Harnessing GIST-Enabled Resources in the Classroom:

Developing A Story Map for Use with Secondary Students

by

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Dedication

To Eratosthenes and all those who came after.

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Abbreviations

COVID-19	Coronavirus disease 2019
EGP	Eastern Geographical Perspectives
Esri	Environmental Systems Research Institute
GIS	Geographic information system
GISci	Geographic information science
GIST	Geographic information science and technology
POI	Point of Interest
SSI	Spatial Sciences Institute
USC	University of Southern California
UI	User Interface
UX	User Experience

Abstract

The number of K-12 educators utilizing Geographic Information Systems (GIS) is on the rise. As more tools become available, through companies such as Esri Geoinquiries, Google Maps Treks, and Esri Academy, an ever-rising number of educators employ such tools in their classrooms. This thesis provides a model that educators can use to 1) synthesize the delivery of content in tandem with GIS, 2) ensure adherence to standards-based instructional requirements while using ArcGIS Story Maps, and 3) teach secondary age students to use GIS itself. The case study on which the thesis was based was a template for an ArcGIS Story Map that can house traditional classroom content and GIS-enhanced resources while adhering to national, state, and local student learning outcome standards, as well as incrementally increasing the students' understanding and use of GIS. The course that was the case study covers eastern hemisphere geography and is taught primarily to freshman in a high school in Meridian, ID. The ArcGIS Story Map was created using the Classic Map Series template and organizes each map around a region of study in the class (e.g. the Middle East, North Africa, etc.). The content of each regional map was based on standards which are linked to student learning outcomes associated with a specific theme (e.g. culture is the thematic focus of the Middle East and North Africa unit). Enrichment content in a variety of multimedia formats was embedded within the content of each region. In addition, each successive regional map asks the student-users to utilize increasingly advanced GIS skills and proficiencies. A survey was fielded to gauge the attitudes of other educators as to the effectiveness of this approach as well as the extent to which they might adopt this approach in their own classrooms. Survey data showed that educators were receptive to this approach and were more likely to adopt it after viewing this application.

Chapter 1 Introduction

The potential that geographic information systems and technologies (GIST) have to influence secondary education is enormous. The companies that produce these tools realize this; Esri routinely publishes “Geoinquiries” for topics from American history to earth science, and Google hosts focused tours of specific locations around the globe called Treks. Both of the above mentioned technologies are geared towards students at the secondary level. One of the challenging issues facing GIST in secondary schools is that many of the resources available focus on GIST as alternative modes of delivering lesson-specific content rather than a system which can map, organize, and enhance an entire semester of material. This project will address that challenge through making GIST an irreplaceable part of the class by creating a web application using Esri’s Story Maps that will act as the textbook for a secondary geography class while also harnessing the power of GIST to include enrichment and extension opportunities within the application.

Over the last two decades one of the most oft-utilized tools to reinforce the goals of geography education has been the incorporation of geographic information science and technologies (GIST) in the classroom. The push for more GIST-based education goes hand-in-glove with the understanding that contemporary secondary students have both a higher awareness of computer-based resources and more acuity using those resources than previous generations of students (Downs 2014). The incorporation of GIST has therefore been a force to reinvigorate geography education in schools. This thesis will focus on using GIST in a freshman level human geography course.

1.1. Geography Classes and GIST

In this author's school district in Idaho, freshmen can still take a geography course titled "Eastern Geographical Perspectives" (EGP); in fact, this course is still considered a graduation requirement for the district. At first this might seem like the perfect course to implement GIST resources in. You have a young, technologically savvy group of students who have to be in the class and can easily be introduced to GIST so that they might benefit from those skills in later grades and other subjects. The reality, however, is that the most geographic thing about this course is probably the title. The curriculum, upon close inspection, reveals that this course is more about regional history and current events than it is about geography.

Although EGP is not strictly a geography course it does represent a unique opportunity to showcase GIST resources to students. The author of this study previously attempted to incorporate GIST-based lessons in this class and had limited success due to a variety of factors. It was during this process of seeking out and trying to use GIST resources that the idea to create a single resource for the entire semester was born. EGP covers such a wide area and so much unrelated course material that to approach the topic and try to pick and choose various GIST-based lessons is a Herculean task which would likely end in a spreadsheet full of links to different online resources. If, however, a single resource could be created to organize all of the material – both standard class content and GIST-enabled resources – spatially then this might in fact be the perfect course to showcase the usefulness of modern geographic information science and technology.

1.2. Motivation

The primary motivation for this project is to design and implement a spatially-enabled digital resource for secondary students. Specific choices associated with the technology and platform for this project are covered in Section 2.3. This section will briefly discuss the primary goal of this project, several secondary goals, and the logistical issues associated with it.

1.2.1. Primary and Secondary Goals

The primary goal of this project to create a spatially-enabled digital resource will be completed using Esri Story Maps. The technical specifics behind this choice are covered in the next chapter, however there are some other considerations outlined here. First, the primary device that most students access the web on is their smartphones. That precludes the use of any advanced GIST use for this application because they are not designed to work with smartphones. Second, as an educator the author of this paper has found that modern students are sometimes more familiar with the functioning of applications then they are of standard web pages. Currently, teachers might simply post their resources online and expected students to have the skills necessary to both navigate to and then access the material. By using a Story Map the material of this course will instead be organized using a web application. While Story Maps do not operate on a mobile application (such as social media platforms or games) they do share the same designs as many of these applications and could therefore be more accessible to secondary students.

Two secondary goals which will act as contributing factors for the choice of Story Maps is to make the application user-friendly and interactive. Both ease-of-use and the ability to manipulate the application have been shown to have positive impacts on the outcome of student interaction (Strachan and Mitchell 2014). In addition, Story Maps do not require the user to sign in to access the content. Students can simply follow a link or bookmark the application and be able to access the material throughout the semester.

1.2.2. Logistical Considerations

Overall, the motivation for this project has a solid foundation in related work done by others in the fields of education and GIST (see Chapter 2: Background). There is, however, also a logistical motivation presented by the reality of the situation in the author's school district. As mentioned previously EGP is a course which focuses heavily on current events; for that reason, the district decided to forgo the purchase of physical textbooks for the course. Logically it does not make sense to buy a physical and unchanging textbook which would lock teachers in to teaching only what is in the book. In some ways the lack of a textbook allows more flexibility for teachers to focus on current events and incorporate them into the class "on-the-fly."

Although there are some advantages, the lack of a textbook also creates challenges for teachers with regard to organizing and storing information for students to access. Especially in asynchronous situations students who miss the in-class instruction may find it difficult to recover the missed material because they cannot read chapter "x" in their textbook and get the idea of what was covered. At the time of writing this challenge is making itself very apparent during the COVID-19 crisis. Teachers can post PDFs of slide decks and they can record voice lectures for students to listen to as they advance the slides, but ask yourself if you were the student would you want to do that? A spatial resource like a Story Map is a step in the right direction in terms of organization which encourages interaction. Students can navigate to the region in question, they can simply get the slides or they can explore the map and maybe discover enrichment material. Story Maps allow for material organization which encourages interaction rather than simple retrieval.

One of the reasons why it is possible to receive a GIST degree online is that most of the work is done by individuals who engage with the material on their own terms and on their own time. Although academic studies on the subject are forthcoming, the effects of COVID-19 on education will be far-reaching and transformative. Even if schools do not transition to a blended in-class/distance format they will undoubtedly create a crisis plan which calls for distance learning. GIST can and is routinely taught online; opportunities to create meaningful online learning experiences using GIST may be in even higher demand in the near future.

1.3. Study Area and Target Audience

This section will outline the study area associated with the application itself as well as some characteristics of the imagined user. More detailed information about both the study area and the regions covered can be found in Chapter 3: Methods and in Table 3.

1.3.1. Study Area

The study area for this project is mainly the eastern hemisphere and is outlined by the curriculum documents of both the state of Idaho and the school district. Notable exceptions to this are some areas of Western Europe as well as Australia and Oceania. Western Europe is covered in the 8th grade version of this course, Western Geographical Perspectives. Unfortunately, Australia and Oceania are not covered by either course. Figure 1 shows the borders of the class content outlined by region. The only region not included on the map is the Ancient World, which overlaps the existing regions but is excluded because modern borders are not applicable to the time period covered.

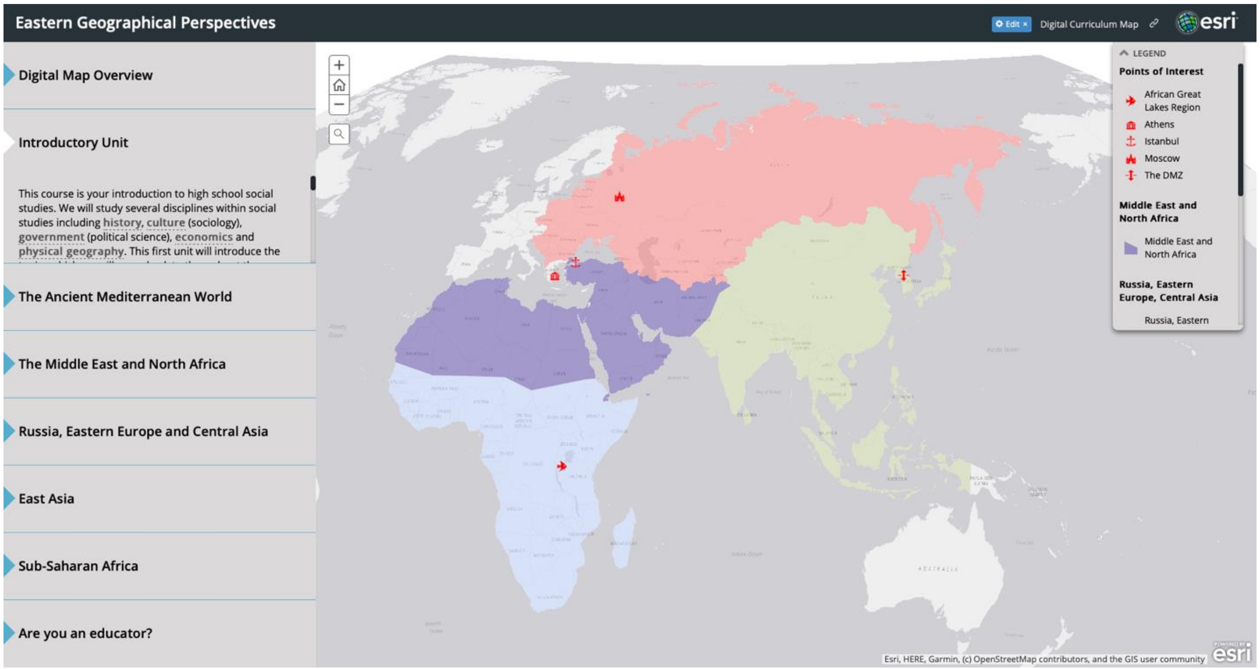

Figure 1: Map of Study Area

The reader will notice that the geographic area covered by this course is rather large and will lead to a massive amount of information. In addition to the geographic scale the scope of information presented is also quite expansive. For example, students will receive instruction on topics such as the Agricultural Revolution in Mesopotamia, the Israeli-Palestinian Conflict with regard to Jerusalem, the rise and collapse of the Soviet Union, the role of Shenzhen, China in electronics manufacturing and the topography of the African Great Lakes region, to list just a small sample. Organizing all of the information presented is a challenge under any circumstances, especially when considering current events and how that may lead to the inclusion of unforeseen content material. This project organizes the material by region and by focus (see Chapter 3.3.3) in order to better organize the content.

1.3.2. Target Audience and User

The audience for this application is freshmen students in a standard high school social studies course. The course is not part of a gifted and talented program such as Advanced

Placement, International Baccalaureate, or university dual credit course. These students are generally 14-15 years old and have had some education in geography prior to EGP (Western Geographical Perspectives in 8th grade). Despite the prior geography education, most if not all students this author has encountered have not been asked to use GIST resources in any class before. There are also students who have previously failed this course and must retake it; the course is a graduation requirement and therefore must be completed by all students. The third and final type of student in this class are transfer students. Students who transfer from a district that does not have a geography graduation requirement must take this course regardless of grade level. For example, if a senior transfers to West Ada School District from Boise School District (the two share a border) then that senior would be required to take EGP even though they are not a freshman. The course is one semester in length.

A general perception among students is that geography is simply memorizing both country names and physical features on a map. This belief may come from elementary classes or some middle school teachers who use the word geography to mean studying maps. On the first day of EGP this author generally administers both a map quiz and a quiz over content to gauge the prior knowledge of students. The map quiz asks students to identify all of the continents and oceans as well as place one physical and one human feature of their choice on the map. The average score on these quizzes over the last three years has been roughly 20%. From this the author has concluded that prior geographic knowledge, whether it be spatial or associated with the patterns and processes we study in the class, is relatively limited on day one.

Despite the limited nature of prior geographic knowledge most of the students in the class have a good deal of prior technological knowledge. Over time the percentage of students who have and carry a cell phone on a daily basis has increased; currently over 95% of students in any freshman class have a cell phone. In addition to having a phone some of the students have also used online learning aids before (i.e. Kahoot, Khan Academy, etc.). Despite their exposure to other learning applications and the internet more basically, instruction via both digital maps and Story Maps specifically will be new to most students using this project's application.

1.4. Methods

This thesis designed and implemented an Esri Story Map as a GIST-enabled digital resource for students; something like a digital textbook and atlas and video game rolled into one. The broad steps associated with completing this thesis were: (see Chapter 3 for details)

1. Outline and understand content of Eastern Geographical Perspectives
2. Design and construct Esri Story Map populated with course content
3. Gather feedback from other educators relative to the application

The process of choosing specific technology and making specific decisions within that technology is outlined in both Chapters 2 and 3 of this document. It is worth noting that this project, in order to be recreated by others, imagines a creator who is already engaged in teaching a subject and already has prior content. As this document will show, this Story Map is not designed to replace existing instruction; on the contrary, this application will showcase and spatially enhance things that a teacher is already doing. This should not be viewed as something that is passed to a new teacher and they can use to fill class time.

Chapter 2 Background

The field of geographic information science and technology in education is diverse and growing with much work being done to implement and discover best practices. GIST is no longer restricted to a few specialized classes in universities with the proper licenses to run the software; increasingly we see GIST incorporated into secondary curricula and educators making efforts to utilize GIST to enhance student learning. The first section of this related work chapter will outline the current state of GIST relative to teaching geography and outline some of the contemporary issues associated with teaching GIST at a secondary level. The second section of this chapter will investigate UX/UI (user experience/user interface) choices and design considerations associated with the target audience of secondary age students. The third and final section will discuss Esri Story Maps as a medium for hosting the application described in this project.

2.1. GIST in Education

Geographic information systems and the science associated with their use continue to grow in popularity including among educators as a tool for teaching. Geographic information systems designed and made available by companies like Esri (ArcGIS Online; Geoinquiries) and Google (Earth; Treks) are increasingly incorporated as features of instruction in secondary classrooms. These GIST tools and resources are not just an alternative way to present information; they change the way that students approach content and ask them to engage with the spatial nature of the content in order to better understand it (Kerski 2003; Unwin 2011).

2.1.1. Justifications for GIST-enabled Learning

Concurrent with the advent of new technologies geography and geography education experienced something of a renaissance over the past thirty years. In 1994 a committee from the National Geographic Society published a set of “National Geography Standards” with the aim of informing curricula throughout the United States (Geography Education National Implementation Project, 1994). Curriculum designers, state officials and individual teachers consult these standards in order to inform and direct instruction within the K-12 classroom. Of particular interest to this project is the first essential element outlined by the standards: “The World in Spatial Terms.” This essential element calls on students to “use maps and other geographic representations, tools, and technologies to acquire, process and report information from a spatial perspective” (Standard 1). In addition, this element requires students “to analyze the spatial organization of people, places and environments on Earth’s surface” (Standard 3). The authors of the standards clearly recognized the importance of spatial technology in geography education and modern technologies are making the realization of that goal easier.

The College, Career and Civic Life (C3) Framework For Social Studies Standards is another national-level guide when considering tools to teach at the K12 level. In the C3 Framework a standard students are expected to meet by the end of grade 12 is to “Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions and their political, cultural, and economic dynamics” (National Council for the Social Studies, 41). The expectation that students use maps in this pursuit is hardly a new concept with regard to geography education, however our ability to carry out that instruction is enhanced by the incorporation of GIST and the vast amount of public data available to educators. In addition to educators seeking these resources, there are several companies who assist in this effort by designing technology for K-12 students and making it available for use in the classroom.

Incorporating modern spatial technologies into geography education is possible today because of advances in the spatial tools available as well as concerted efforts by the publishers of those tools to make them available to secondary students (see Esri Education, 2020). Esri is one such publisher, and they make a suite of products available to the general public for free as well as waiving fees for school systems hoping to use more advanced products. According to Esri, their products are attractive for a variety of reasons which dovetail with the National Geography Standards and C3 Framework. In addition to the inherently spatial nature of Esri's mapping technologies they believe that "GIS-enabled classrooms" will lead to students developing "problem-solving skills... critical thinking skills... (and) data literacy skills" (Keranen, Malone and Wagner 2018, 4).

This section covered the standards-based rationale behind incorporating spatial technology in the classroom as well as a specific example of a private company which is facilitating that incorporation today. Esri's available tools, specifically Story Maps, are covered in greater detail in Section 3.3. Additionally, specific standards addressed by this project are covered in detail within the methods section.

2.1.2. Implementation and Effectiveness of GIST in Secondary Schools

Increased acceptance of GIST as an element of an effective geography curriculum necessitates research that substantiates its inclusion and investigates best practices associated with incorporating these technologies and tools. Although not the focus of this project, it is worth mentioning the work being done concerning the effect of digital spatial tools on cognitive functions in young people (Downs 2014). The current generation of students came of age and have never been without digital maps; in contrast many current geography teachers grew up with analog maps and came to use digital maps later in life. The younger generation is therefore often referred to as “digital natives” and spatial technology/understanding is intertwined with this larger concept. This section will investigate the attitudes of both teachers and students relative to GIST in the classroom.

Data-driven studies gauging the effectiveness of GIST are, if not widespread, then certainly on the rise and available more so than they were thirty years ago. Key studies on the effectiveness of GIST in schools and clear evidence of their effectiveness in certain areas are available (Kerski 2003). One of the reasons for the increased adoption of GIST in schools is that teachers believe that the technology “effectively engage(s)” students in ways that traditional instruction may not (Unwin 2011, 28). As more teachers turn to GIST resources we see more studies outlining the effects these tools have on instruction. Certain studies show that there is a quantitative effect of using GIST, essentially scores on assessments associated with geographic content increase when the material is taught using GIST resources (Demirci 2008). Other studies show more qualitative effects, for example students using GIST are more motivated to engage with the content (Artvinli 2010).

This project will rely on the research into the proven effectiveness of GIST done by other researchers. The main difference between previous studies and this project occurs in the implementation of GIST. This topic is covered further in Section 2.2.3.

2.1.3. Obstacles to Implementing GIST-enabled Resources in Secondary Schools

Despite the proven effectiveness of GIST resources in secondary education there still exists a great many obstacles to effective implementation. Deciding which technology to use in the classroom is often the first step of implementing GIST resources. Educators essentially have a choice between attempting to use “industry-grade GIS software” or software designed specifically for educational purposes (Kerski 2008, 552). Although educators have this choice, a common theme throughout the related literature is that using the same GIST tools that professionals use invariably leads to issues with students being able to competently accomplish their tasks. Studies suggest that “professional GIS software is not adapted to the needs of students and teachers, and is too difficult for use in secondary geography education” (Favier and van der Schee 2012, 675).

Despite that claim, as educators there is a reasonable expectation that given enough time students could be instructed on how to use professional GIST resources effectively. The main issue, however, is that in a classroom dominated by curriculum content requirements there is simply not enough time to bring students up to speed. One study, conducted among undergraduate students a level above this study’s secondary focus, found that professional GIS “software was deemed too daunting for students learning how to use it in five weeks” (Argles 2017, 343). The solution to this issue is discussed in detail in Sections 2.2 and 2.3.

Another common issue with implementing GIST resources in schools is that teachers are often not equipped to successfully do so (Favier and van der Schee 2012, 676; Degirmenci 2018, 191; Kerski 2008, 553). Even in schools where the technology infrastructure could support GIST inclusion the teachers are often either ignorant of the tools available or not confident in their ability to use them effectively. This project, as a product of a GIST master’s program, will be implemented by a teacher with specialized training in this field. Despite that training, the framework discussed over the next two sections will provide a reproducible methodology for teachers to use even if they do not have a background in GIST. The following two sections will additionally address the obstacles brought up in Section 2.1. as well as provide a new implementation model for GIST resources.

2.2. Design Considerations and Framework for Interactive Projects

The former section outlined the theoretical justification for using GIST resources in the secondary classroom. There are myriad online spatial tools available from a variety of publishers. This section draws on work previously done relative to designing user experiences and user interfaces in an educational setting.

2.2.1. Design Considerations

The first step in determining which technology to use is to determine the imagined functionality of the application. A good framework to use while working through the initial questions is outlined by Roth and directly relates to interactive maps (Roth 2013). Roth approaches the issue of design considerations for cartographic interaction through the lens of the five W's. As this project sets out to design an interactive cartographic application for education Roth's framework is germane to the topic. The following list breaks down the essentials of Roth's framework:

- What? Roth defines cartographic interaction as "the dialogue between a human and a map mediated through a computing device to emphasize digital interactions" (ibid. 64).
- Why use cartographic interaction? Roth argues that interactive maps ask users to "examin(e) the problem from a different, perhaps more informative approach." (ibid. 67)
- When to use? A key point here is that cartographic interaction can be used "for communication of additional details once the overview is first understood" (ibid. 73).

