapping part the best, that they turned in the highest quality work during this period, and that they ended up spending the most time with the maps because students enjoyed interacting with them so much.

The final facet of the question asked if digital maps had a positive impact on student mastery of the curriculum material. Students showed greater improvement on the mapping sections. Furthermore, their answers on these questions directly cited mapping examples. This study showed that digital mapping resources, like ArcGIS and StoryMaps, had a positive impact on the classrooms they were used in, in terms of ease-of-use, engagement, and quality of turned in work without a resulting loss in productivity.

Value of the Study and Consideration for Future Research

This data collected in this study show that not only did students and teachers enjoy a digital, map-based curriculum, but that they learned well while using it. Pre and posttest data showed that students improved more on mapping answers than on non-mapping ones and

qualitative data showed that the visual elements GIS maps brought helped students make deeper connections that would have been impossible otherwise.

Perhaps most importantly is that no teacher reported confusion with the GIS maps or the instructions within the curriculum for the maps. Technology is often seen as a barrier to trying new teaching tools because it can cost extra money, take time to learn how to use and implement, and it can distract students from what they are supposed to be learning. Put simply, new technology can be all flash and no substance. It can also be confusing for teachers to learn, especially if they do not have any help or the necessary support. Teachers did not experience this at all with the curriculum or the GIS maps. This study and the results it yielded could be the basis for future research on how easy it can be to integrate new technologies into the classroom. Further studies similar to this one can also help teachers to know which new classroom technology is worth trying because it has been vetted by other students and teachers.

This study had tremendous value for the student and teachers who participated in it. The combination of science and history in a technological format was something teachers commented on, saying the combination was one of extreme value. It allowed students to have a way to visually represent historical, scientific, and geographic information in one spot. For the teachers in the study, they conveyed that the best part of the curriculum was that it had a unique ability to combine different types of information in a new way, leading students to experience eye opening and “aha” moments in their learning that would not have been possible with a more traditional teaching approach.

In terms of concrete accomplishments for the classroom, the pre and posttest data showed statistically significant improvement of students. Additionally, students felt comfortable and confident with making their own maps by the end of the curriculum. While teachers had a few

modification recommendations for the written portion of the curriculum, they all expressed a resounding desire to teach the curriculum again and mentioned it well suited their classroom needs.

Impact of Action Research on Author

Participating in and conducting this action research project in the classroom has permanently changed me as an educator and archaeologist. Prior to this research project, my approach to teaching had no semblance of evaluation and I was unaware of basic statistical analysis or how to use it to evaluate learning. As an educator, I valued more old-fashioned, "tried and true" teaching methods and tools, viewing digital teaching tools as largely unnecessary and a kind of passing fad.

The action research process in this research as well as in my larger time with the MSSE program has taught me not only the value, but the necessity of constant and varied engagement with students. From quick questions to formal assessment techniques to ensure learning, I have seen how my students have benefitted from this varied practice instead of lecture after lecture. Most importantly, understanding how to create and execute an action research project independently was an invaluable skill to learn. It is a practice I will implement in all future classrooms to better understand my teaching situation and environment.

In short, this research project and learning about the action research process has been a revolutionary experience that has improved my teaching abilities and quality enormously. In the future, I plan to include at least a small action research project once a year in my classroom. I also plan to use engaging teaching techniques. I will include qualitative and quantitative evaluations at the end of all education programs, especially in more informal educational

environments, like museums. Finally, I plan to continue teaching with the techniques I learned from the MSSE programs.

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APPENDIX

APPENDIX A

IRB APPROVAL

MONTANA
STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Katherine Hodge and Erika Malo

FROM: Mark Quinn Mark Quinn CJ
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: August 25, 2020

SUBJECT: *"Pre- and Post-Testing of 7th and 8th Grade Classrooms Piloting Project Archeology: Investigating Migration Curriculum"* [KH082520]

The above proposal was reviewed by expedited review by the Institutional Review Board. This proposal is now approved. See below for follow up instructions.