- The final two questions, who and where, have largely been answered in section 2.1. For this project the target audience will be students in secondary education and the where will be in school. For specific considerations with the school infrastructure see Section 2.2.3.

Although not every study of interactive cartography uses Roth's approach, we can examine other academic studies within his framework in order to better inform our understanding of how others have answered the 5 W's Roth outlines.

Cartographic interaction has taken many forms and continues to evolve leading to varied answers to the "what" question posed in Roth's framework. In early educational GIS, students were very likely to engage with GIS in a multimedia classroom, or what we might call a computer lab, and utilize industry-grade GIS software (Kerski 2003). Over time, the availability of laptop carts overcame the need for a lab setting and eventually students' cell phones came to be viewed as the device used to engage with GIS. As the available devices changed, so too did the "what" of cartographic interaction. Story Maps and other applications catering to student-users with streamlined interfaces and simplified controls came to replace the necessity for industry-grade GIS technology (Egiebor and Foster 2019). Student-driven learning opportunities, such as Esri Geoinquiries or Google Treks, take the software one step further by designing the interaction from start to finish in student-centric language and with student-friendly software interaction.

The key question educators must answer before adopting GIS in their classroom is why? Why should they use it and why should students use it? Roth contends that through GIS students change the way they solve problems in a beneficial way (Roth 2013). Research supports this contention, for example the study done by Demirici which outlined how students were more excited about the lessons and felt that they better understood the content after using GIS

(Demirici 2008). Specifically, some researchers have used GIS to teach local history through field work and GNSS incorporation (Lambrinos and Asiklari 2014). In Lambrinos' and Asiklari's study, they found that the answer to the "why" question was both to deliver their content and improve their students' outcomes; they documented that some students showed improvement rates in geographic knowledge of over 90% from before the incorporation of GIS to after (ibid.).

When to use GIS in the classroom is just as important a question and it applies to both how educators incorporate GIS and at what point in the curriculum GIS is appropriate, e.g. at what age can students begin to derive the benefits of GIS? Lambrinos and Asiklari's study was conducted with students as young as 10 years old and they documented the benefits they observed (ibid.). Modern educational concepts have also informed this discussion. Scaffolding is a common practice in education and building knowledge must start somewhere. When it does start, being able to make the content relevant and accessible to students is key (Vavoula and Karagiannidis 2005). Research on this issue continues, however the studies outlined here have shown that GIS can be effective for very young students and that once it is implemented in the curriculum it must be reinforced over time through on demand resources.

Another aspect of the "when" question has to do with the educators' ability to effectively implement GIS use in their classes. For some educators they may not have the infrastructure available to effectively implement GIS in the classroom; for others, they may be ignorant of GIS resources and therefore uncomfortable with implementing them (Favier and van der Schee 2012; Degirmenci 2018; Kerski 2008). The when question then does not just apply to students; teachers and researchers must also consider when to implement GIS as a serious component of any interactive cartographic instruction. How Roth’s five W’s specifically relate to this thesis is covered in the next sub-section.

2.2.2. Application of Interactive Cartography Framework to this Project

This project will utilize interactive cartography in order to assist the delivery of the secondary curriculum. As a result, it is advisable to consider this project within Roth’s framework and inform the decisions being made.

- What does this project have to do with interactive cartography? The goal of the project is to create a digital resource for students to access spatial material. The subject matter of the course itself is geographic in nature and lends itself to spatial materials, although before this project the materials are overwhelmingly analog.
- Why create an interactive cartography project for secondary students? As mentioned in the previous sub-section, this approach asks students to engage with the material in a new fashion. Also, researchers claim that contemporary students in the digital age seek out tools which can deliver “just enough” content, “just in time” and “on demand” (Vavoula and Karagiannidis 2005). An interactive cartography tool meets all three of these requirements by allowing instantaneous online access to course materials both synchronously (in-class) and asynchronously.
- When should interactive cartography be employed? The previous sub-section mentions that a project such as this can essentially be a supplement to material already presented. This is particularly interesting considering the nature of secondary education; students still have required “seat times” meaning that they must be in school for a certain number of hours. The goal of this project is not to have students break out computers and sit there

in class while using the application. As Roth pointed out, projects like this are best used as a tool for enrichment once direct instruction is completed.

- Who should use interactive cartography? Section 2.1 outlines the justification for educators using tools like the one outlined in this project. Ultimately, however, the educator must consider who will be using the application and decide how that will impact the user experience and design. For this project two distinct scenarios should encompass nearly all of the users on the application. First, students who are seeking enrichment either on their own or at the direction of the instructor. Second, students who missed direct instruction in class and need to recover the content material. Despite these clear categories, there will be those who are more adept at using a tool like this and those who are less so. Roth argues that it is "possible that much of this variation in performance (using interactive cartography) can be explained by individual user differences" (Roth 2013, 72). If that is the case then the disparity between users is actually a strength for secondary teachers; all secondary teachers are trained in instruction differentiation for students with different abilities. Adapting an application to accommodate users with various skills should come naturally to secondary teachers.

This section outlined how this project fits within a framework of interactive cartography. Despite the claims advanced here there are still several obstacles and challenges associated with implementing a project like this in a secondary environment. The next section will outline some of those considerations.

2.2.3. Considerations for an Interactive Cartography Application in Secondary Schools

The physical infrastructure available to secondary teachers is a concern when planning or implementing an interactive cartography project, however it is not the primary concern. Some educators are concerned with access to multimedia classrooms and whether students will be able to access the applications at all (Kerski 2003; Ivan and Glonti 2019). This project, however, is not something that imagines students sitting in a classroom using the application during class hours. For that reason, the availability of cell phones in order to facilitate use of the application is paramount (Ivan and Glonti 2019). The web-based nature of the application also mediates many of the problems brought about by incompatible software across different hardware devices (Vavoula and Karagiannidis 2005). Does this mean that the few students who do not have access to a mobile device are simply forgotten about in this project design? No; secondary teachers have access to devices within their classroom (namely Chromebooks in many schools) that students can use. Again, however, this would not be during class hours. Teachers are routinely contracted to have a built in period of time in which they are available to help students; students could utilize that time to engage with the application as well as offering real-time feedback to the teacher on the application's performance.

More important than the physical environment of the classroom in 2020 is the design of the application itself. Several of the design considerations have been addressed in the previous sub-section and still others were raised in Section 2.1.3. One thing to bear in mind is that the target audience, high school students, have grown up with technology and they can recognize a sub-par application (Harvey 2011). Even if an application is technically very useful a complicated design can frustrate plans to use GIST in the classroom (Kerski 2003; Argles 2017; Favier 2012). Therefore, any application that is designed must be "intuitive," meaning users can easily grasp the structure of the application and use it without investing too much time in learning how to do so. By designing such an application educators at the secondary level can avoid extended periods of time teaching how to use GIST and instead spend that time using GIST to enrich their content.

The root of many of the issues associated with interactive cartographic projects in secondary schools is that GIST is often seen as a tool to replace traditional instruction. Recalling the work of Vavoula and Karagiannidis (2005), it is sometimes hard for educators to recognize that students may not care about their content as much as the teacher. Students have multiple classes which they are responsible for and being asked to learn how to use GIST and the content at the same time may often seem like an unnecessary burden. This is where this project fundamentally differs from others and aims to advance the discussion concerning GIST in secondary schools. Take for example the work of Ivan and Glonti; they recorded the results of two different GIST activities in school and documented the results via a survey (Ivan and Glonti 2019, 9-10). Where their approach can be improved, and where indeed many of the secondary education GIST research can, is outlined by asking two questions. First, what if the student was absent? Regardless of method, there is no guarantee that a student who missed that lesson will ever engage with the material in the same way as a student who was present. Second, what if the student still does not understand the material after the GIST-enabled lesson? Despite the well-documented advantages of teaching with GIST there will remain a certain percentage of students who will not grasp the material. Teachers are the faced with the question of how to remedy that. It appears that many studies of GIST in secondary education continue to re-prove what we already know: GIST is a powerful tool and can be used for teaching content. This project will advance that discussion by thinking about GIST not as a tool for *content presentation* but rather as a tool for *content retrieval and enrichment*; traditional methods of primary instruction will still be the primary method of instruction.

The question then remains of which software platform to utilize in order to create a spatially-enabled content retrieval and enrichment resource. This section outlined many of the design considerations that the chosen platform must meet. The next section will discuss the technology which was ultimately chosen for this project and discuss why it meets the requirements outlined in this section while also addressing the concerns brought up in Section 2.1.

2.3. Esri Story Maps as Educational Tools

Esri Story Maps is the technology chosen to complete this project. Story Maps are available to the public and can be created and hosted for free online which makes them an obvious choice for educators in public schools without the resources to fund specialized software. The cost of the product is not the only, nor even the most important, consideration for this project. The following two sub-sections will discuss why both teachers and students should use this technology and ultimately why this project will utilize it.

2.3.1. Benefits Teachers Derive from Story Maps

One of the oft-cited issues associated with teachers adopting GIST resources in the classroom is that they are not familiar with them or are uncomfortable with the amount of time required to generate lessons using them (Strachan and Mitchell 2014; Walshe 2016). Despite these concerns, the usefulness of GIST resources is well-documented (Kerski 2003; Aladag 2014). Egiebor and Foster also relate how, specifically, “Story Maps can be applied across all social studies disciplines to improve student learning” (Egiebor and Foster 2019, 52). As a master’s thesis for a GIST program, I am trained in GIST; this training alleviates the concerns brought up in many studies but also reinforces the call of many to make GIST training part of teacher preparation programs. If GIST, Story Maps in particular, are indeed a useful tool for student learning then they should be incorporated into teacher education.

Teachers will also discover that Story Maps have a range of advantages even outside of the classroom. As mentioned above, this project will design an application assuming that the user is not always in direct proximity to the instructor. The COVID-19 pandemic closed school districts nationwide and forced educators to turn to digital instruction techniques. A Story Map is a unique and powerful tool to engage students when they are not, or in the case of COVID-19, cannot be in the classroom. This is where the approach of this project again differs from traditional studies; rather than imagining the use of the Story Map in the classroom this project imagines that students are using it on their own devices. For me, Story Maps cannot replace well-planned and effective instruction in a classroom. During a situation such as the COVID-19 outbreak, however, a Story Map can act as a backup to lost instructional time, especially if it is specifically designed to do so.

It is worth noting that another common issue that teachers and researchers mention is the logistical problem of providing students with the technology to use GIST tools (Strachan and Mitchell 2014, 207). If the application is designed for students to use their own technology outside of the classroom then this issue is also addressed. Note that although the initial design of the application in this project imagines users on their own devices, it doesn't not preclude the incorporation of GIST-based lessons in the classroom when and if the technology infrastructure is available.

Teachers can also access Story Map technology on their own devices or at home work stations. When that is the situation, the application can be updated with current events and new material when access to traditional classrooms is limited. In addition, students who are already familiar with Story Maps are not limited to just what a teacher produces. According to Esri there has been "a veritable explosion of Story Maps" recently as educators begin to grasp their usefulness (Keranen, Malone and Wagner 2018, 22). This ties into Roth's argument that "interactive maps enable a unique form of visual storytelling" (Roth 2015, 111). An entire library of Story Maps is available to help instructors facilitate and supplement student learning both in and out of the classroom.

2.3.2. Benefits Students Derive from Story Maps

A major concern for students and GIS technology is the problem of an overly-complicated user interface. This issue has been fundamental to the understanding of how to implement GIST in secondary classrooms for quite some time (Kerski 2003, Walshe 2016). Roth discusses this phenomenon as the "productivity paradox," wherein the incorporation of advanced technologies does not lead to increased outcomes (learning in this case) and therefore necessitates "interface constraint" to guide the user on a pre-determined path (Roth 2013, 72). By design, Story Maps are based on pre-designed templates which limit the user's actions. Favier and van der Schee mention the propensity of students to spend a good amount of time on symbology and not actually engaging with the content of the maps (Favier and van der Schee 2012). By presenting content in a predetermined template and limiting user interactivity, to a certain extent, educators can focus content and students can more effectively engage with the desired material.

Another key issue which Story Maps address for students is that they are interactive, fun, and in many cases lead to increased student engagement. Although not specifically tied to Story Maps, Demirici records that over 70% of students in his study of GIS in the classroom strongly agreed that "GIS-based application(s) increased my interest towards geography lessons" and that

GIS “help(ed) me understand the lesson better” (Demirici 2008, 176). Aladag also reports that “GIS increased content retention (and) made learning fun” (Aladag 2014). Egiebor and Foster claim that through GIST teachers can “create a more powerful and engaging classroom” (Egiebor and Foster 2019, 62).

This section outlined the advantages that a tool like Story Maps can bring with regard to students. In addition, Story Maps are a free technology available to educators (see Section 2.1.1.1). Both teachers and students can use the technology free of charge. As students become more comfortable with learning from Story Maps teachers can create more opportunities to put students in the design seat and have them craft spatially-enabled resources. In this way Story Maps act as a gateway to the GIS world for young students.

2.3.3. Distinction Between Existing Uses of Story Maps in Social Studies Education

A key feature of this project is thinking about Story Maps and GIST resources on a different scale by changing the method of implementation. At first glance the most glaring difference between this project and others that have been implemented is the amount of content contained within the application; this project will encompass an entire semester of material rather than one lesson or topic. The following section will outline other uses of Story Maps and where this author believes they can be improved upon by a new method of implementation.

The first element to engage with is the belief that GIST is useful for teaching students about “a particular geographical place, theme or concept” (Walshe 2016, 117). I agree with this sentiment, however by using the term “particular” the educator limits their outcomes when using a Story Map. This tendency rises from the trend to view Story Maps as a replacement for traditional instruction.

One example of a study which engages Story Maps as a lesson is a collaborative project between GIST professionals and teachers to deliver content concerning the Trail of Tears in American history (Egiebor and Foster 2019). There are several challenges identified by the methodology of the Trail of Tears project. The first challenge is the amount of time dedicated to this single lesson. Before the lesson the researchers had students engage with Esri Geoinquiries so they were somewhat familiar with manipulating digital maps. When the lesson itself implemented it took seven days to deliver the content, including an entire day dedicated to working on student-generated Story Maps in the classroom. The researchers clearly show that the lesson was effective and had positive student outcomes, however the timeline is unsustainable in social studies classrooms nationwide. A teacher operating on a block schedule will see students roughly 40 times in a semester. A single lesson which utilizes seven of those days would undoubtedly lead to greater student understanding of that single topic, however it would come at the expense of other content which the state and district require students to receive. Also, this type of lesson, including a lab day, assumes a dedicated technology infrastructure which has already been discussed as an issue in previous sections. Students were also asked to sign up for Esri accounts, which may become an issue for districts who do not allow ".com" utilization for student email accounts based on FERPA requirements. In that case, students could use personal emails which may also prove problematic.

This project addresses the issues perceived with Egiebor and Foster's study by changing the implementation model. Rather than viewing Story Maps as a mode of delivering single lesson content the Story Map would act as a storehouse for *all* content delivered in a semester. It would also be a supplement to direct instruction and not replace the in-class time required to teach the content. The Trail of Tears Story Map study argued that the goal of implementing Story

Maps in social studies classes is to make the subject "more interesting and relevant (by using) different instructional strategies, technologies and multimedia" (Egiebor and Foster 2019, 52). Assuming that Egiebor and Foster are correct in their assumption that Story Maps can achieve that goal, it makes sense to implement a project which can do that for *all* lessons and content rather than one specific topic.

Another challenge raised by the Trail of Tears study concerns the Family Education Rights and Privacy Act, or FERPA. This is a Federal law which requires school districts to protect students' personally identifiable information. If students are asked to create Esri accounts, the district has no control over what Esri then does with that minor's information. One method for addressing the FERPA considerations is to create generic Esri accounts within a school account, an approach that this project utilizes. In that way students could create their own content within the high school account with no danger of their PII being exposed. With regard to simply using Story Maps, however, students can access them without logging in and remain completely anonymous.

Ultimately, the Trail of Tears study is a perfect example of what this project will not be in terms of using Story Maps to deliver specific lessons. Egiebor and Foster created an amazing lesson which students will likely remember and learn more from than a simple lecture. That being said, the sentiment that Story Maps can replace traditional instruction does not match the reality in the classroom. Teachers are constrained by curricular requirements and until that changes Story Maps should be considered as a tool to supplement current instruction rather than replace it. Undoubtedly as teachers and students became more proficient in using and creating Story Maps they could work through more content in less time. In that scenario we might ultimately see these types of activities "act as a springboard for both teachers and students to move to using the full GIS functionality" while still delivering the required curriculum content in the allotted time (Walshe 2016, 117). This project is an example of how educators might try to enhance student proficiency in order to alleviate the issues associated with using GIST for individual lessons.

One project which is more similar to this one in scope is the Wyoming Student Atlas. This atlas is designed for students to be able to use and engage with content from an entire atlas including physical and human geography. The design and implantation of the study was carried out by students and researchers from the University of Wyoming (Berendsen, Hammerlinck and Webster 2018). Each section of the atlas is hosted online and contains a link to "Go Interactive" which then takes students to a Story Map which outlines the subject in greater detail with interactive maps and graphics.

Although undoubtedly more in depth than this study will be, there are also issues with the Wyoming Student Atlas, specifically considering its usability and effectiveness relative to students. As Favier noted, students struggled with GIST resources because "they had little idea of what they were expected to do or how to do it" (Favier and van der Schee 2012, 673). Essentially, the Atlas is a digital version of a textbook which is made available to students. It is a fantastic example of GIST-enabled resources; however, it still requires the teacher to design highly specific lessons to guide student interaction in order to avoid the situation described by Favier. Also, teachers do not have a direct impact on editing the Atlas and therefore cannot make it reflect current events as easily as one which they control. In addition, each "Go Interactive" button within the Atlas leads students to a separate Story Map; there is not one shell where students can navigate through the information.

This project addresses the perceived issues of the Wyoming Student Atlas by once again considering obstacles it contains relative to the design and implementation of the project. First, by tying the content of the Story Map in this project to specific content previously covered in class it will narrow the focus only to those issues covered in class. Specific enrichment activities can be designed and incorporated to build on previous content within the application. Also, the interactivity can be constrained by the Story Map to guide students in the desired direction to serve the ultimate purpose. Limiting the interactivity to control the application through design is a key issue raised by Roth (Roth 2013, 72).

This section covered two examples of Story Map usage in social studies instruction. The first (Trail of Tears) was deemed by the author to be too narrow in focus and the second (Wyoming Student Atlas) too broad. The first example would require the sacrifice of too much other content, especially when constrained by the requirements of a curriculum. The second lacks a clear objective and would lead to little student engagement. Considerations for this project must therefore take this discussion into account. By creating a semester-long shell for the course the teacher is not precluded from building more in-depth lessons like the Trail of Tears example, although that would not be the primary focus. Also, by including specific instructions for either content retrieval or enrichment the teacher would give students a clear objective to achieve while using the application. In addition, each linked lesson within the Story Map will have a set of learning outcomes associated with it to guide students through the multimedia content and the spatial resources available.

2.4. Cartographic Considerations

This project was designed and implemented by a member of the GIST community with training in cartography however any educator could replicate the outcomes found within by following some basic cartographic principles. Although these principles will help educators design more effective maps, there are certain constraints introduced by the use of web maps over maps designed in a professional GIS software such as ArcGIS Pro or Desktop. The following section will outline the major cartographic principles associated with interactive cartography tools for students.

One of the basic elements of a map, and one which is greatly enhanced by access to digital displays, is color. Designing a map around datasets which are displayed with varying color schemes is one of the best ways to ensure the user can interpret the map (Field 2018). Different colors can help differentiate between features but they can also aid the user in understanding both quantitative and qualitative differences between locations. For example, quantitative variables such as national GDP can be expressed using sequential color schemes where darker colors represent higher values. If the goal is to draw attention to the higher GDPs color hue can be controlled to create bolder colors (ibid.). Qualitative color schemes can be used to differentiate between features with different characteristics. For example, a map of NATO countries and Warsaw Pact countries would not be a good area to use sequential color schemes as the features would share the same hue with only differing saturation. A qualitative color scheme would assign the two groups different hues and make them easily distinguishable as distinct entities. Saturation can also be used to draw attention to features while desaturated colors (lighter or washed out) tend to de-emphasize that feature. When making maps it is also worth noting that some colors are “reserved” for traditional uses, e.g. blue for water or green for land on small scale maps.

Symbolization refers to how a map incorporates symbols in order to mark points of interest or tell the user something. Symbols can be generated as points, lines or areas on two dimensional maps (Field 2018). Generally, a symbol will be a simplified representation of a mapped phenomenon. For example, a line representing a road may not show every twist, turn, dotted line or mile marker along that feature. Users, however, when they see the symbol should be able to tell what it is if the symbol represents a common feature. When mapping points of interest the cartographer will often be drawing attention to historical events or occurrences which are not features common to most maps that users will see. In that instance, the cartographer may attempt to use "mimetic or literal" symbols which hint at the symbol's meaning by resembling the mapped phenomenon itself (Field 2018, 456). One example of this would be a picnic table being used as a marker for a picnic site or roadside seating area. Other considerations with symbols are the size and hue of the symbol used. Larger symbols suggest they are more significant, especially if used in concert with smaller symbols of the same type. The same concepts discussed above with regard to hue also apply here; darker (saturated) hues will draw more attention than lighter hues, hues that contrast sharply with the background will appear more prominent, etc. Another consideration for symbols is orientation; if the symbol itself suggests some spatial element, e.g. a border crossing symbol, then the symbol should be oriented to match the reality it is representing.

Labels are also a key part of most maps and they convey information through text. As discussed in both previous paragraphs, decisions concerning labels will determine how prevalent they are to the map user. Large labels will draw more attention than smaller ones at first glance. Saturated labels placed against unsaturated backdrops will pop out at the users. As a general rule, labels should be as unobtrusive as possible when they are not conveying the primary information. A qualitative map meant to show differences in GDP may be hindered by dozens of labels which draw the user's eye away from the intended information.

Web maps create unique situations with regard to each of the elements discussed in this section. Colors on computer screens are displayed differently than if the human eye perceives them on a piece of paper. Symbols which are overly complicated and can be printed on paper may not show up well on computer screens. Labels which are drawn using web-based GIS systems might show up as cluttered and not go through the same prioritization that would have went into a printed map. Despite all of these concerns, web-based GIS maps also have some amazing opportunities. More colors are available to the application designer and they can be adjusted on the fly. Symbols can be changed based on the viewing scale and 3D objects which better convey the significance can be used. Labels can be deconflicted or set to appear only at certain scales to enhance the map in the area where it is being used.

The ability to deconflict labels is only one element of web mapping that is related to a larger theme, that of multi-scale mapping. Scale is how much area a map shows. Large-scale maps show a small area and small-scale maps show a much larger area. Cartographers in the past had to make decisions about scale that would best highlight the data they were mapping, e.g. large-scale for a street map and small-scale for a map of a continent. With web maps users have the ability to pan and zoom, thus changing the scale at which data is displayed. Users can begin at a continent-wide view and then zoom in to see individual houses on a street. This functionality is important when designing web maps as symbology and data can become confusing if they are included at all scales. Web maps enable designers to set visibility ranges to mediate that issue; large-scale features will not display until the user zooms to the appropriate scale when visibility ranges are active. Data resolution, that is the relationship between mapped data and scale, should be considered when configuring web maps and visibility ranges (Field 2018).

A final element to consider with web-based maps is the basemap which acts as the backdrop for the data being presented. When used properly, "basemaps provide the locational reference or context for an application" and can enhance the data being presented (Fu and Sun 2011, 43). If the data on the web map is primarily human geography (e.g. cities, roads, borders, etc.) then the basemap should be chosen to highlight those features, or at the very least not clash with them. A concern with basemaps is that they can, if used improperly, draw attention away from the mapped area. Imagine a highly detailed satellite image which lies underneath your data; it is not a stretch to imagine users being distracted by the other information available to them. One way to mitigate this is to design basemaps which do not contain the focusing elements discussed here, namely saturated colors, significant symbols or even labels. Although that option exists, basemaps should be chosen on a map-by-map basis and reinforce the overall message of the map. Many web maps will also allow for users to change the basemap. This option can be disabled, however in certain cases it may be appropriate to allow for users to further investigate the mapped area.

2.5. Educator Feedback

Many educators today teach the same or similar content, a situation which curriculum design contributes to at the national and state level. The 1994 National Geography Standards and the C3 Framework covered in section 2.1.1 act as a source of inspiration for many state curriculum committees during their design phases. States design their own curricula and often the state standards are further focused by district-level curriculum committees. While this leads to some variation between states and between districts within states, it also creates an environment in which a large number of teachers are teaching the same or similar content. As a result, Professional Learning Communities (PLCs) at individual schools routinely act as sounding boards for teachers on best practices and most effective approaches to delivering content. Although there is no state or national-level PLC, teachers who are familiar with the practice of providing their peers with feedback are a valuable resource to tap in order to gauge the effectiveness of new technologies such as the Story Map proposed in this project.

Surveys of how educators utilize GIS often organize their questions into a series of categories. The first category of questions generally deals with the demographics of the educator taking the survey (Singh et al. 2012). Another common category of survey data concerns the proficiency or comfort level of the educator with regard to GIS technology (Singh et al. 2012, Johansson 2003, Baker et al. 2004). Another common category covers obstacles to the use of GIS in secondary classrooms.

Educator surveys which allow for expert feedback to be incorporated are a benefit to many educational GIST projects. By keeping the questions simple and the feedback requested brief surveys will encourage participation. As mentioned, there are many educators teaching similar courses throughout the country with good knowledge of GIST tools and the content covered. Drawing on their expertise for educational GIST projects will allow projects to go through a more refined design cycle as well as a more informed revision cycle. When surveys are designed properly educators, even from differing fields, can draw on their expertise to provide feedback on the tool itself as well as the content. Once the feedback is gathered the final product can be improved/altered in order to better meet the original design goals of the project. Figure X in the Methods section outlines the cyclical workflow imagined for this project as it relates to educator surveys and feedback.

Chapter 3 Methods

This section outlines the methodology of this project and describes the implementation of the design decisions raised in the previous chapter. The first section (3.1) covers the background and guiding documents associated with this project. Section 3.2 will summarize the data and availability of datasets for this project. Section 3.3 outlines the stages of the workflow that were taken to create this application. Section 3.4 outlines the specific cartographic processes utilized in this project as well as the role of student standards with regard to map design. Section 3.5 outlines the timetable to complete a similar project and provides a review of the steps taken for this project.

3.1. Background and Guiding Documents

This application is designed for a freshman-level geography course in an Idaho high school. The course is called "Eastern Geographical Perspectives" (EGP) and focuses largely on the eastern hemisphere. The author of this project teaches this course to an average of 75 freshmen per semester. A semester is roughly 3.5 months long and this course is a graduation requirement.

EGP, being focused on geography, naturally lends itself to being the case study for tools which utilize geographic information systems and technology. The curriculum for the course is outlined in a broad sense at the state level; the state of Idaho publishes geography standards which they expect all students to meet. The individual school districts then design and implement courses which deliver on the standards outlined at the state level. It is up to the teachers to determine how those standards are met in their classrooms. For these reasons, the topical content of this project is largely predetermined and constrained by the guiding documents of the state of Idaho and the individual school district. The teacher has some leeway in determining specific content used to teach certain standards (e.g. using certain current events to teach about migration patterns). The impact of the topical organization outlined by the state and district is discussed in further detail in Section 3.3.3.

3.2. Data and Availability

Table 1 in this section describes the data required to complete this project. The use of Esri Story Maps is discussed in Section 3.3 and is why the Living Atlas, an Esri online database of layers and resources, is included in the data for this project. Because this application focuses on an entire hemisphere there are large datasets which would take up a good portion of the project time if they were created by hand (e.g. country borders or major cities). By utilizing the Living Atlas and ArcGIS Online content this application benefits from layers created by Esri and the larger ArcGIS community. The regional maps are created by the project author using resources from the Living Atlas, ArcGIS community, and ArcGIS Online. The regional distribution of these maps is discussed in the next section.

3.2.1. Dynamic Data

The most highly variable data in this project are the points of interest (POIs) as well as any current events APIs brought into the application. The POI layers as well as the APIs will be something that is constantly updated and curated by the instructor or owner of the application. For this project, a predetermined set of dynamic data based on the last semester taught is used to illustrate the functionality within the application.

Places of Interest will be less dynamic than current events, but still subject to change. For example, one place of interest on the map of Eastern Europe is the Chernobyl Nuclear Site in northern Ukraine. This place of interest has come up in recent times because of similar incidents like the Fukushima Daiichi nuclear disaster in 2011 as well as a surge in popularity surround the

HBO series *Chernobyl* (2019). While this may continue to be relevant into the future, it is worth mentioning that data for POIs is dynamic and can be changed to better teach current events.

Any APIs that focus on current events will change often, either the specific API used or the data presented through the API. These APIs can focus on different regions or events and the content changes rapidly. In the Middle East just within the last three years an API focused on the region encompasses the Syrian Civil War, the rise of ISIS, the Kurdish-Turkish conflict and many others. With regard to data, it is important to note that APIs would be the most dynamic and therefore must be reevaluated constantly to ensure the content aligns with the project and the overall goal.

Table 1: Data Categories

Source	Description	Scale, Precision, Accuracy	Availability
Living Atlas Layers	An online repository of shared data for use with ArcGIS products.	These layers are created at various scales and will be investigated individually for accuracy	Freely available to ArcGIS users
ArcGIS Online User Community	Shared data from other ArcGIS Users	These layers are created at various scales and will be investigated individually for accuracy. When known, each layer is also cited.	Freely available to ArcGIS users
Regional Maps	Cartographically sound maps of each region covered in the geography class.	Scale determined by district curriculum. Precision and accuracy will depend on my work.	Created by application author
Points of Interest	Point layer unique to each region with pop-ups	Each set of POIs will be limited to a specific region. Once again precision and accuracy will be a variable dependent upon my work	Created by application author

3.2.2. Detailed Data Information

Chapter 4 of this thesis will outline each of the layers that were created within the regional tabs of the Story Map, however an illustrative sample of those datasets is provided here in order to give the reader a sense of what specific datasets were eventually generated, what those layers contain, how the data is stored, and data quality. Table 2 below outlines this information for the Introductory Unit map and is indicative of how all data layers used in the Story Map are curated.

Table 2: Data Specifics

Layer Name	Contents	Storage	Data Quality	Attribute Fields
Intro_POI	Point data associated with various points of interest.	Stored in the Meridian HS ArcGIS Organization content as a hosted Feature Layer	Precision, accuracy and consistency based on my work. Completeness is relative.	Name (text) Significance (text) Country (text) UnitCoveredIn (text) OBJECT ID
Region 1 Region 2 Region 3 Region 4	Polygon data outlining the specific regions of study (4 total layers)	Stored in the Meridian HS ArcGIS Organization content as a hosted Feature Layer	Complete as per my needs. Precision and accuracy suffer at large scale as these are continental-size layers.	Shape_Area (double) Shape_Length (double) OBJECTID
World Light Gray Reference	Image of political boundaries, populated places, water, roads, urban areas, building footprints, parks	Part of Basemap layer stored on Esri servers	Very High; draws from Esri, HERE, Garmin, OpenStreetMap and the user community data	N/A, PNG32 raster data

Each region will have its own set of layers similar to the ones described above, however they will obviously concern data specific to that region. Table 2 shows the general framework which all maps adhere to. Each layer is named based on the unit it belongs in and the information found within (e.g. Intro_POI is the introductory unit points of interest layer). The contents vary greatly based on the unit and the focus of that unit; these specific decisions are discussed in detail in Chapter 4. All layers are stored in the MeridianHS organizational account of ArcGIS. All layers are also hosted as feature layers to enable their use within web maps, dashboards and the Story Map. Data quality is largely dependent on my work and quality control is my responsibility. The attribute fields, much like the layers themselves, vary greatly and depend on the focus of the region. Generally, a name, description and piece of data related to the regional theme are included in each as a text field. Each regional map also uses a basemap and reference layer which, like the one described above, are curated by Esri and stored on their servers.

A final note on data concerns the course content which is embedded within the application itself. This content is stored in PDF format for both slide decks and text documents. These PDFs were then uploaded to the West Ada School District Servers. This was done to limit the amount of data used within the MeridianHS organization and because the amount of storage is unlimited for me. There are over three dozen PDFs linked throughout the application, each one is stored in the manner just described and then hyperlinked within the Story Map.

3.3. Stages of Workflow

This section outlines the workflow in detail. This can help others to recreate the process of this project should that be desired. The workflow begins with planning, moves through the choice of platform, outlines how that platform is utilized, discusses specific choices made with regard to content, and ends with the design of a survey meant to collect feedback from other educators. Figure 2 below outlines the workflow of this project; each step of the workflow is broken down in the following sub-sections.

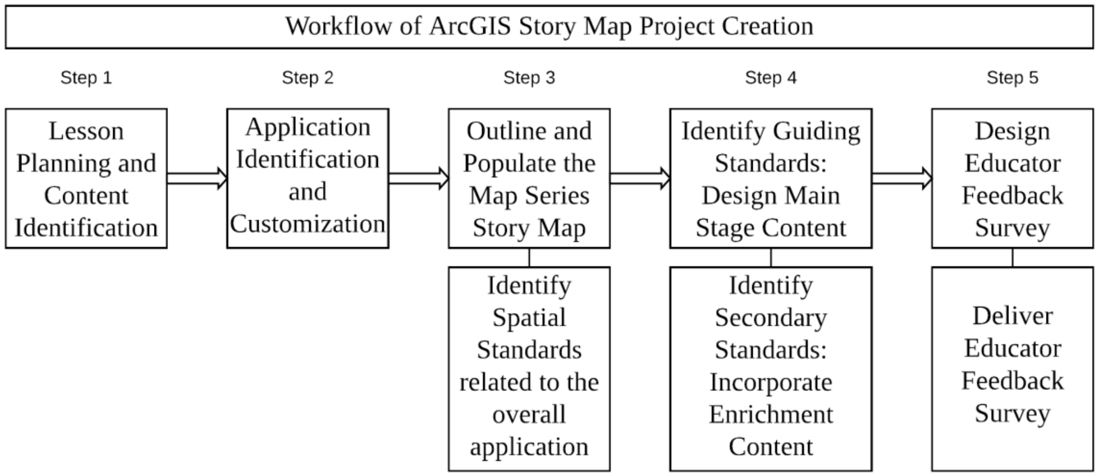

Figure 2: Workflow of ArcGIS Story Map Project Creation

3.3.1. *Planning and Content Identification*

When considering this resource, most teachers have their own content based on district/state/national standards and have already identified resources that they are familiar with and find effective. Therefore, it is essential to identify a resource which will allow the teacher to keep their content while at the same time adding a spatial element to the resources students have available to them. Unlike some other GIS education projects (Egiebor and Foster 2019; Esri Geoinquiries), this application does not seek to replace traditional instruction time in the classroom, but rather to supplement and enhance it.

Central to the planning process should be the questions “why should I create this” and, if a suitably convincing answer is found, then “who will use it?” The answer to the former question is found in the Background chapter of this document. The answer to the second question is, naturally, students. But when and how would students actually use this application? For this project two unique users are identified:

1) The student who missed the traditional instruction in class and is looking for the material that was covered. Traditionally this user would be a student who was absent from class

for any number of reasons while the majority of students still received the standard instruction in the classroom. In light of the asynchronous learning environment necessitated by the COVID-19 pandemic, this user could also be imagined as an entire classroom population who do not receive the standard in-class instruction but are still responsible for the content. The assumptions associated with this user is that they have a device which can access the internet outside of the classroom.

2) The student who enjoyed the traditional instruction and wishes to learn more about a specific topic or region. In education this is often described as "enrichment," or content/material which is in addition to the standard instruction and is generally not graded. At this time, the course this application was designed for (Eastern Geographical Perspectives) does not have an honors or Gifted and Talented version. It is a graduation requirement for all incoming freshmen. For that reason, Gifted and Talented students and future AP students will be taking this course and the ability to offer enrichment for students in that category is available by design.

These two user scenarios are something that teachers will encounter whether they have an application like the one described in this project or not. This project utilizes some of the spatial tools available to us in order to address these perennial student scenarios.

Although this project describes an application that can store all of the teacher's previous material, it is not meant as a "spatial filing cabinet" where teachers upload every single resource they have and simply put a map next to it. The teacher should go through a process where they identify the resources that are *most key* to delivering on the standards they are responsible for. This project discusses national-level standards relevant to this project in the background section and each map within the methods section identifies guiding standards. State and district curriculums should also be consulted by educators hoping to recreate this project in their own classroom. For each teacher this will be different, however this project outlines the process of the author in Section 3.3.3.

3.3.2. Application Identification and Customization

The choice of application for this project is Story Maps by Esri. The justification for that choice is discussed in detail in Chapter 2 of this document. In order to utilize Story Maps, the user must create an Esri account. In the United States, public education entities are afforded free access to Esri's software, including advanced items such as ArcGIS Pro which can be used to create online maps for use within a Story Map application. In order to qualify for these resources teachers must register their school through the Schools Mapping Software Bundle program on the Esri website. The author of this project utilized the School Bundle resources by creating maps in ArcGIS Pro and hosting the Story Map application on Esri's servers.

Educators looking to recreate this process should note that there are two versions of Story Maps available through Esri- Story Maps and Classic Story Maps. This project utilizes Classic Story Maps specifically because it allows the creator to choose the "Map Series" template. This template organizes additional content within tabs associated with various maps. The choice to organize the material around several different maps is covered in Section 3.3.3.

3.3.3. Outline and Populate the Map Series Story Map

EGP, as with most high school classes, is organized into units which are united by a common theme. In this particular class the uniting element is geographic in nature; each unit is specifically associated with one geographic area. Because of the geographic focus of the units this application utilized one map per region and then organized supplemental multimedia information within that region. The maps themselves serve to highlight a secondary unifying theme for each unit in addition to regionality. Table 3: Region-Topic Pairings outlines which units are paired with a secondary focusing theme.

Table 3: Region-Topic Pairings

Region	Subject / Focus
Introductory Unit	Basic Vocabulary, Introduction to Web Maps
The Ancient World	History: Change over time
The Middle East and North Africa	Culture: The customs, arts and norms of a social group
Russia, Eastern Europe and Central Asia	Government: Who rules?
East Asia and India	Economics: The production, consumption and transfer of goods and services
Sub-Saharan Africa	Physical Geography: Physical patterns and processes

For each region a separate tab was created using the regional title as the title of the tab. These regions are outlined within the district curriculum document, however sometimes borders between them are not exact. For example, where is the western edge of the Middle East? By organizing each region around its own map, the designer focuses the user's attention on the region and also on the specific topics discussed in class. For specific choices associated with regional maps, see section 3.3.4.

Once each tab was created, the designer uploaded the traditional content from their class into the Story Map. The traditional content in this application was limited to PDF documents containing slide decks or PDF documents of class readings. Although there is often more material covered in class (not to mention class discussion), the user who is focused on the prior content (User 1 from Section 3.3.1) will want to recover the material as quickly as possible. If they missed the class then they most likely missed at least three other classes that day; they need to be able to get in, recover the material, and get out in a timely manner. Content loaded into the regional shells is numbered in order to show the chronology of how the material was presented. If a student missed a class they can look back to their notes at the last class they were in to determine what came next. Once a student clicks on the link for the material, a new tab opens in their browser rather than directly in the Story Map. This allows students to print materials from slides or documents directly from the new tab without having to navigate a print feature in the Story Map. For this project the large amount of original content (slide deck and reading PDFs) is hosted on the school district servers because the space available is unlimited and secure. The links within the Story Map open directly to the content with one click/tap and users do not have to navigate to the district website.

3.3.4. Design Main Stage and Enrichment Content

Once the shell of the application is built and the traditional materials included the main stage content (the main element which appears in the largest display area for each unit tab) was designed and incorporated. As mentioned in the previous section, this process is guided largely by what specific topic each region is tied to. Trying to create maps that incorporate history, economics, government, culture and physical geography for every region is feasible, especially within the realm of geographic information systems which can organize layers of information. The issue, however, is that the more information is included in each map the more a user must be familiar with GIST in order to successfully navigate it. As noted in the background chapter and pointed out by Walshe, projects such as this imagine the application (Story Maps) as an introduction to digital maps and GIST and therefore students' options should be intentionally limited in order to avoid confusion (Walshe 2016). Each region does, however, incorporate more complex geographic information and user controls based on the assumption that students will be more familiar with the application later in the semester. Section 3.4 will outline each regional map and the processes and decisions associated with its creation.

Each regional tab within the application is organized in such a way that the focus of the main stage content reinforces the overall theme and learning outcomes of the unit as well as progressively exposing students to more advanced GIST data and techniques . This will first be done by setting the scale and scope of the map to cover the region in question and then further designed to enhance focus. The Introductory Unit is the most basic and restricts user interaction the most. The Ancient Mediterranean World Unit contains more information and is designed to highlight change over time in the region. The Middle East and North Africa is the first unit map which allows greater customization via an Esri Dashboard which allows users to browse layers of cultural information. The Russia, Eastern Europe and Central Asia map highlights international boundaries during the Cold War-era, the key event used to teach governmental content in that region. The Russia, Eastern Europe and Central Asia map also incorporates temporal data and allows users to navigate through layers of national boundary information based on different time periods. The East Asia and India unit utilizes data displayed at different visibility ranges as well as multiple overlapping layers of data to highlight the economic differences in the region (mainly the modern communist countries of East Asia). It also contains both raster and vector datasets which students can use to customize the map interface. The Sub-Saharan Africa main stage content utilizes a map focused on physical geography so students focus more on the physical environment rather than the built environment of the region. This final unit also utilizes an embedded ArcGIS Online interface and represents the most advanced use of GIST that students will be exposed to in the course. Each of these regional themes and maps is further reinforced by standards from the C3 Framework, National Geography Standards, Idaho Content Standards and District Curriculum Document. The specific standards addressed are discussed within each region in Section 3.4.

3.3.4.1. Enrichment Content

In addition to the main stage content, the tabs for each region contain region-specific enrichment material for the imagined User 2. Students in this category are not necessarily looking for the material already covered, but rather seeking further information about the region or the topic covered. For that reason, enrichment content is included in the main stage as a layer of Points of Interest (POIs) and in the side menu as a series of color-coded links. The points of interest should stand out to users while at the same time not confusing or drawing the attention of User 1 away from their intended purpose. Symbols which clearly represent a POI but also blend into the overall content are incorporated into each regional map.

Although the POIs themselves can be useful, Favier and van der Schee (2012) point out that students must have a clear expectation of what to do if they are to engage with a GIST task as enrichment. In this application each lesson embedded within contains two learning objectives associated with that material. The standards for each lesson act as the clear expectation discussed above. Each POI in a region relates to 1) the overall theme for the unit, and 2) one or multiple learning objectives identified within the lesson content. Students have the ability to access the enrichment content within the app and, when necessary, change the main stage content to better facilitate the process. For that reason, links to enrichment content within each lesson are nested underneath the numbered lists of lessons within each region (see Figure 3).