Please keep track of the number of subjects who participate in the study and of any unexpected or adverse consequences of the research. *If there are any adverse consequences, please report them to the committee within 3 calendar days.* If there are serious adverse consequences, please suspend the research until the situation has been reviewed by the Institutional Review Board.

Any changes in the human subjects' aspects of the research should be approved by the committee before they are implemented.

It is the investigator's responsibility to inform subjects about the risks and benefits of the research. Although the subject's signing of the consent form, documents this process, you, as the investigator should be sure that the subject understands it. Please remember that subjects should receive a copy of the consent form and that you should keep a signed copy for your records.

Due to the change in the Common Rule effective January 21, 2019, you will not receive follow-up renewal forms unless your research was reviewed via full committee or is sponsored by the FDA. Enclosed is a "Project Closure Form" which we would like you to fill out and submit to our office upon completion of the research project so that we can close out the protocol. Please keep this form with your application and approval letter so that you remember to submit it at the termination of your project.

Enc.

APPENDIX B

LEARNING MIGRATION THROUGH MAPS PRE AND POSTTEST

1. What reasons might people migrate (move) from one country or place to another?
2. Give one example of people migrating in the 1800s.
3. Give one example of people migrating today (in the present day).
4. How has migration impacted the United States?
5. Name two types of primary sources we could use to learn about people's migration experiences.
6. Select the best fit answer. The relationships between historic Native Americans and early European/American settlers were: positive, negative, both.
7. Why? Please explain your answer to question #6.
8. Rate yourself on this scale: How confident are you with reading and using maps? (1-5 scale, 1 being the least comfortable, 5 being the most comfortable.
9. List three types of information a map could provide:
10. Have you ever created your own map using a digital resource (like a website, mobile app, GIS, or software)? (yes or no)
11. If you answered YES to question #9, rate yourself on this scale: How confident are you with your digital map-making skills?
12. How can a map tell a story or help to solve a problem?
13. What is the main job of archaeologists and why is this job important?
14. Archaeologists collect data while investigating archaeological sites. How might an archaeologist use this data with modern mapping technology to learn even more about the past?
15. Name 2 things you think people should do if they find or visit an archaeological site and explain why people should do these things.
16. Name 2 things you think people should not do if they find or visit an archaeological site and explain why people should not do them.
17. How does learning about past people and cultures benefit us today or in the future?
18. Explain the relationship between the following words: human migration, maps, archaeology.

APPENDIX C

TEACHER ROUNDTABLE QUESTIONNAIRE

1. Did you teach the whole curriculum sequentially? Skip any lessons? Or take any lessons out of order?
2. How many weeks/class periods were required to complete this curriculum?
3. Did you (personally) learn any new knowledge?
4. How did this curriculum impact your understanding of GIS and Story Maps as teaching tools?
5. Did you feel comfortable teaching the curriculum as written? Did you make any modifications to increase your level of comfort?
6. Did the curriculum content meet your curricular and classroom needs? How and/or how not?
7. Do you intend to continue using this curriculum in the future?
8. If so, do you intend to teach it as written or will you make modifications to better suit your needs?
9. Which Final Performance of Understanding did you choose and why? Can you briefly tell us how it went and how you feel it worked as an assessment of the whole unit?
10. Which option did you choose for Lesson 4 and why?
11. Did your students have any "a-ha" moments? If so, can you describe?
12. Is there anything we didn't ask about that you would like us to know? Anything else that stood out or recommendations for revisions?
13. Can you summarize your thoughts on how your students did with the following components: A) Using GIS/Creating and Understanding Story Maps:
    B) Understanding that relationships between Native Americans and early settlers was complex and sometimes challenging to learn about:
14. Relating movement and migration in US History to modern day issues:
15. What feedback do you have regarding: a. Curriculum content. b. Lesson procedures. c. timing d. length. e. materials. f. assessment g. use of technology