As discussed in Section 2.4, color is a key consideration when designing maps. It was also a key consideration when incorporating enrichment content. The content is color-coded based on the type of multimedia resource included as enrichment; red for videos, green for alternate maps, and blue for online quizzes (formative assessments). These colors were chosen because they are three of the easiest colors to differentiate on the gray background of the Story Map content area.

Figure 3: Nested Enrichment Content

3.3.4.2. Incorporation of GIST-based Lessons

Although this project is designed to use GIST as a supplement to traditional instruction, the benefits of GIST-based lessons is well documented and discussed in Section 2.1.1 and 2.1.2 of this document. The potential to use this application as a "home base" for GIST-specific lessons is clear. Users will be familiar with the application itself so they will know how to navigate the content. A GIST lesson, e.g. using Story Maps to introduce a region and including a set of spatial questions and tasks, is easily embedded within the larger application. As seen in Figure 3 the user can open other Story Maps within the application and work through a Story Map or other application designed for a specific topic or lesson. Once users work through the more specific lesson, Figure 4 shows how quizzes and assessment tools can be built into the application. Essentially, this application does not preclude the use of GIST-based lessons although that is not its stated purpose. In fact, incorporating GIST into standard lessons may be made much easier if students are already familiar with this type of application. They will be familiar with accessing and manipulating digital maps, navigating the tools on those maps, and using the application to reach a desired goal (aka a clearly defined Learning Outcome).

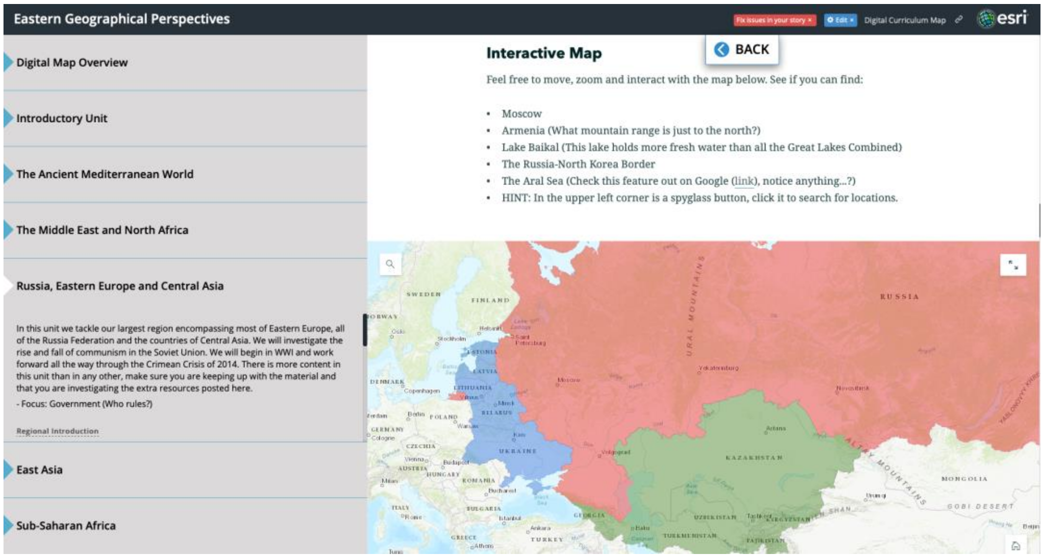

Figure 3: Embedded GIS-Enabled Content

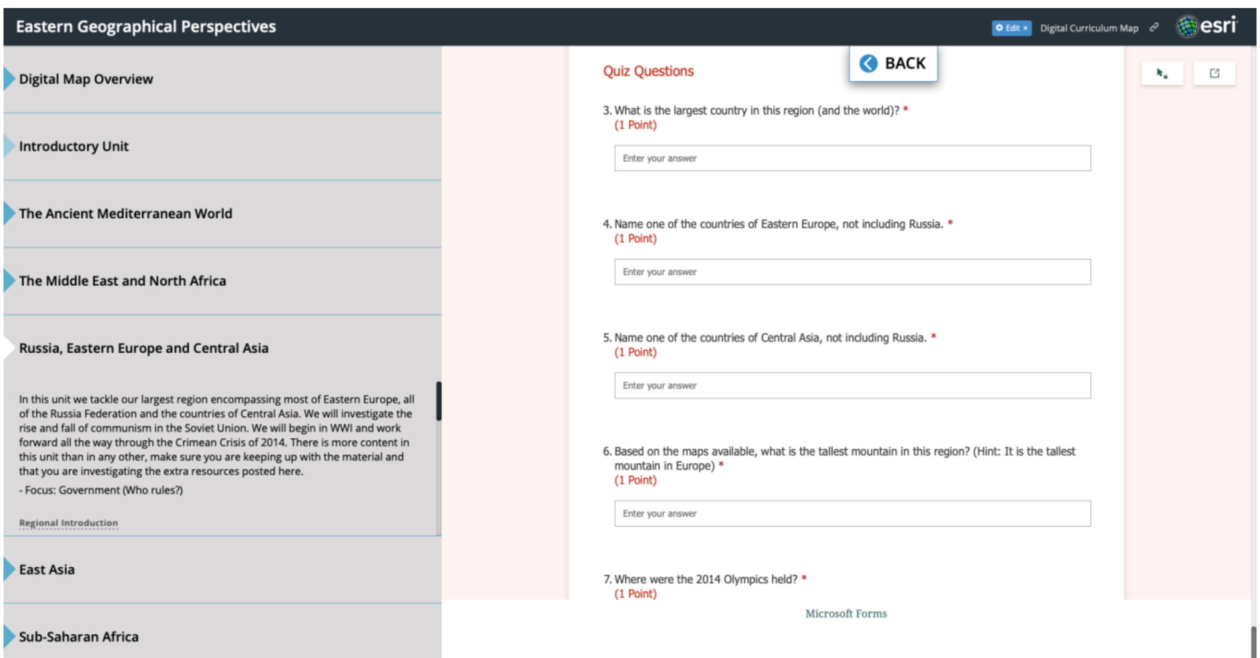

Figure 4: GIST-Enabled Content Embedded Formative Assessment

3.3.5. Designing and Collecting Feedback from Other Educators

As mentioned in Section 2.5, there are many educators teaching this exact course or a similar one which the author can draw on for feedback. The educator survey is a key component in the methodology of this project. By keeping the questions simple and the feedback requested brief the survey encourages participation. It also provides both scaled scores and opportunities for more in-depth feedback. The survey is not specifically tied to this course and allows for subjective interpretation. Educators, even from differing fields, could draw on their expertise and experience to provide feedback. Table 1 below outlines the survey questions designed for this project.

Table 4: Educator Feedback Survey

Question	Response Options
How would you characterize your background knowledge of GIS?	1 – 5 scale, none to expert
To what extent do you already use GIS in an educational capacity?	1 – 5 scale, not at all to daily
If you use GIS in an educational capacity is it to (select all that apply):	- Null, do not use GIS in ed. capacity - Prepare lesson material - Help present lesson material - Deliver content in-class through student projects or workshops - Deliver content asynchronously - Other (Please explain)
How familiar were you with Esri Story Maps before seeing this project?	1 – 5 scale, completely unfamiliar to very familiar
How comfortable are you using Esri Story Maps as a resource for students?	1 – 5 scale, uncomfortable to very comfortable
If you don’t feel entirely comfortable, what are barriers to implementing Story Maps as spatial resources for students? (Check all that apply)	- Amount of time required to create - Unfamiliar with the platform - Doubt effectiveness of Story Maps in this capacity - Already have physical textbooks, Story Map would be redundant - Concern posting copyrighted material online - Other (Please explain)
After viewing this application, are you more or less likely to use Story Maps as educational tools in the future?	1 – 5 , not at all likely to very likely

Although Section 2.5 outlined how demographic data are generally incorporated in these surveys , this project does not utilize demographic data because the main avenue of investigation is whether educators have used or will use a specific technology. The survey is less interested in specific demographics and more interested in the broad appeal of Story Maps to teachers of any subject. As illustrated by Baker, Palmer and Kerski, the use of GIS technology has gained appeal across subjects over time. At the time of their initial survey in 2004, science teachers were almost twice as likely as geography teachers to use GIS for instruction (Baker et al. 2004, 182). By the time of their second survey, five years later, the numbers were almost equal. With regard to this project, the new model of Story Maps as semester-long educational tools is the key point of investigation rather than which subject the surveyed educator teaches or the age/experience of the educator.

Considering the interest in creating a broad-based appeal applicable to multiple disciplines, the survey in this project aimed to investigate both the background knowledge level of the educator with regard to GIS and the extent to which they currently use the technology regardless of the teacher's age, experience or subject (Questions 1 and 2). For example, the second question of this project's survey asks the extent to which the educator already uses GIS. By quantifying the educator's use of GIS regardless of subject this project can better gauge how well the project acts as a model spatial project that can subsequently be recreated. Including other demographic data would contribute to knowledge about the potential use of Story Maps which lies outside the scope of this project. For example, if it were discovered through the survey that veteran teachers of geography were less likely to implement the methodology discussed in this project that would not fundamentally inform or change the overall goals of the project. Utilizing questions such as the educator's familiarity with Story Maps or their comfort level using them with students are more valuable in terms of discovering likely users and will inform our understanding of the educators most-likely to recreate this methodology.

Question 3 seeks to clarify how the educator uses GIS currently, if at all. This question offers a range of responses for those who are familiar with GIS. This question is designed to identify areas where educators already use GIS and then compare that to other responses, specifically their likelihood of using Story Maps in the future. In this way the survey links pre-existing uses to the likelihood of future use modeled on this project's approach. It should be noted that Question 3 is not an exhaustive list of methods that educators employ in terms of GIS and student use. Alternative methods of utilizing GIS include the constructivist approach, where "students' roles (change) from passive recipients of geographical information to active members of an interacting group" (Johansson 2003). If teachers employ GIS in that sense or any other not listed, the "Other (Please explain)" option for this question allows educators to provide long-form text responses and outline how they use GIS.

As with any study encouraging a new approach to an educational tool, another key aspect of the survey will attempt to determine the prior knowledge of the tool as well as obstacles educators perceive in their implementation of this methodology (Questions 4, 5 and 6). Questions 4 and 5 are designed to gather information regarding the educator's familiarity with Story Maps and their comfort level using them as instructional tools. Regarding question 4, this survey does not allow educators to identify familiarity with similar software. As a model for a Story Map, the survey is primarily concerned with Story Maps, however the limitations of not including other forms of software are discussed in Chapter 5. Question 6 asks educators to identify the main friction point with regard to their own use. The main obstacles are distilled from other surveys of educators' use of GIS (See Section 2.5 for background on similar surveys).

One of the most oft-cited reasons for educators avoiding a technology is the amount of time required to establish the tool in question; that is the first obstacle identified as an option for educators in Question 6. The second option states that educators would not implement this technology due to unfamiliarity with the underlying software. This response works in tandem with other questions which gauge the educators' prior knowledge of Story Maps and allow us to answer questions such as: are educators who are more familiar with Story Maps more likely to utilize this methodology in their own classrooms in the future? This is accomplished by comparing the responses for Question 6 with the responses for Question 7.

The final survey question (Question 7) concerns the likelihood of educators using this technology in the future. By quantifying this concern and comparing it to the educators' familiarity with GIS and their perceived obstacles this project identified ways in which the methodology of using Story Maps as digital textbook resources can be improved. Also, by focusing the survey to PLC and building-level social studies departments I can identify the potential for working with colleagues to implement similar projects.

The survey described in Table 3 was distributed to several groups of educators in various educational capacities and at various levels. The first cohort to receive the survey was the PLC group discussed in Section 2.5. These were teachers that are engaged in teaching the same Eastern Geographical Perspectives. There are three other teachers just in the same high school as I am; they were the first to receive the application and the survey. The next cohort was the social studies department within the high school where I teach. There are 13 of them, although not all of them teach Eastern Geographical Perspectives.

The third group able to access the survey were members of Esri's Teachers Teaching Teachers GIS (T3G) group which is a cohort of educational specialists engaged in using GIS to teach either students or other teachers with GIST. The application and survey were both posted in a discussion within GeoNet, an online platform for Esri users to collaborate, interact, and learn. There are dozens of teachers within the T3G group and they teach a variety of subjects at all levels, from pre-K to higher education.

Survey respondents were a convenience sample of educators and GIST education specialists. As potential users of the methodology described here, educators in particular were the population of interest for the survey. The survey was not a random sampling of a certain population and is not meant to be representative of any specific demographic group. The results of the survey are discussed in detail in Chapter 4.

3.4. Cartographic Process and Linked Standards for Regional Maps

Table 2 in Section 3.3.3 outlined how each region covered in Eastern Geographical Perspectives is linked to a specific unifying topic or theme. These themes mimic the division of the C3 Framework, National Geography Standards, State of Idaho Standards and the District Curriculum Guide where the course is taught. The following section will outline how each theme guided the cartographic process for each regional map displayed as main stage content. It will also outline how those processes were executed within ArcGIS Pro and then uploaded for use with Story Maps to ArcGIS Online. The following sections will appear in the same order as they do in the application.

3.4.1. Linked Standards for the Use of the Story Map

This section will outline the standards that are addressed by using the Story Map as an educational tool. It will also introduce the model used to highlight the various standard addressed throughout the regional content. Section 2.1 of this paper explained the use of the C3 Framework and the National Geography Standards relative to designing geography instruction. In this section readers will also see how the standards specific to this application, the Idaho Content Standards and District Curriculum Document, were also incorporated. Table 5 below identifies the specific standards addressed using online geospatial technology.

Table 5: Standards Associated with the Use of Geospatial Technology

C3 Framework	National Geography	Idaho Content	District Curriculum
D2.Geo.2.9-12. Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions and their political, cultural, and economic dynamics.	Standard 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information	6-9.GEH.2.1.2 Apply latitude and longitude to locate places on Earth and describe the uses of technology, such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS).	{Idaho Content Standard used}
D2.Geo.3.9-12. Use geographic data to analyze variations in the spatial patterns of cultural and environmental characteristics at multiple scales.	Standard 3: How to analyze the spatial organization of people, places, and environments on Earth's surface	6-9.GEH.2.1.1 Explain and use the components of maps, compare different map projections, and explain the appropriate uses for each.	{Idaho Content Standard used}

As shown in the table above, the use of geospatial technology is an integral part of the standards at all levels in order to facilitate explanation and analysis of spatial information. The use of spatial technologies is not included for its own sake; it is tied to improving student understanding of specific topics such as civics, culture, economics and geographic distributions of people and features on the Earth’s surface. The number of standards associated with the application are myriad and a full list of standards at each level is included in the Appendix of this document. In order to maintain the spatial focus of this article and not confuse the reader with mass amounts of educational data only a select set of standards is displayed for each region that follows. The standards that are shown, however, were used to guide the creation of each regional map and acted as a focusing matrix for the cartographic processes employed. The standards listed in this section also apply to the Introductory Unit map as that unit is not tied to a specific topic or theme.

3.4.2. Digital Map Overview

The Digital Map Overview is the landing page for all users when they first launch the application. The Main Stage content for this section is William Faden's 1786 "Old World or Eastern Hemisphere" map. This map was chosen for aesthetic purposes and because it focuses on the eastern hemisphere which is the focus of this course. The Faden map is not interactive by design; this tab is meant to introduce the user to the basic premise of the application and then to encourage them to move on to the content in other tabs. As discussed in section 2.3.3, constraining student interaction is a useful tool in order to ensure students do not become bogged down in the areas of the application with little relation to the curriculum or content.

The text in this section explains how the app is organized and how to use the information found within. It explains the color-coded nature of digital resources and points of interest which students can examine for further information. It also calls on students to submit requests for more points of interest. There is a small note on how to access content on mobile devices at the end of the section.

3.4.3. Introductory Unit

As the first unit and an introduction, the map for this unit covers the entire study region for the Eastern Geographical Perspectives course. The application user can see all regions as well as major political and physical geographic features within them. Within this map elements which can be manipulated by the user are limited to points of interest. This limitation is intentional as the content covered in this unit is foundational and not specifically tied to spatial content. For example, the key lessons in this unit cover vocabulary associated with types of governing systems. These systems are found throughout the study area and the basic vocabulary will apply across the region. The map for the Russia, Eastern Europe and Central Asia Unit, which specifically focuses on government, provides more functionality in terms of introducing the spatial element of governing systems.

The regional layer for this map was created using a countries of the world layer from the Living Atlas. Once imported to ArcGIS Pro, the layer was duplicated four times to outline the regions and make the task of symbology simpler. As separate layers the regions are also reinforced as separate entities within the legend of the web map. In order to form the regions, the select tool was used to lasso the region in question. Once the countries within were selected, the dissolve tool removed the boundaries between countries. With the remaining polygon the vertices were adjusted to reflect non-country boundaries. For example, the border between the Middle East and North Africa runs through the center of the country of Pakistan. Culturally, Pakistan fits well within the Middle East unit and can be discussed in terms of culturally similarity with other Middle Eastern countries. Pakistan, however, is also closely tied to China in terms of both imports and exports and can be discussed through an economic lens in the East Asia unit. Pakistan is also engaged in conflict with India in the Kashmir region, drawing them further into the discussion of East Asia. Another example would be the border between North Africa and Sub-Saharan Africa. Sub-Saharan Africa is defined by physical geography and that boundary, the Sahel and southern edge of the Sahara Desert, does not match the country boundaries found in the region.

In order to supply the map with the needed human and physical geography characteristics the Light Gray Basemap is used. This basemap automatically adjusts to show country names at different scales as users pan and zoom. In addition, the reference layer which accompanies the Light Gray Basemap was separated from the basemap within ArcGIS Online. The visibility scale for the reference layer was set to appear only within a scale of 1:20,000,000. Although initially set in ArcGIS Pro, the visibility scale was easily adjusted with a slider in ArcGIS Online. In this way the map avoids the clutter of reference material such as city names and only populates those data once a user zooms into a region.

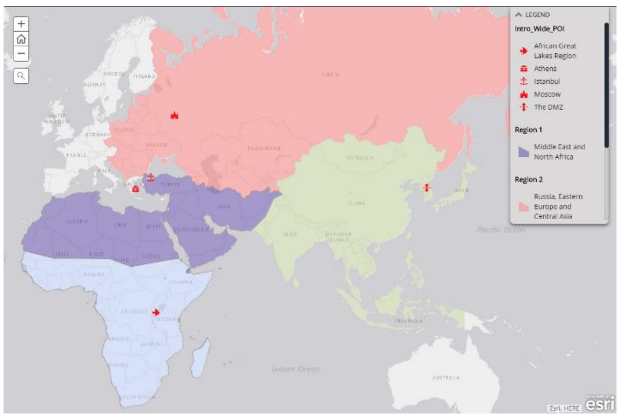

Figure 6: Introductory Unit Overview

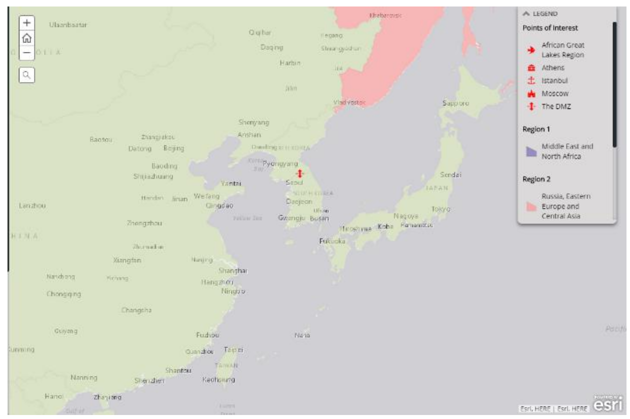

Figure 5: Introductory Unit Large Scale Labels

The Points of interest for this map were designed to call attention to each of the subsequent units. On a map such as this, the number of points of interest could be literally endless. In order to limit cluttering the map the points chosen are located within the region they relate to contain their name, the country they are in, a description of their significance and the name of the unit which they are covered in. This was accomplished by creating a point feature class within ArcGIS Pro. Once the feature class was created, the fields view of the attribute table allowed for the addition of the fields which would contain the popup information. The Object ID was removed from the Pop-up as it did not contribute to understanding what the point of interest is. The Points of interest are also designed to reinforce the themes of the units that contain them. For example, Istanbul is a key location in cultural exchange between Europe and Asia and has been for many centuries. The Middle East and North Africa unit, where content on Istanbul is found, is tied to the concept of culture. Moscow is a point of interest for the Russia, Eastern Europe and Central Asia Unit. As the capital city of the Russian Federation, students' attention is focused on the seat of Russian power for this unit which will cover government systems and changes.

3.4.4. The Ancient Mediterranean World

The following discussion of cartographic choices associated with The Ancient Mediterranean World were focused by the standards outlined in Table 5 below.

Table 6: The Ancient Mediterranean World Linked Standards

C3 Framework	National Geography	Idaho Content	District Curriculum
D2.His.2.9-12. Analyze change and continuity in historical eras.	Standard 17: How to apply geography to interpret the past	Goal 2.5: Explain how geography enables people to comprehend the relationships between people, places, and environments over time.	Unit 3: The Middle East and north Africa Priority Standard 1
	17-1: Using Geography to Interpret the Past: Analyze and explain the connections between sequences of historical events and the geographic contexts in which they occurred	6-9.GEH.2.5.3 Give examples of how land forms, water, climate, and natural vegetation have influenced historical trends and developments in the Eastern Hemisphere.	Analyze visual and mathematical data presented in charts, tables, graphs, maps, and other graphic organizers to assist in interpreting a historical event. (6-9.GEH.2.1.4)

This unit focuses on many of the same geographic areas covered in the Middle East and North Africa Unit, however the unit is primarily concerned with historical events, civilizations and places from long ago. The basemap is specifically designed in order to encourage the user to think about this region in a historical manner, essentially recognizing that this view of the region is not the same as they would see today (see Section 2.4 for background information on the importance of basemaps). The Modern Antique basemap is used to impart an aesthetic of age to the digital map. This basemap does not contain modern borders or labels by design; In the time period studied during this unit, the borders we reference today did not exist. Some of the labels would carry over from places like Athens or Jerusalem, however many of the names have changed over the centuries and would only confuse the message of the map. In addition to the basemap a multidirectional world hillshade layer is included. This layer provides texture to the basemap to make it more visually appealing. It also provides a physical geography frame of reference as the user moves around the map.

One of the main features of this map are the civilizational polygons representing the homeland of three major groups of ancient peoples. These polygons were created using the Create Feature Class tool in ArcGIS Pro and then entering the borders by hand. A buffer tool from specific rivers in the case of the Nile and Tigris/Euphrates systems would also have worked, however these were not definite boundaries and there is not a concrete criterion by which to set the buffer. Instead, the polygons were drawn to encompass the rivers around which the civilizations flourished. In the case of the Greeks, the peninsula of modern-day Greece served as the guiding boundary for the polygon.

The borders of the Persian Empire were established and mapped based on the map "The Persian Empire about 500 B.C." by historian Thomas D. Clark, Ph.D. Clark's map, shown in Figure 7, shows the extent of the Persian Empire right before many of the main events of this unit took place (e.g. the Greco-Persian War). In order to import Clark's borders several steps had to be taken in order to correct the positioning and account for Clark's map being presented in a conic projection and the Story Map being presented in a cylindrical projection (Mercator). In order to do this Clark's map was imported as a raster file and added to the table of contents of the Ancient World map in ArcGIS Pro. With the raster file selected, I georeferenced the image using the tool found in the imagery toolbar. This consisted of finding prominent points that could be matched between the original image and the Ancient World map. This is best accomplished by using very distinct points to match, e.g. the Absheron Peninsula which juts out prominently into the Caspian Sea is easily found on both Clark's image and the digital map. Following this method, including matching coastlines, the image was ultimately mapped correctly and minor corrections were made as needed.

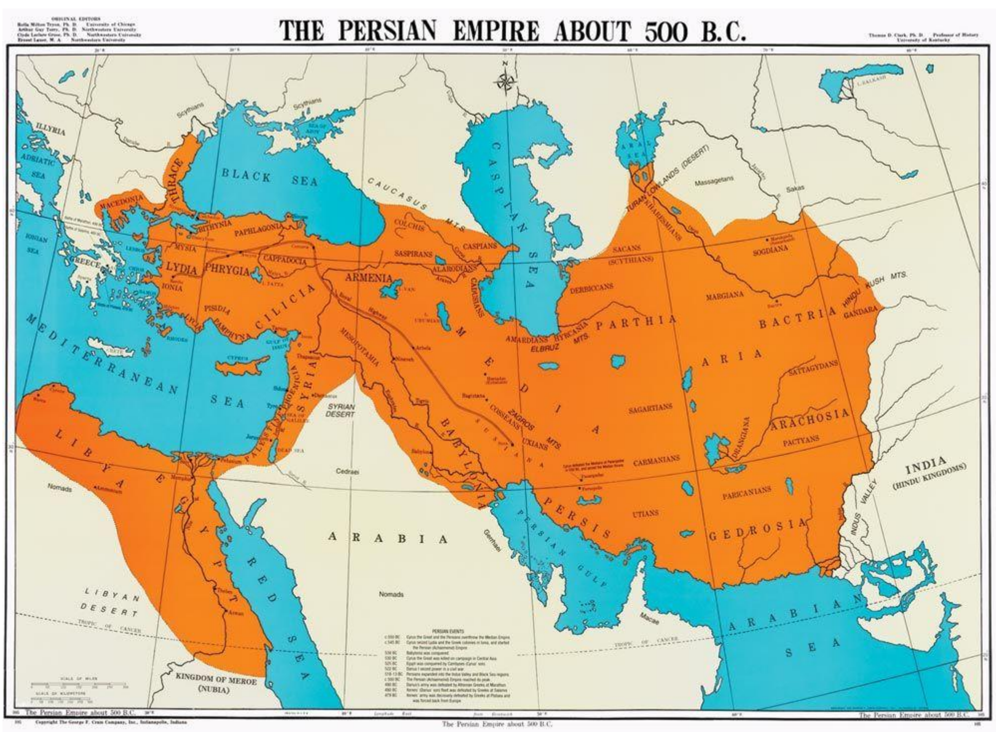

Figure 7: Clark's Persian Empire Map

The final features on this map are a series of point layers which mark the positions of ancient cities, major geographic features, and the points of interest for the ancient world map. Each of these layers was created using the Create Feature Class tool in ArcGIS Pro. This process was discussed in section 3.2.3. The points of interest for this map were chosen as highlights to draw attention to topics that we will discuss in class. For example, there is a point of interest located in Mesopotamia which explains to students why this area was important. As discussed in Section 2.4, color is very important when designing a map. For that reason, the points were colored “Mars Red,” a heavily saturated hue, in order to stand out from the surrounding features.

One of the major themes in this unit is that these things are still important today and they have changed over time. For that reason, the Mesopotamia point of interest calls on students to further investigate the topic by navigating to the Map: The Fertile Crescent, shown in the content tab for the region. When students navigate to this secondary map, they will see modern satellite imagery of the region in question. It is one thing to be able to tell students that this area was important for farming, but by using modern imagery we can show them that it is still important for the same reason today. Students will be able to see the bleak deserts that constrain this area and spot the verdant green areas which still mark the boundaries of the Fertile Crescent.

3.4.5. The Middle East and North Africa

The following discussion of cartographic choices associated with The Middle East and North Africa were focused by the standards outlined in Table 5 below.

Table 7: The Middle East and North Africa Linked Standards

C3 Framework	National Geography	Idaho Content	District Curriculum
{No Specific Standard for Culture}	Standard 10: The characteristics, distribution, and complexity of Earth's cultural mosaics	Goal 2.4: Analyze the human and physical characteristics of different places and regions.	Unit 2 Priority Standard 3: Social Structure in the Middle East
	10-2: Patterns of Culture: Identify and analyze the spatial patterns of cultural landscapes at multiple scales	6-9.GEH.2.4.3 Compare and contrast cultural patterns in the Eastern Hemisphere, such as language, religion, and ethnicity.	Explain how aspects of culture impact the lives of people in the Middle East

The layers for this map were created in order to highlight two interconnected regions, a core and a periphery of the Middle East and North Africa. Based on the guiding standards identified for this unit the regions were defined by spatial patterns of cultural characteristics, specifically language and religion. It is possible to symbolize these two elements together, however it led to an overly complicated visualization of the region. Ultimately language was chosen as the predominant characteristic to highlight. As many of the countries in this region utilize Arabic as either their official or co-official language it highlighted the spatial distribution of this cultural attribute. Religion is a key cultural factor in defining this region, however Islam is not as central to the region as the Arabic language.

In order to create the regional layers, the World Countries (Generalized) layer available through the Living Atlas was imported in ArcGIS Pro. The countries of the core were identified through CIA World Factbook data on language and religion; countries which were predominantly Islamic and Arabic-speaking were selected by hand from the World Countries layer. Once selected, the data was exported to a new a new feature layer in order to allow for more accurate symbolization. The periphery region was also selected by hand based on proximity to the core as well as the prevalence of high Muslim populations (>70%) and Arabic speakers. This selection was also exported from the World Countries layer as a new feature layer.

One each layer was created as a new feature class within a geodatabase (done automatically within ArcGIS Pro) the attribute table was amended in order to add fields for the Islamic percentage of the population, a description and the status of Arabic as either an official language, a secondary or minority language, or not widely used in the country. These fields were populated with CIA World Factbook data in order to allow the Pop-Up for each layer to be configured. Configuring the Pop-Up took place after the map was uploaded as a Web Map to ArcGIS Online. Fields necessary to interpretation of spatial patterns, such as Country Name, Islamic population percentage and Arabic language status, were retained for the Pop-Up while unnecessary attributes, such as Object ID and Object Area, were deselected in order to unclutter the display.

The process of refining the Pop-Up content also allowed for ease of symbolization as only the remaining attributes could be selected to symbolize the layers. As discussed in Section 2.4, quantitative symbolization calls for various saturations of the same hue in order to suggest differences between features regarding a shared characteristic. For that reason, a single hue (Turkish Red) was used to symbolize the Arabic language status in each country with various saturations based on classification. Darker red suggests more prominence within the schema and therefore symbolizes Arabic as the official language. The least saturated color was used to symbolize countries where Arabic is not widely used.

A further element to this map is that the visualized data changes based on scale. The information concerning the percentage of the population which is Islamic appears at the country level when users zoom in. This was done in order to avoid overlapping symbology in densely bordered regions such as the eastern coast of the Mediterranean. This layer utilizes a graduated symbology of green circles, where larger circles represent a higher percentage of the population practicing Islam. This is another example of quantitative symbology as it visualizes changes in a similar attribute between multiple features.

The basemap chosen for this region is the dark gray canvas. This layer is devoid of detailed information, which helps focus the user on the content in question. It also fits into the color scheme imagined for the entire region. Most of the national flags in this region consist of three colors: red, black and green. The symbology of the Arabic language layer introduces the red, the basemap is black and the Percentage Islam symbology is green. This scheme makes the most important features the most colorful and, as discussed in Section 2.4, is more likely to draw the attention of the user to the features of the region.

The Points of Interest for this unit were chosen based on the guiding standards listed above. Two holy cities, Mecca and Jerusalem, were chosen based on their cultural significance to the religious peoples of the region. Tunisia was chosen as the origin point of the Arab Spring, a wave of popular uprisings throughout the region. Iran was selected to highlight their status as a majority-Shia Muslim country and introduce the two sects of Muslims. Turkey was chosen because it is an outlier for linguistic and ethnic purposes. Turkey is also the only member of NATO in the region.

Section 3.3.4.2 of this study outlined how each regional map would progressively incorporate more complex GIST operations as users became more familiar with the application and the concepts associated with studying geography. This is the first regional map which utilizes an Esri Dashboard, a tool which allows users to customize the layer visualization within the Story Map. This most basic operation allows the user to navigate between layers and visualize the core and periphery regions separately. With a dashboard the application designer loses the option to automatically display the map legend; the user, however, should at this point be familiar enough with the map to display the legend. The legend button is also right next to the layer control button in the dashboard layout.

3.4.6. Russia, Eastern Europe, and Central Asia

The following discussion of cartographic choices associated with Russia, Eastern Europe, and Central Asia were focused by the standards outlined in Table 6 below.

Table 8: Russia, Eastern Europe, and Central Asia Linked Standards

C3 Framework	National Geography	Idaho Content	District Curriculum
D2.Civ.8.9-12. Evaluate social and political systems in different contexts, times, and places, that promote civic virtues and enact democratic principles.	Standard 13: How the forces of cooperation and conflict among people influence the division and control of Earth's surface	Goal 5.1: Build an understanding of multiple perspectives and global interdependence.	Unit 5 Priority Standard 1: Borders & Population Distribution
	Conflict: A: Explain the ways conflict affects the cohesiveness and fragmentation of countries B: Explain the causes and consequences of political and social revolutions resulting from issues of control of land and resources	6-9.GEH.5.1.4 Discuss present conflicts between cultural groups and nation-states in the Eastern Hemisphere.	Explain why borders and population distribution in Eastern Europe and Russia have changed and continue to evolve.

The layers for this region were created in order to highlight the governments in the region and how they changed over time. Guided by the standards in Table 6 above, the Cold War was identified as the major event in this region through which to highlight political systems and how that conflict impacted the boundaries of the region. There is an added level of complexity in this region because it incorporates boundary data over a large period of time (1800-2000). Historical events - including both World Wars, The Cold War, and the Collapse of the Soviet Union - have had a major impact on both the physical location of boundaries as well as the governing system within. Rather than try to document every single change in government, the political changes are limited to focus on the rise and fall of communism as the defining political struggle of the Cold War.

In order to create the layers for the two major groups of countries, the Soviet Union and their allies and NATO-aligned countries, a dataset containing historical boundaries was imported from the ArcGIS Online user community (courtesy University of Minnesota via the Library of Congress). The layer containing country boundaries in 1990 was isolated in order to highlight boundaries just before the collapse of the Soviet Union in 1991. A similar process to that discussed in Section 3.4.5 was used to extract the desired countries for the Soviet Union and allies from the global dataset. Once the new feature class was created fields were added to house data on the year that the Soviets gained control of the country, there status as a member of the Warsaw Pact (yes or no), the type of government they employed, the year communism ended and their status as either a member of the USSR proper or an allied state. These data fields were populated with information from the CIA World Fact Book and similar online resources. The process was repeated for NATO countries and excluded inapplicable fields such as Warsaw Pact status and the dates for communist control.

The symbology for the applicable layers was chosen based on the discussion of color in Section 2.4 and considered colors which would fit into historical and military representations of the conflict. The Soviet Union and allies were symbolized using red for both its highly visible characteristics as well as the association with the Soviet Flag and the close association of "Red" with communists in American history. The allies of the Soviet Union were symbolized on a quantitative scheme and appear as a less saturated or pink color. The quantitative symbolization is based on being either within the Soviet Union's boundaries or an allied country with a similar ideological governing system. The NATO countries were symbolized in blue. "Blue on blue," also sometimes called fratricide or friendly fire, is a common expression in the U.S. military today. Geographic Information Systems within the U.S. military highlight this concept via their name, Blue Force Trackers. As a result of the association with blue and this class being taught form an American point of view the American allies of NATO were symbolized in that hue.

Only countries which are members of either the Soviet Union or their allies are labeled on this map when first presented. This was done to focus the user's attention on the region in question. Not all countries are labeled as the map engine for ArcGIS Online automatically deconflicts overlapping labels by removing them. Additional labels for world capitals become visible at larger scales when the user manipulates the zoom of the map. This deconflicts the placement of labels in regions with densely packed countries such as the Baltic region and Central Asia.

Unplaced labels limit the information which is displayed, however the user can still obtain information on the underlying feature via Pop-Ups. When clicked, the Pop-Ups display the overall allegiance of the selected area as well as the underlying attribute table. The Pop-Ups were configured in order to remove unnecessary data such as Object ID or Object Area. The Pop-Ups also allow a "Zoom to" function which will adjust the scale of the map in order to focus on the selected feature.

In addition to the Soviet Union layer, this map contains a layer which outlines the border of the Soviet Union itself. This feature outlines the overall territory and acts as a disambiguation for users confused by the appearance of labels for each of the S.S.R.s (Soviet Socialist Republics) within the Soviet Union. The border layer is symbolized with a highly saturated hue of red and appears in the legend in order to explain its purpose. It is also configured with a Pop-Up if users do not utilize the legend. The border was created from the Soviet Union and Allies layer using a Select By Attribute tool. The attribute to select was USSR Member. Any country polygon with a “member” designation in that field was selected. The Copy Feature tool was then run to create a new layer. With the new layer a Dissolve Boundaries tool was run to remove the internal boundaries between Soviet Socialist Republics and leave only the total polygon remaining. That polygon was then symbolized, and the fill was set to no color in order to allow visualization of the data layers below.

The points of interest for this region were chosen within the focusing matrix of the identified standards in Table 6. As with all other regions, the points of interest are symbolized with a highly saturated hue of red in order to catch the eye of the user. They are also displayed within the legend in order to encourage the user to search for them on the map. The Central Asian Nations which emerged following the fall of the Soviet Union are symbolized with a border crossing symbol, suggesting borders within a region which is initially symbolized as one feature. The site of Chernobyl where a nuclear reactor melted down in 1986 is symbolized with a radioactive symbol. This event is a key teaching point in the unit to help explain the weakening of the Communist Party in the Soviet Union. The Crimean Peninsula is symbolized with a chevron, a common symbol used within the military. The Crimean Crisis of 2014 is a modern example of changing borders and territorial disputes between nations. East Germany appears purple on this map as it lies sunder the semi-transparent red of the Soviet Layer and over the blue layer of NATO countries. The symbol for this point is a starburst and the Pop-Up associated with it explains why East Germany, a country which no longer exists, appears different from the surrounding regions. St. Petersburg, known as Leningrad during the Soviet years of control, is symbolized with a star. This symbol is often used on maps to represent the capital of a region or country. St. Petersburg was the capital of Russia prior to the Russian Revolution in 1917. The

Aral Sea is symbolized with a dust devil swirl. The government of the Soviet Union decided to use this body of water for extensive irrigation in the 1970s; as a result, population distributions are changing in this region due to the desertification due to over-irrigation. The Turkish Missile Sites utilize the mimetic symbology discussed in Section 2.4 and appear as a missile. The Pop-Up for this point explains the importance of Turkey as a bulwark against the spread of communism in the Middle East and the Levant.

Temporal datasets are an added level of complexity for users to control in this map. The same dataset used to extract the Soviet Union and Allies layer and NATO layer was used for this. In total, there are eight layers in this dataset ranging from 1800 to 2000. Hues of purple, green, yellow, orange and brown were used to ensure that these historical borders stand apart from the initially displayed layers. These layers are not initially visible and require the user to interact with the user interface of ArcGIS Dashboards. This serves the purpose of requiring users to engage in more complex GIST operations as discussed in Section 3.3.4.2. It also allows users to configure a Time Animation within the dashboard and to play the changes in borders from 1800 to 2000. Within this Time Animation users can control the speed of playback, the time span covered, the intervals and division of the time periods animated, and the layers displayed during playback. This further reinforces the overall theme of changing political divisions over time. The reasons for those divisions require some background knowledge provided through linked class content. For example, why 1945 (the last year of WWII) is an important year to document in terms of boundary changes is brought out within the class instruction if the user does not already have that knowledge. The temporal datasets are limited to the region in question or association with regional countries (e.g. historical colonies of regional states). This was done by performing a Select by Location function on the Soviet Union and Allies and NATO layers. The tool was run with the intersect setting in order to highlight changes within the region in question. Once selected the features were exported using the Feature Class to Feature Class tool. In order to enable the time function a new field called Date was added to each dataset. To populate the date field the Calculate Field tool was used and the specific date for each layer entered in place of an equation. This prevents the designer from having to enter the date manually in each cell of the attribute table.

The basemap for this region is the Khaki Vector Basemap with the reference labels removed. This limits the information outside of the zone of focus and discourages users form wandering over the map. Because all the border layers are semi-transparent, however, users can see modern borders under each layer even if they are not labeled. This once again reinforces the concept of change over time in terms of political distribution. At very large scales the reference layers for the basemap become visible for the user. For example, if they click on the St. Petersburg point of interest and "zoom to" it other municipalities, roads and labels will populate.

3.4.7. East Asia and India

The following discussion of cartographic choices associated with East Asia and India were focused by the standards outlined in Table 7 below.

This region utilizes layers which highlight the economic status and differences between countries in East Asia. The first layer created was extracted from the World Countries (generalized) layer of The Living Atlas. The Select tool was used manually to lasso the region and then the data was extracted using the Feature Class to Feature Class tool. With the new layer in place, a further layer containing a point layer of demographic data from the World Bank was added from the ArcGIS Online user community. A Join operation was then run on the World Bank data to link it with the regional countries layer. The join field was "country name" and the operation created a new layer of regional countries with the demographic data in the attribute table. Another layer was then created by selecting the four communist countries of Asia: China, Laos, Vietnam and North Korea. The theme of the unit is economics and highlighting the communist countries outlines differences in patterns of economic systems. The original point layer of demographic data was retained in the final map as well. The data of interest within that layer was the per capita GDP numbers from 1960-2016. This layer is hidden at the initial display and only becomes visible at smaller scales to avoid cluttering the map.

Table 9: East Asia and India Linked Standards

C3 Framework	National Geography	Idaho Content	District Curriculum
D2.Eco.11.9-12. Use economic indicators to analyze the current and future state of the economy	Standard 11: The patterns and networks of economic interdependence on Earth's surface	Goal 3.2: Identify different influences on economic systems.	Unit 4 Priority Standard 3: Current Global Issues in Asia
	Locations and Spatial Patterns of Economic Activities: Identify and analyze the origins and development of and changes in patterns of economic activities	6-9.GEH.3.2.2 Compare the standard of living of various countries of the Eastern Hemisphere today using Gross Domestic Product (GDP) per capita as an indicator.	Investigate and evaluate causes and consequences of current global issues throughout Asia and consider possible responses by various individuals, groups and/or nations (megacities, trade, economic growth, Coronavirus)

The symbology of the initially displayed information on this map is meant to focus the region and highlight the communist countries within. The overall regional layer is symbolized as a single hue to suggest membership in the region. The communist countries are highlighted using a more saturated hue of a different color in order to stand out from the others in the region. When viewed as overlapping layers, the differences in hue between the regional and communist layers act as a qualitative symbology (either communist or not). The hues used, however, are less contrasted than the hues used in the Russia, Eastern Europe and Central Asia map discussed in the previous sub-section. This decision was based on the adoption of market practices by most of the communist countries of Asia (North Korea remains an outlier). Although communist countries have definite economic differences from non-communist countries, the underlying economic activities compared to non-communist countries are less pronounced than the civic divisions discussed with regard to the Soviet Union. The final symbology choice was made regarding Taiwan. In The Living Atlas World Countries layer Taiwan is a part of the mainland China country polygon. This is a point of contention between the Chinese government and the residents of Taiwan. In order to highlight that contention a layer containing a single feature, Taiwan, was created within ArcGIS Pro. The layer was then symbolized as dark green, a hue not used anywhere else on the map and more likely to draw attention.

Once attention is drawn to a region, the Pop-Ups within provide the user with information that helps explain the chosen symbology. Within the region the Pop-Ups contain demographic data concerning population and the percentage of the population within that is urban. These are two features we highlight in the class to help explain economic concepts such as urbanization and industrialization. The Pop-Up for the communist countries layer also includes a description of the nation and explains why it is symbolized differently. In addition, the year that the country adopted communism is given in order to provide temporal context to the mapped phenomenon. The Pop-Up for Taiwan also contains explanatory text for why it is symbolized differently. It also contains GDP per capita data as the layer containing that data is spatially associated with mainland China.

Points of interest within this region are designed to highlight economic aspects of various cities within. Many of these cities are categorized as “megacities” and are some of the largest metropolitan areas in the world. The standards identified for this unit call for comparing locations using GDP per capita, for that reason city GDP per capita is given to compliment the country GDP data and encourage comparisons at various scales (e.g. the GDP per capita of Mumbai, India is significantly higher than the GDP per capita nation-wide). Dhaka, Bangladesh was chosen due to being one of the fastest growing metropolitan areas in the world as well as one of the largest. The symbol chosen was the monetary symbol for the Bangladeshi taka, their unit of currency. Hong Kong was symbolized as a large city to suggest major urbanization as well as high rates of development. Mumbai was symbolized as a bank due to its position as the economic capital of India. Pyongyang was symbolized as a factory in order to suggest industrialization. Seoul, South Korea was symbolized using the South Korean monetary symbol, the won. Shanghai was symbolized using a ship due to its position as the busiest port city in the world in terms of gross tonnage. Tokyo was symbolized using the Japanese monetary symbol, the yen. Each symbol was chosen to be either mimetic or associated in some way with economics (e.g. monetary symbols). The final point of interest in this region is Wuhan, China. As the reported source of the COVID-19 outbreak this will be something that users will want to find, and this map makes it easier for them. The Wuhan symbol is a quartered circle and is slightly larger than all other symbols, suggesting importance and relevance to current events.

Regarding the increasing complexity discussed in Section 3.3.4, this map contains the most varied layers of information to this point as well as both vector and raster data. The initially displayed layers contain information on total population as well as projected population in 2025. GDP per capita by country data appears at smaller scales when the user navigates the map.

Additional layers which the user must enable via the Dashboard controls contain information on the percentage of the population that is urban dwelling, use density of shipping lanes worldwide and world population density. These last two layers are in raster format, displayed as images rather than points, lines or polygons. This marks the first time that users will be able to analyze raster data and compare it with the overlapping semi-transparent vector data.

The basemap for this region is Streets, a scalable layer which contains reference information. This was done to aid in interpretation of global layers, including population density and shipping lanes. For example, the shipping lanes will show heavy concentrations near the U.S. cities of Seattle and Los Angeles. If a basemap with no reference data were used, then users would be forced to guess which cities those concentrations appeared near. Using the streets basemap with reference data also eliminated the need to configure labels for the several overlapping layers within this region. The users can identify the locations within the layers because the displayed layers are semi-transparent and the dark labels used in the Streets basemap are clearly visible.

3.4.8. Sub-Saharan Africa

The following discussion of cartographic choices associated with Sub-Saharan Africa were focused by the standards outlined in Table 8 below.

The main stage content for the Sub-Saharan Africa unit is qualitatively different than the main stage content for the other regions. Sub-Saharan Africa marks a shift away from designer-based cartographic design and towards user-based cartographic interaction. The main stage for this region is populated by the ArcGIS Online user interface and populated with data from the Esri Geoinquiry “A river runs through it” in the Earth Science category. Section 2.3.3 of this document outlined how the Story Map itself is not meant to replace primary instruction; the map for this section would at first glance suggest that the application is trying to do exactly that. This map, however, is meant as a launch point for students to complete on their own time, either after direct instruction in class or at home.

Table 10: Sub-Saharan Africa Linked Standards

C3 Framework	National Geography	Idaho Content	District Curriculum
D2.Geo.1.9-12. Use geospatial and related technologies to create maps to display and explain the spatial patterns of cultural and environmental characteristics.	7: The physical processes that shape the patterns of Earth's surface	Goal 2.2: Explain how human actions modify the physical environment and how physical systems affect human activity and living conditions.	Unit 3 Proficiency 2: Human Environment Interactions
	Components of Earth's Physical System: A: Explain how the effects of physical processes vary across regions of the world and over time (hydro, litho, bio, atmo) B: Explain the ways in which Earth's physical processes are dynamic and interactive	6-9.GEH.2.2.6 Explain how physical processes have shaped Earth's surface. Classify these processes according to those that have built up Earth's surface (mountain-building and alluvial deposition) and those that wear away at Earth's surface (erosion).	Supporting Standard 8: Describe major physical characteristics of regions in Africa.

As mentioned by Walshe (2016) and also covered in Section 2.3.3, one reason an application such as this is desirable is because it first introduces students to GIST and then opens the door for more advanced use of the systems and tools in question. This region therefore represents the most complex GIST interface the students will engage with because it asks them to utilize all of the tools they have gained up to this point (navigating digital maps, manipulating layers, analyzing multiple datasets for information, etc.) in order to achieve specific goals, aligned with the standards in Table 8, through the use of ArcGIS Online. Although Sub-Saharan Africa is the shortest unit in this course, the GIST methods students will need to employ to be successful are the most advanced.

In order to gauge student outcomes with regard to this task the first step was to download and edit the Esri Geoinquiry guide for this map. The specific standards students are to achieve were adjusted to align with the standards for Eastern Geographical Perspectives. Students still work through the introductory portion of the Geoinquiry based in the United States. This allows them to become familiar with the content and concepts (watersheds and river systems) in a geographic area that is more familiar to them. The heaviest revisions were done in the Elaborate and Evaluate sections; these were rewritten to focus the students' attentions on the region of Sub-Saharan Africa. The student deliverable for this section – how they prove that they worked through it – is to either take a screenshot or digitally print a PDF of a watershed in Sub-Saharan Africa that they successfully outlined. In order to further link the students' activity with the identified standards they are asked, through a series of questions on a digital quiz, to predict where human settlements would appear within the watershed they outlined and why.

Maps of elevation and precipitation in Sub-Saharan Africa are linked within this unit on the navigation pane in order to provide students with more information about the region. These maps, when compared to others in the series, are relatively simple and straightforward. In the edited Geoinquiry students are given the enrichment opportunity to modify the Geoinquiry map and add the data used on these supplementary maps. The supplementary maps therefore act as enrichment content which reinforces the overall focusing standards but also introduces the myriad standards associated with each unit that were not identified as focus points for the regional maps. The process of selecting enrichment content to incorporate more standards is covered in greater detail in the next section.

3.5. Enrichment Content: Pulling in More Standards

As illustrated in Section 3.4.1, the standards identified to focus each region's main stage map represent only a fraction – and a small one at that – of the overall content standards for a course. The standards helped focus the content while concurrently building the background GIST skills of each student through increasing levels of complexity in each unit. By the end of the course students should be achieving the spatial thinking standards outlined in Section 3.4.1 as well as the standards identified in each of the sub-sections of Section 3.4. As this project has consistently asserted, however, the application was designed as a complement to rather than a replacement of traditional instruction. In order to aid students as they attempt to master all of the identified standards, this application can assist via the incorporation of standards-based enrichment content.

In order to explain the usefulness of enrichment content with regard to standards this section will briefly outline some examples. To outline every piece of enrichment content would be both tiresome and lengthy. The examples given here will provide readers with a sense of how enrichment content can work in an application like this. If readers are to recreate this project, their own enrichment content could be as little or as extensive as they wished. For an elementary or middle school class less content might be included. For an honors or AP class the amount of enrichment content is almost boundless within this model. For this project multiple pieces of enrichment content were included for each region via several forms of multimedia.

One of the standards addressed at all of the levels studied for this project is the concept of how the physical environment impacts the spatial distribution of populations. It is perhaps best stated by National Geography Standard 15: How physical systems affect human systems. Within Standard 15 students should: “Analyze the concept of “limits to growth” to explain adaptation strategies in response to the restrictions imposed on human systems by physical systems.” This is a concept which is used to study societies today, however it can also be studied within the context of the past. In The Ancient Mediterranean World tab of the Story Map there is a piece of enrichment material titled “Map: The Fertile Crescent.” This enrichment content is also referenced in the points of interest layer for this region. When students click on that map they will see the main stage content change to the Fertile Crescent not as it was 5,000 years ago but as it appears today with modern satellite imagery. They can still see the verdant fields and green valleys which break up the otherwise barren deserts of the Levant and North Africa. They can visually observe the Zagros Mountains to the east of Mesopotamia and the vast sands of the Sahara to the west of the Nile. They can actually see the limits to growth on the screen in front of them. Points of interest within this secondary map help students understand agriculture as it is still practiced today and, hopefully, get them to better understand the guiding standard of the unit which is to interpret historical events through the lens of geography.

The example given is just one of many ways in which enrichment content addresses standards not identified as primary to the design of the regional maps. All of these standards would be, and indeed have been, taught through traditional instruction in the past. Through design this Story Map now organizes those standards into easily retrieved enrichment content which is available to the student 24 hours a day, seven days a week.

In addition to the ease of access discussed above, the enrichment content is also organized according to the color principles outlined in Section 3.3.4.1. This project separated enrichment content by multimedia type in order to hint at the time requirements necessary to engage with each resource. This is not the only possible division, especially considering the application to linked standards. Alternative classifications of enrichment content are covered in the Discussion chapter of this paper.

3.6. Timetable to Complete Project

This section outlines a timeline to provide the reader with the time commitment needed to develop a similar project. Educators should keep in mind that the timeline can change based on content, individual teaching methods, and the amount of enrichment included in the project. Refer to Figure 2 for a visual representation of the steps outlined in Table 9 below.

Table 11: Timeline of Workflow

Stage of Development	Estimated Time Commitment
Identify and host material online	One week to organize and upload pre-existing material from the course
Identify typology of material	Course dependent; for this class the regions are outlined by the curriculum documents
Build/adjust Story Map shell	2 hours to initially set up the application. Adjustments and revisions will depend on the extent of the changes
Outline content groups and link material	1 week. The typology is already set but the lessons should be mapped into the groups and then uploaded to the internet and linked within the shell
Identify topic of main stage content	Topic dependent: each unit for this course was tied to one specific subject. Outlining the lessons to match that has been the process of three years of work; identifying the main stage content to accentuate those choices can vary
Design main stage content	3-5 weeks. This step includes designing and publishing web-based maps for all of the content areas and represents the bulk of the work for the project. Accurately identifying the main stage content will help guide this process

Design secondary/enrichment content.	2 weeks. This step will vary greatly from unit to unit, however all enrichment content should relate to and reinforce the focus of the parent unit and the learning objectives identified in specific lessons
Incorporate educator feedback.	3-4 weeks. This step is dependent on feedback from others and is outside of the designers control. Once feedback is received the incorporation will go quickly as the application is already built

Chapter 4 Results

4.1. Project Intent

The original goal of this project was to create a web application using Esri Story Maps that would house and enhance an entire semester of content from a high school geography course. Through the course of this project Story Maps have proved capable of being the type of application imagined. Background training in cartography also enhanced the designer's ability to create useful regional maps to accompany the course content. This chapter will discuss the results of the application development and cartographic design as well as revisions to the original application which occurred during development.

4.2. Story Map and Map Design

This project utilized two distinct but interrelated design workflows in order to accomplish the original intent. The first workflow dealt with creating the Story Map shell and populating it with course content such as slide decks, course readings, and related videos and graphics. The second workflow consisted of designing effective maps which would enhance the theme taught within each region. The following section will outline both workflows and highlight design consideration as well as revisions which happened during the design process.

4.2.1. Story Map Design

The Classic Story Maps template chosen for this project was the "Map Series." The following section will outline the setting chosen for the Story Map application. A side accordion layout was used to organize the various units of study. For layout options, the accordion panel was aligned to the left and set to small size, thus preserving more area for mapped material. Numbers were not displayed as the title of each tab is the unit of study and the numbers are not needed. Within the map options settings only the “Address, Place, and Feature Finder” was selected. Overview maps are unnecessary as the regional maps initially display at small enough scales for users to orient themselves. The locate button was excluded as this class is a study of the Eastern Hemisphere and users hopefully already know where they are (which is not in the study area). Notably, “Synchronize map locations” was left unchecked. If this setting is on, all maps in all regions will be linked to the same spatial extent; if a user moves the map in East Asia and then navigates back to the Middle East the map would remain on the East Asia extent. By unchecking this setting, the application can focus in on regions and maintain the regional maps independence from one another. The theme chosen utilizes a gray background for the side accordion. This highlights the color-coded enrichment material. Finally, the header was configured to show basic information about the application. The share button was activated, and the Twitter and Facebook buttons were deactivated. A compact header was used to keep the header small and preserve screen area for the maps themselves. Figure 8 below shows the location of the application settings; the blue pencil within the side accordion will open the settings for each tab.

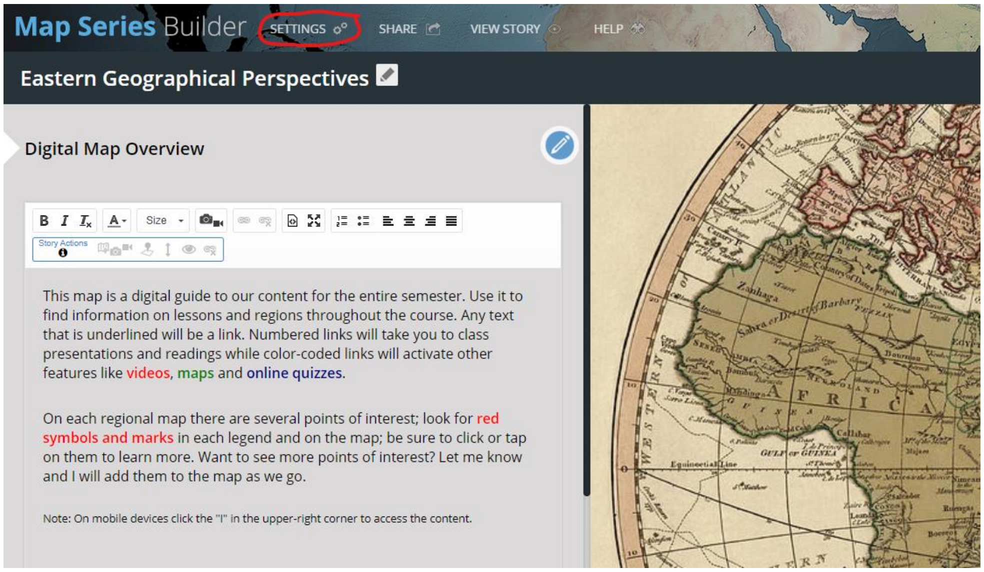

Figure 8: Settings for Story Map Application

4.2.2. Digital Map Overview

This tab provides initial instruction to users of the application but does not allow interaction, thus encouraging users to move "deeper" into the app. The main stage content is an image file which was uploaded to Esri and then set to fill the main stage. Figure 9 below shows the appearance of this tab on a desktop computer.

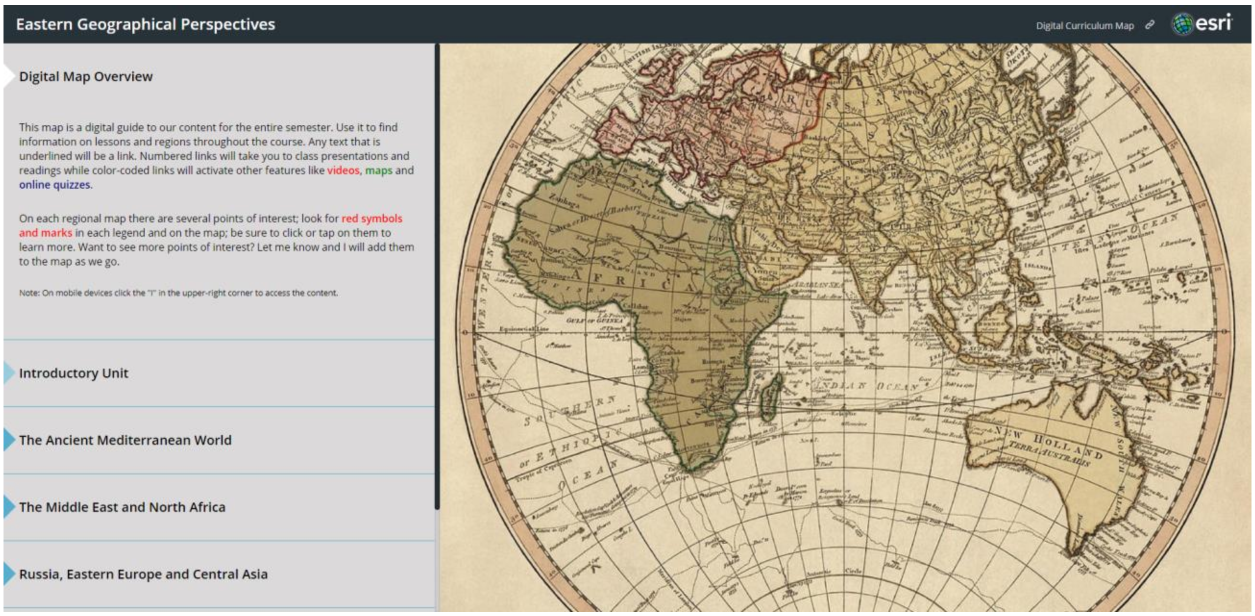

Figure 9: Digital Map Overview Results

4.2.3. Introductory Unit

This tab contains the first seven lessons of Eastern Geographical Perspectives and the main stage content, shown in Figure 10 below, is a small scale map of the Eastern Hemisphere. In this unit, which is where students begin to build the background knowledge they will need through the rest of the course of study, there are two formative online quizzes included with the content. The main stage content was a map which was initially designed in ArcGIS Pro and then uploaded to ArcGIS Online. Once uploaded, the map was shared with everyone so that users of the Story Map would not need to sign in to ArcGIS in order to view the map.

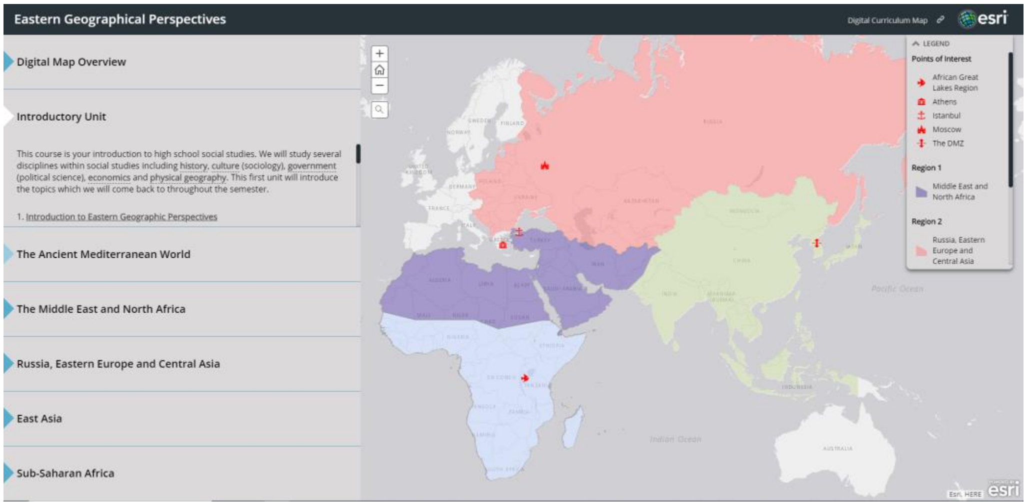

Figure 10: Introductory Unit Results

Figure 4 below shows the "Edit Entry" options within each regional tab where designers can select the map they want to use as the main stage content as well as the initial extent of the map, the content (layers) which are displayed to the user and how Pop-Ups will act within the map. The symbology for this map, including the points of interest, was set in ArcGIS Pro and therefore the legend setting was also selected. The labels and pop-ups for this map, and all others, were initially set-up using ArcGIS Online. The edit button next to the map allows for quick editing within the Story Map, however I found that ArcGIS Online in full screen was easier to use.

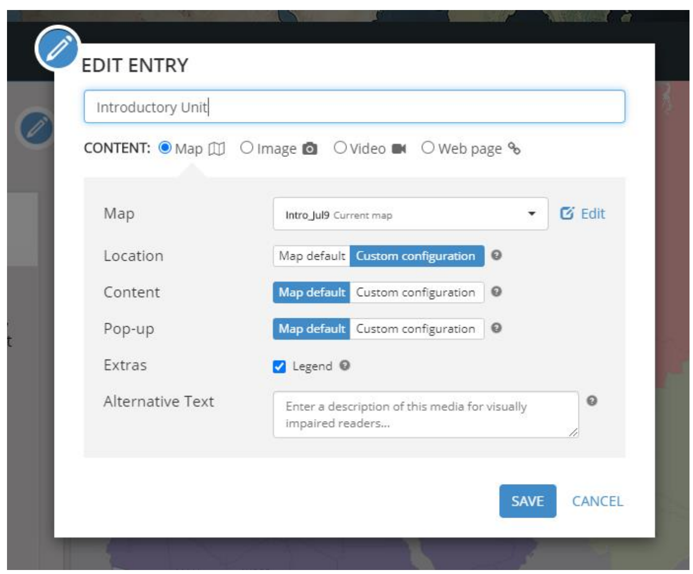

Figure 11: Edit Entry Options for Introductory Unit

4.2.4. The Ancient Mediterranean World

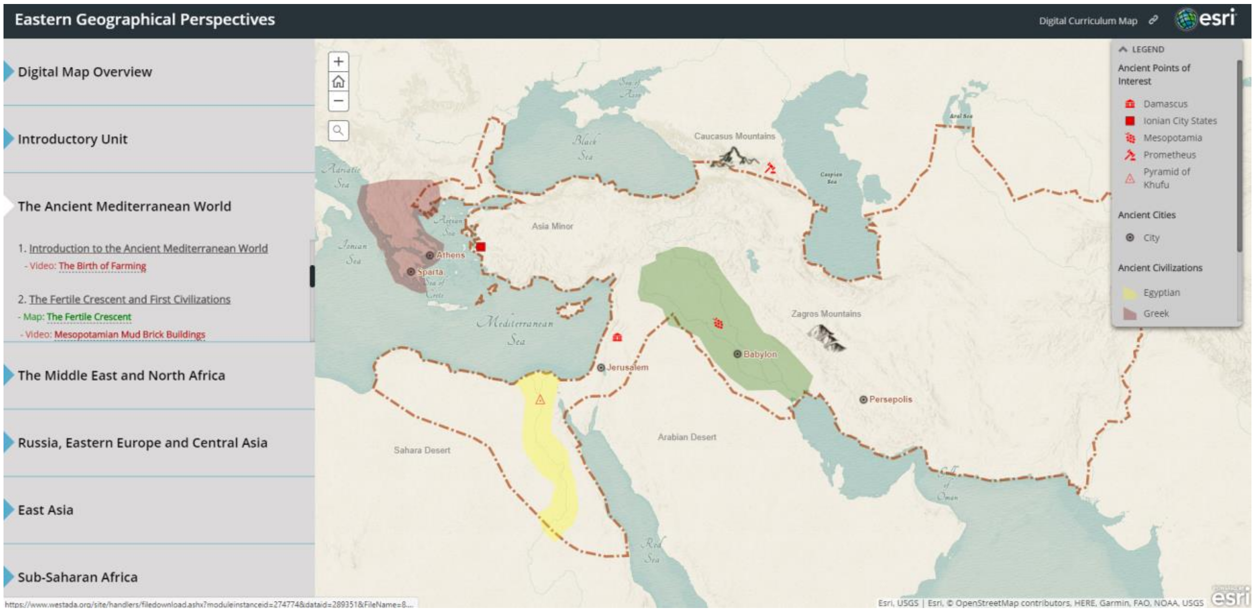

Figure 12: Ancient Mediterranean World Content and Map

This regional tab houses the five lessons associated with the unit and is enhanced by the main stage map shown in Figure 12. There are five lesson links housed within this region as well as several examples of enrichment content shown in the figure. The map included is an ArcGIS Web Map and as such does not allow for layer or basemap customization within the Story Map. The content and Pop-up settings were configured in ArcGIS Online and based on attribute tables constructed in ArcGIS Pro. The location of the map is a custom configuration used to center the map on the region in question. The location is also configured to display the legend in the upper right portion of the map; an area largely devoid of spatial information for the user to peruse.

The content on the left first consists of a chronological numbered set of slide decks associated with the unit; each slide deck is listed in the order it is taught. The enrichment content, such as the Birth of Farming video and Fertile Crescent map will populate within the main stage area when selected, as shown in Figure 13 below. Once users complete the video, a prominent "back" button redirects them to the regional map. Users will already be familiar with accessing content from the Introductory Unit. This unit introduces increased map complexity as well as more complex map operations (Pop-ups from several layer, data from points, lines and polygons, etc.)

Figure 13: Videos as Main Stage Content

4.2.5. The Middle East and North Africa

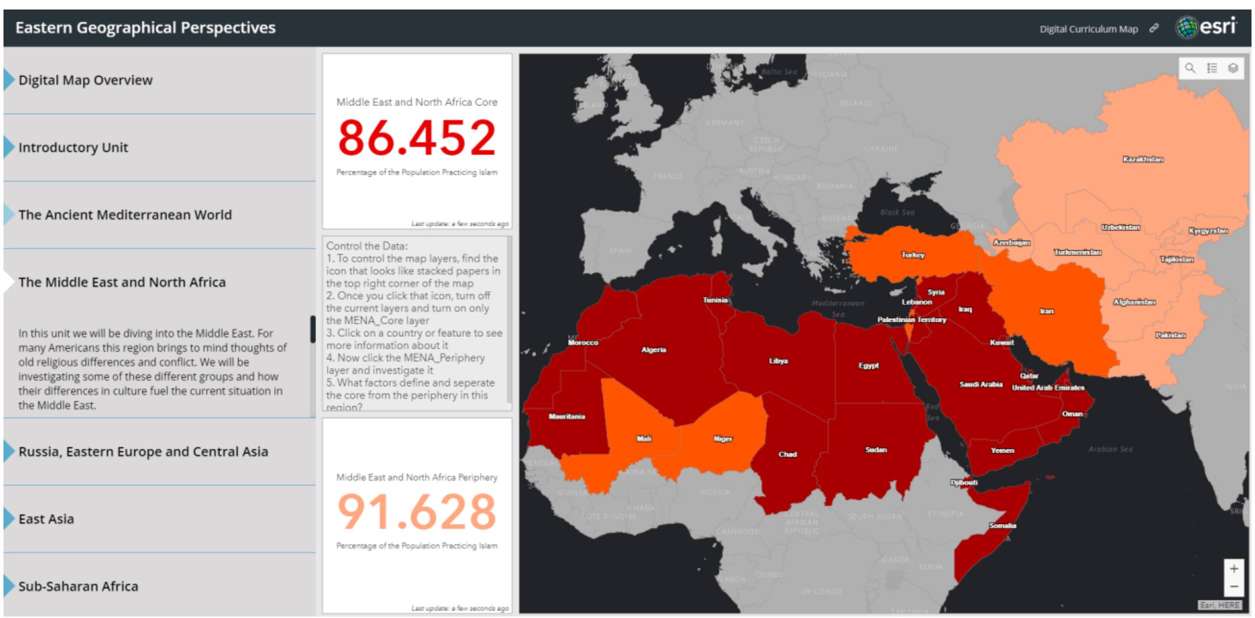

Figure 14: Middle East and North Africa Content and Maps

Figure 14 above shows the initial display for the Middle East and North Africa Unit. In the figure, the reader will see that the content group begins with a brief description of the unit above the lessons. Just below the overview text there is also text which states the focusing theme for this unit, in this case culture. There are five lessons within this unit and they are arranged chronologically in the order of instruction.

This region represents an increase in GIST complexity by utilizing an ArcGIS Dashboard. This allows users to control the basemap, layer and legend of the displayed map. It also incorporates data points summarizing some of the data, in this case the percentage of the population in the core and periphery regions who practice Islam. As it represents the first time users can manipulate the displayed layers of the map this Dashboard also contains a set of instructions titled "Control the Data." These instructions walk users through how to turn layers on and off and how to investigate the layers for information from Pop-ups pulled from the underlying attribute tables of the layers. Users will rely on the ability to manipulate Dashboards for this regional map as well as the next two in the application.

4.2.6. Russia. Eastern Europe and Central Asia

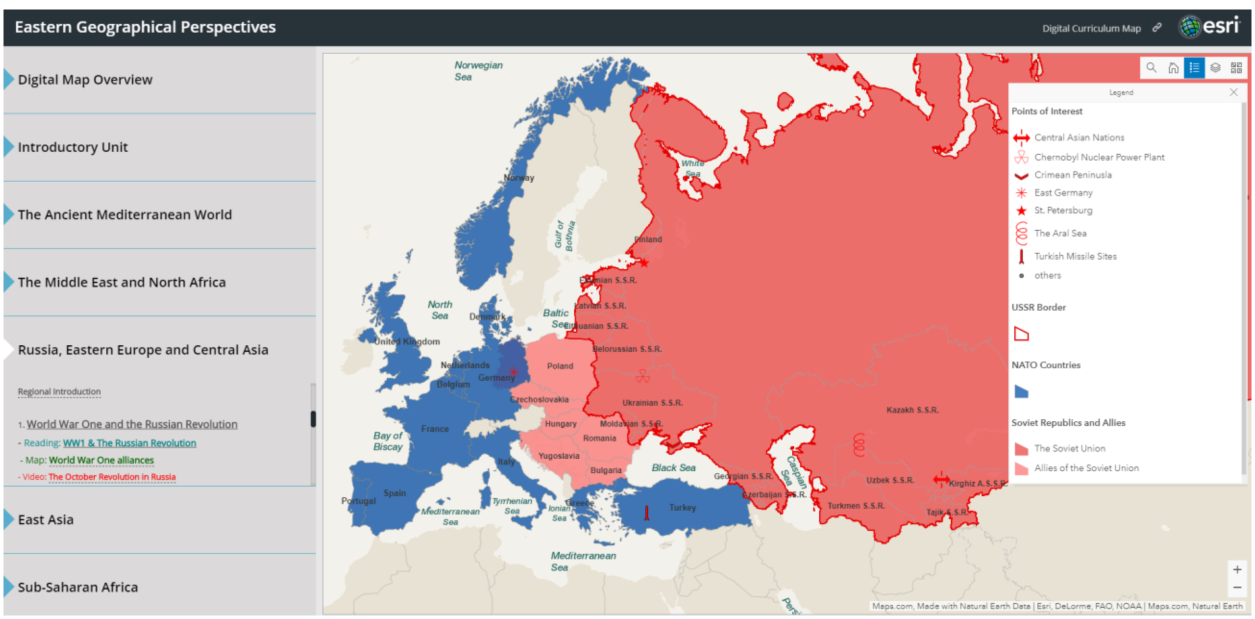

Figure 15: Russia, Eastern Europe and Central Asia Content and Map

This is the longest and most academically rigorous unit in this course and as such contains the most content as well as a fairly complex ArcGIS Dashboard. Figure 15 shows the initial display with the legend turned on. There are eight lessons housed in the content area of the application along with several pieces of enrichment content and a mid-unit online quiz used for formative assessment. The enrichment content is configured to populate within the main stage content when users interact with it. There is also a Regional Introduction included in the content. This introduction will populate the main stage area with another Story Map created using the current iteration of Story Maps rather than Classic Story Maps.

Incorporating spatial datasets in the regional map achieved the increased complexity of GIST described in Section 3.3.4. Users, familiar with the ArcGIS Dashboard following the MENA Unit, can control eight layers of data which display historical country borders over a 200-year time period. When selected, additional layers will populate within the legend to facilitate ease of understanding. As shown in , students can retain layers such as the USSR border and view it with relation to historical boundary data. Pop-ups are also enabled for these layers to provide more information about the historical boundaries displayed.

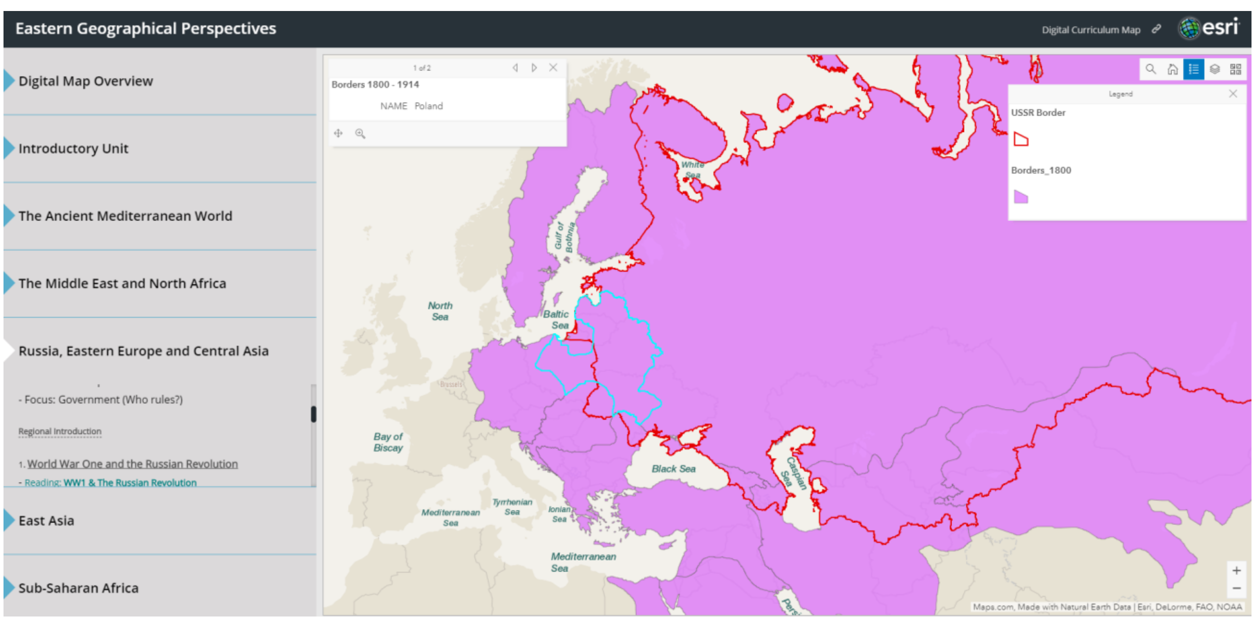

Figure 16: Russia, Eastern Europe, and Central Asia 1800 Borders with USSR Border

The Russia, Eastern Europe, and Central Asia web map was initially designed to incorporate the time animation function where students could play an animation with several layers. This functionality was lost when the web map was incorporated into the Dashboard. Although the time animation could be retained by using the web map as opposed to the dashboard, users then lose the ability to control layer visibility. In that case, the map would be populated with 12 layers of data and no easy way to differentiate between them. For that reason, the time animation approach was abandoned in favor of retaining the same ability through the manipulation of layer visibility within the Dashboard. Other approaches to this, and other issues encountered in the development process are covered in Section 5: Discussion.

4.2.7. East Asia

Figure 17: East Asia Content and Map

This region covers East Asia and India and is primarily concerned with economics, as identified in the content area seen in Figure 17. There are six linked lessons as well as multiple maps which, when selected, populate the main stage area. The linked maps will display items such as a live maritime map showing vessels and their current positions in this region. Another map will show an animation of goods traded between countries divided by the type of good and/or service. There are also video links to enrichment content concerning the Korean Peninsula. As always, these links are color coded and nested under the lesson to which they are most applicable.

This regional map increases the complexity for users by incorporating several layers of information, temporal data (GDP per capita 1960-2016), as well as both vector and raster datasets. By manipulating the visible layers in the Dashboard users can visualize these data in relation to one another. For example, a raster data layer of world population density can be enabled and the GDP per capita layer can be used as an overlay to further analyze the data table of the vector GDP layer. Figure 18 shows the population density layer displayed below a layer of overall population by country in 2015. Users can then analyze high density population within the context of a countries overall relative population. The relative population data was divided via natural breaks in the data.

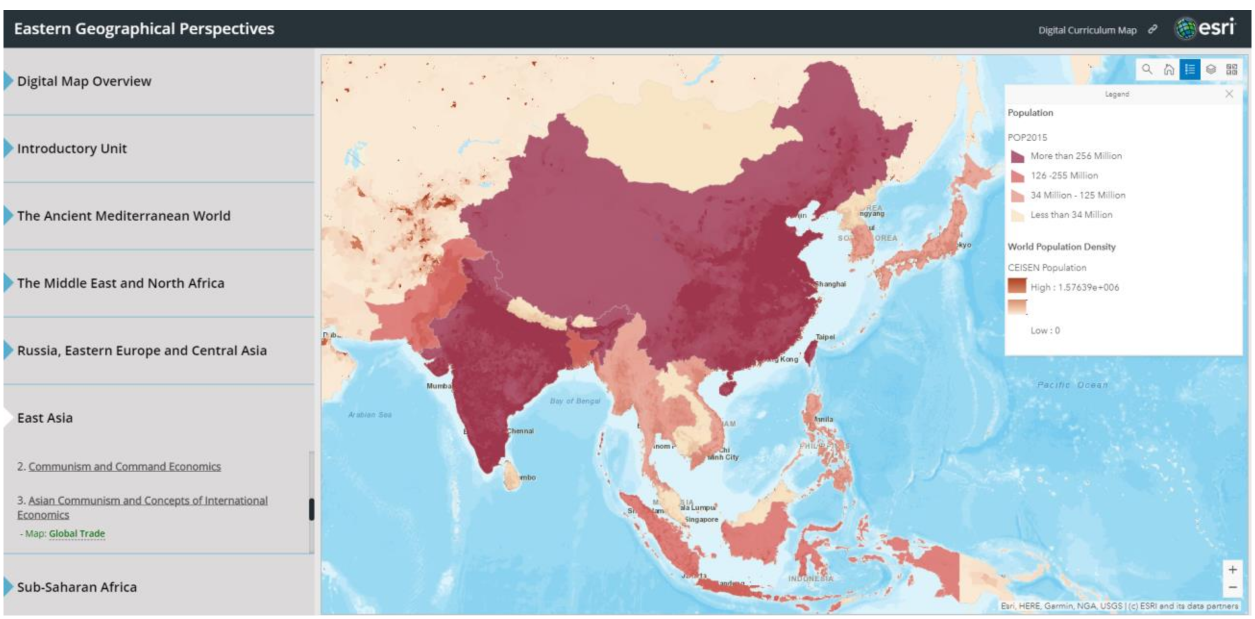

Figure 18: Visualizing Vector and Raster Data Together in East Asia

4.2.8. Sub-Saharan Africa

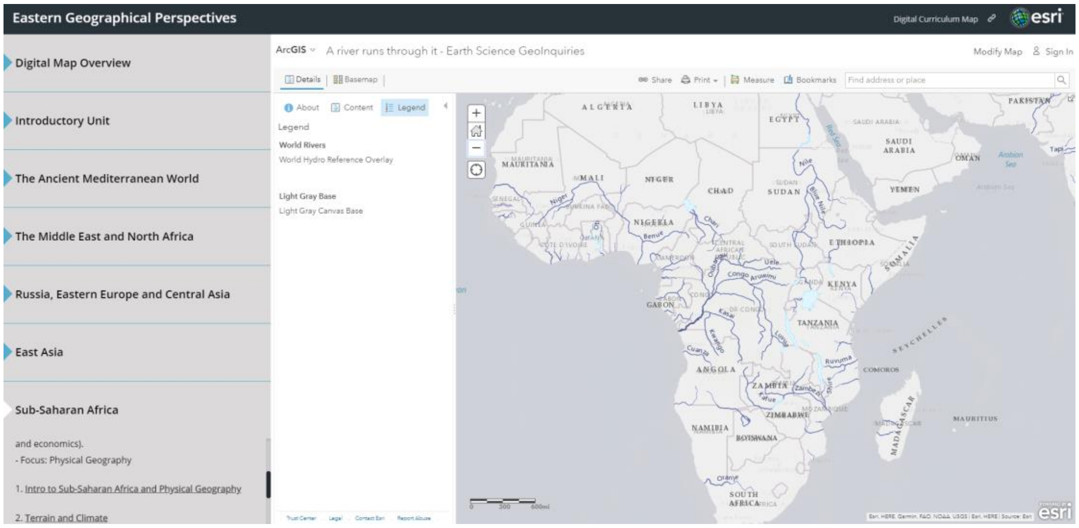

Figure 19: Sub-Saharan Africa Content and Map

Sub-Saharan Africa is the shortest unit in this course and the focus is physical geography, however students also apply their knowledge of the other themes (history, culture, government, and economics) throughout the unit. There are four linked lessons within the Sub Saharan Africa unit. These units are supplemented with regional maps which highlight specific characteristics of the physical environment, e.g. elevation and precipitation.

As discussed in Section 3.4.8, the regional map associated with Sub-Saharan Africa is qualitatively different from the other regions. As seen in Figure 19, the main stage content is populated by the user interface for ArcGIS Online. Specifically, the displayed map is from the Esri Geoinquiry “A river runs through it.” An edited version of the Geoinquiry was designed in order to focus the user on the region once they work through the foundational understanding section and is linked within the content section of the Story Map as well as included in the appendices of this document. With regard to increased GIST complexity, this unit is the height of what will be expected of students and is therefore located at the end of the course. Via the Geoinquiry, students will be asked to manipulate layers, analyze data at various scales, and ultimately create their own layers within ArcGIS Online (executed within the Story Map). This approach gives users complete control over the map and allows them to add their own data and perform self-directed analysis.

4.3. Descriptions and Metadata

This project relied heavily on design within ArcGIS Pro and subsequent web maps uploaded to ArcGIS Online for use with the Story Map and ArcGIS Dashboards. As a result, there were dozens of layers of content uploaded to ArcGIS Online ranging in content from points of interest in the Ancient World to a polygon layer used to symbolize Taiwan as separate from communist China. Most of these layers were further enhanced by amended attribute tables to enable the Pop-up functionality within the web maps. Also, in order to enable users to visualize the Story Map without logging in to ArcGIS all the layers were shared as Everyone (Public). This allows any user, including anonymous users, to make a copy of the feature and/or export data from it (ArcGIS Online Resources 2020). Metadata and proper attribution where appropriate were, therefore, a primary concern of this project. An example of the metadata format for the layers created in this thesis is included in Appendix C.

The layers of data for this project fall into two broad categories: 1) data published by Esri and, 2) data made public by ArcGIS users including me. With regard to Esri data, the metadata for these items is already established and includes important information such as spatial reference and design scale. For user data within the ArcGIS Online community the inclusion of metadata is not standardized nor required to create and publish layers (although the layer does have an “item information” meter when viewed in the designer’s organizational content). When data from other users was used, copied, or imported this project included the original source attribution as well as any additional metadata that user included. Ultimately, even when using

ArcGIS Online community data, I had to publish and make public the layers within my own organizational school account.

For all layers created by me the metadata was provided in order to provide the courtesy of information to users down the line. The original date of creation, the spatial reference data, and my organizational details were included along with contact information. The contact information was included for subsequent users with questions as well as for anyone with concerns over copyright use and/or terms of use infringement (although no data with stated restrictive terms of use was used). In addition, tags for each piece of data were included to aid with searches. The tags were specific to each region, however each piece of data also included the tags "Eastern Geographical Perspectives" and "EGP Story Map." A full list of data attribution used in this project is included in the appendices of this paper.

4.4. Results of Survey

The survey associated with this thesis was suggestive of attitudes towards this specific model of Story Maps and are not representative of any specific demographic other than the nexus of education and GIS. The three broad cohorts that were surveyed were 1) the PLC that teaches EGP within the same building as I do; 2) the social studies department within my high school; 3) educators enrolled in the T3G GeoNet community. In total, nine respondents chose to complete the educator survey included with this thesis. This section will outline a question-by-question summary and outline some preliminary trends.

The first question in the survey was "How would you characterize your background knowledge of Geographic Information Systems (GIS)?" A shown in Figure 20, a plurality of respondents had only some background knowledge in GIS (44.4%), with a majority (77%) rating themselves as a three or less in terms of background knowledge. This question also showed a clear division between expert GIS users and those with only some background knowledge.

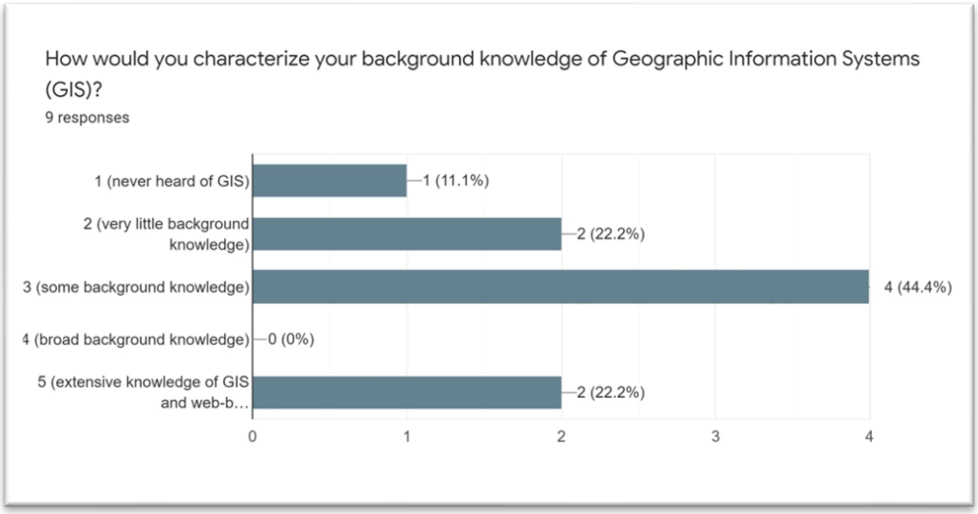

Figure 20: Survey Results for Question 1

Question two asked respondents to identify how often they currently use GIS in an educational capacity (Figure 21). The division between GIS experts and less-experienced users is clear in these responses as well. Seven of the nine respondents said that they had either never used GIS in the classroom before or, if they do use it, they use it once a semester or less. Two of the respondents used GIS in the classroom daily. This question outlined the fact that many of the respondents are not currently using GIS as a routine; this was significant to this project as it is a model for teachers to begin using GIS with their students. Figure 21 below outlines the results of this question.

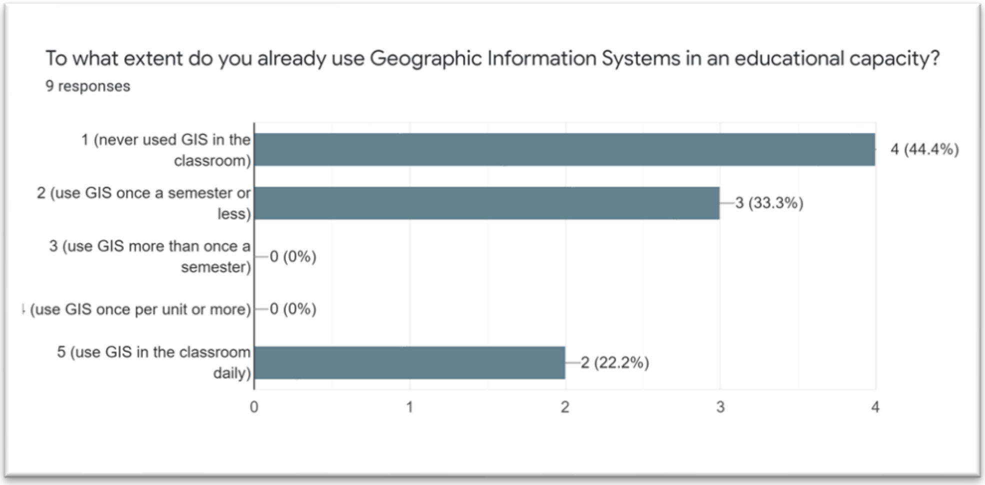

Figure 21: Survey Results for Question 2

Question 3 asked users to identify how they currently use GIS in the classroom if they are currently using it (Figure 22). Interestingly, this question revealed that although 44% of respondents do not use GIS in the classroom, some of them may use GIS to prepare lesson materials. Respondents were able to choose all options which applied to them. Four respondents stated they used GIS to present content or to have students engage with material in the classroom. Although an “other” option was included for educators to fill in alternative ways that they use GIS in an educational capacity, none of the respondents chose that response or provided elaboration on what their alternative approach might be.

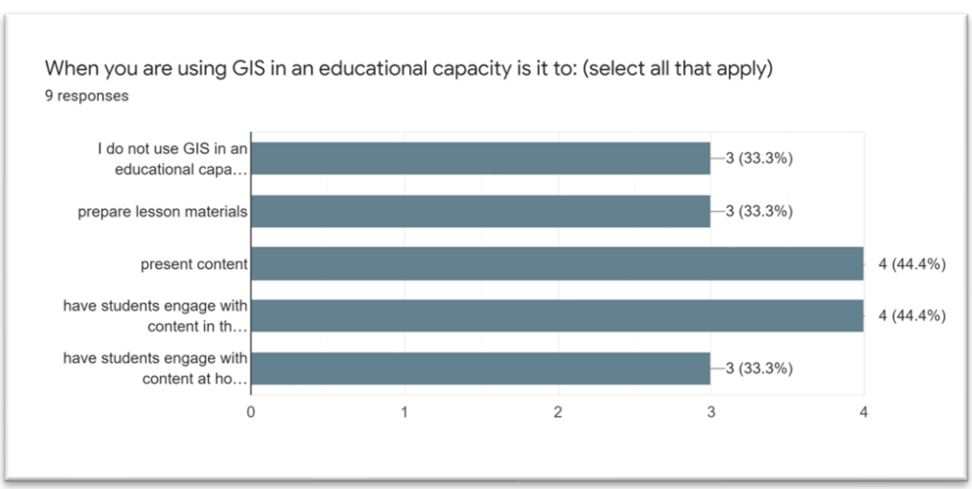

Figure 22: Survey Results for Question 3

Question 4 asked respondents about their familiarity with Esri's Story Maps and the results are outlined in Figure 23 below. More than half (55%) of respondents had never heard of Story Maps before seeing this application. Two respondents each identified that they had either both seen and heard of Story Maps before this or were very familiar and had created their own Story Maps in the past. Regarding this thesis, it is worth noting that only the two respondents who identified as having extensive GIS knowledge had ever created their own Story Maps before. Both of these respondents were members of the T3G, meaning that no respondents in the high school where I teach had ever created their own Story Maps, including teachers from the PLC who teach EGP.

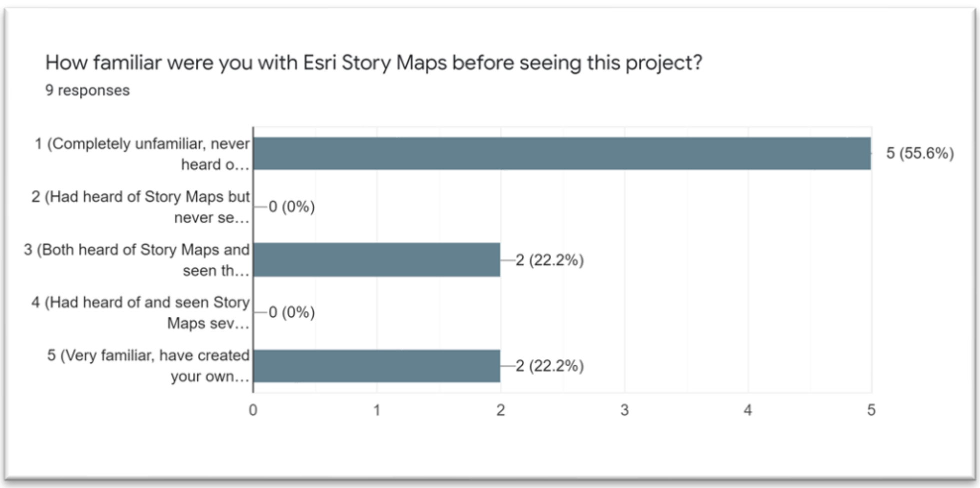

Figure 23: Survey Results for Question 4

Question 5 asked users with their comfort level relative to using Story Maps as a resource for students and the results are outlined in Figure 24 below. For this question, most respondents (66%) said they would use Story Maps when appropriate but stopped short of saying they would use them frequently. Three respondents said they would use Story Maps frequently or would use them routinely (daily, if possible). This question was important to document that teachers would be willing to use Story Maps, even though 55% of them had never heard of Story Maps before seeing this application.

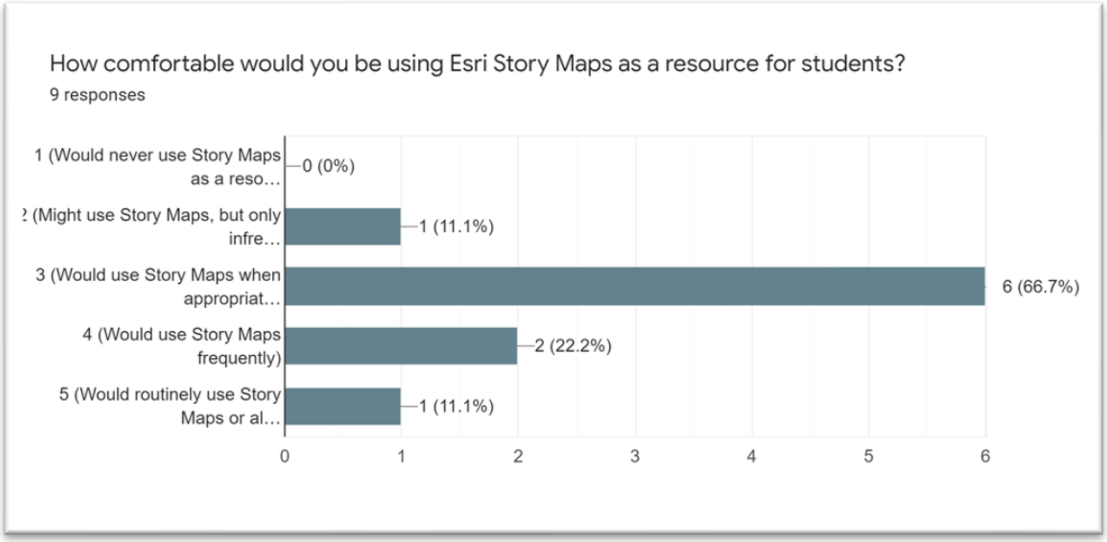

Figure 24: Survey Results for Question 5

Question 6 asked what educators perceived as the obstacles to implementing Story Maps as a resource for students. Shown in Figure 25 below, the respondents overwhelmingly identified the amount of time required to create Story Maps (62.5%) and being unfamiliar with the platform as the greatest obstacles to their own use. This is an understandable result, considering that the majority of respondents had never heard of Story Maps before. Also, as outlined in Chapter 3 of this thesis, the timeline for a similar project would be near eight weeks in length. For teachers this represents quite a commitment and that showed in the survey responses. Two respondents were also concerned with posting copyrighted material online. An “other” option was also available here, although no respondents chose that option or elaborated on other perceived obstacles. Notably, none of the respondents doubted the effectiveness of Story Maps as a resource for students after viewing this application.

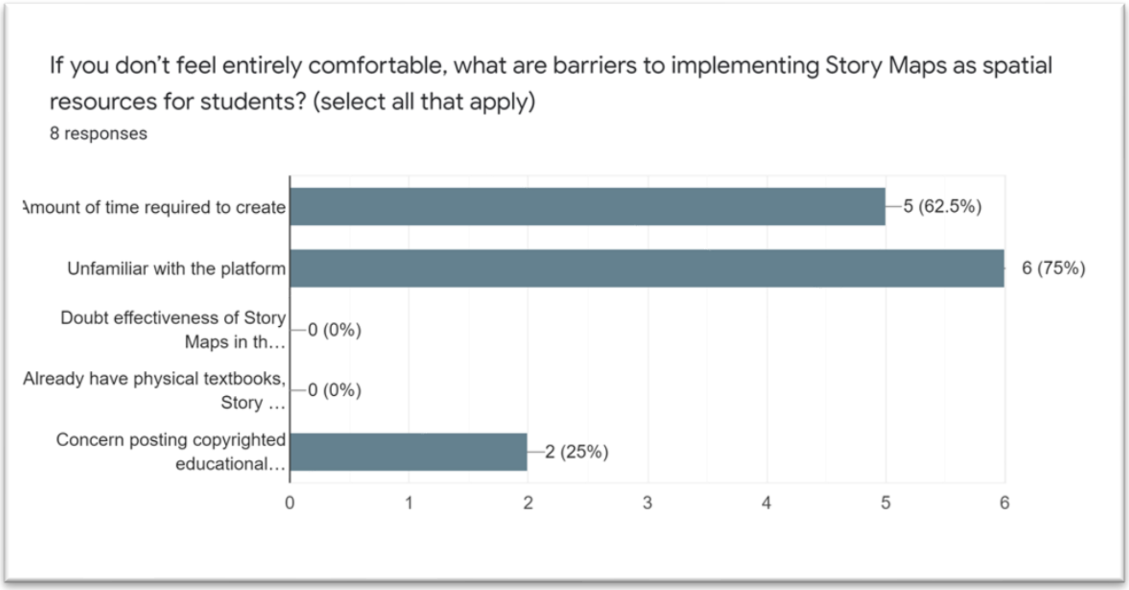

Figure 25: Survey Results for Question 6

Question 7, the final question, asked respondents how their likelihood of using Story Maps changed after viewing this application. In sum, the respondents were either neutral or more likely to use Story Maps after viewing the Story Map in this thesis. Notably, 77% of respondents were more likely to use Story Maps even though more than half of them had never seen the software before viewing this application. No respondents were less likely to use Story Maps after viewing the application. Two respondents were neutral in this regard; however they were also respondents who identified as having used and made their own Story Maps before. This suggests that they already use Story Maps and would continue to do so after viewing this application. Seven respondents from within the building where I teach were more likely to use Story Maps, which is encouraging regarding the suggestion that this thesis could be used as a model for others to adopt.

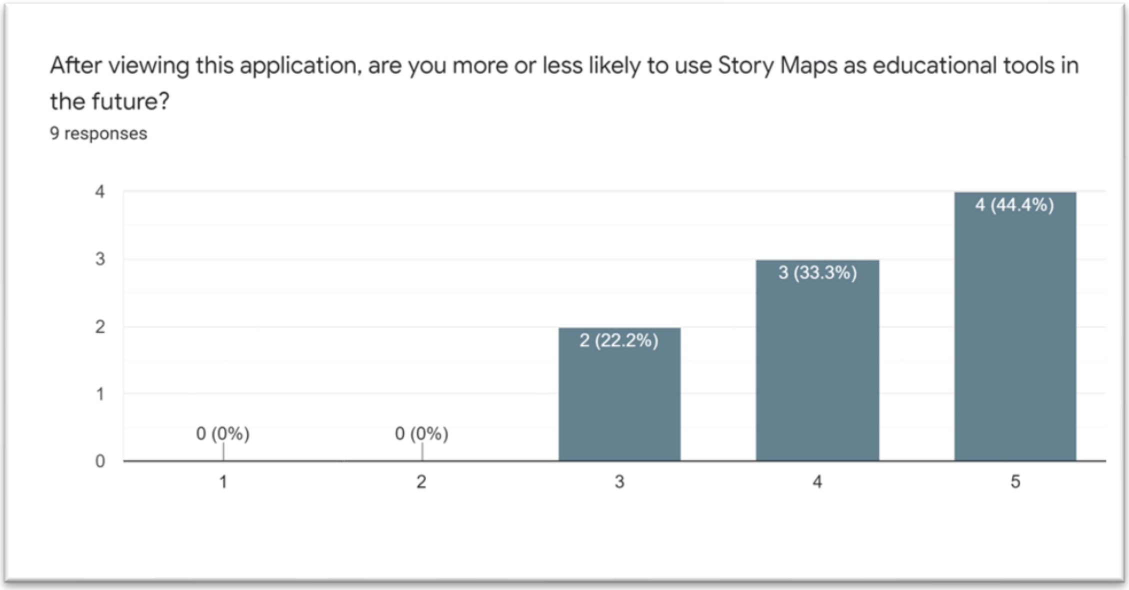

Figure 26: Survey Results for Question 7

This survey was designed to gauge educator attitudes first and foremost within the sphere over which I have the most influence, that is teachers in the same building (7/9 respondents). The number of respondents was limited by the IRB process and the extra time required during the COVID-19 crisis relative to obtaining study approval. Prior to approval, this application was also uploaded to the Esri User Conference Virtual Map Gallery. Five User Conference attendees posted comments in support of the application and it received 15 upvotes during the competition. This application will now remain a part of the Virtual Map Gallery even though the survey has concluded. This will be one way in which educators can learn about the application after this study. The application is also posted on GeoNet for the T3G and other GIS specialists to review and comment on.

Finally, this survey is encouraging in its results however it is only suggestive and there are limitations with its design that are discussed in Chapter 5. Overall, as a model for other educators to emulate the willingness of respondents to use Story Maps as teaching tools despite most of them never having seen them before was highly encouraging. Before teachers will use a resource, they have to know what they and the students will get out of it; what is the point? Focusing on PLC and department respondents within my school allowed me to gauge the level of GIS knowledge and provide opportunities for future work. I will discuss those possibilities in the next chapter.

Chapter 5 Discussion and Conclusion

This project successfully developed a Story Map which houses the content for an entire semester as well as providing embedded enrichment content. The regional maps were designed while considering cartographic norms, student learning outcome standards, and the specific content of the Eastern Geographical Perspectives course. The content for each region was linked within the application and enhanced with enrichment content in a variety of multimedia formats. A survey of educators' attitudes towards Story Maps used in this context was successfully delivered and feedback gathered online. There have also been several challenges and limitations encountered during the process of creating this application; this section will outline both.

5.1. Challenges

This project faced challenges like those a teacher will face in the classroom; there is too much content and not enough time/resources to cover everything as thoroughly as you would like. The primary challenge with regard to focusing the content occurred during the process of identifying the guiding standards for each regional map. A full list of the standards associated with the material taught in this class is found in the appendices of this project. The number of standards is quite large and identifying only one in each region to focus the content proved quite difficult. To resolve this challenge, I started first by considering the District Curriculum Document. As a teacher, my contract explicitly states that I am responsible for delivering the content in the curriculum document. After identifying a priority standard within the district curriculum, I next examined the Idaho Content Standards to discover the best connection to reinforce the district curriculum. The last step was to identify the National Geography and C3 standards which applied to the unit. Eastern Geographical Perspectives is not tied to these national standards in any formal way, however by identifying commonalities between the district curriculum and national standards the project was strengthened in terms of broad educational appeal. This approach also served as a model to others who attempt to implement a similar project; by linking local and national standards this project shows how a course can be more comprehensively designed with regard to the tools we as educators use to deliver content.

Despite the advantages discussed above relative to linking standards, there are certain areas where the standards do not align. For example, the C3 Framework does not contain a specific section associated with teaching culture while the National Geography, Idaho Content and District Curriculum guides all identify culture as a key focus of instruction. In these cases this project simply linked the standards where applicable and noted if there was not a corresponding standard at a certain level. For most teachers, the district curriculum is their first legal obligation and that is why starting from the district standards is key. As seen, however, this approach may lead to areas of the national standards that are not addressed. In those cases, an application that utilizes GIST could focus in on one of the spatial standards instead of a specific thematic concept. This challenge highlights once again that this application, despite its described uses, cannot replace traditional instruction.

5.2. Limitations

Section 2.2.3 of this document discussed the limitations of GIST in terms of K-12 education. A potential solution, and the approach adopted by this project, is to design an application which structures users' experience to minimize the complexity of GIS interfaces. Over time, the complexity can be increased as it was in this project by advancing students from Story Maps basic maps to ArcGIS Dashboards and ultimately to ArcGIS Online itself. Although this project was successful in this aspect as imagined, there are limitations associated with Story Maps and educational GIST.

The first limitation, and perhaps the most relevant to students, is the difference between accessing a Story Map on a computer or on a mobile device. Mobile devices have clear limitations, not the least of which is the smaller screen size. Standard Story Maps that incorporate maps from ArcGIS Online which do not allow much, if any, user customization are quite mobile-friendly and display quickly and accurately. The limitation on this issue comes with the incorporation of more advanced GIST user interfaces like ArcGIS Dashboards. The Dashboards are more complex and require more interaction which is hindered by the small screen on a mobile device. Also, key elements of the Dashboard such as the legend and layer visibility buttons are hidden behind the content indicator for Classic Story Maps. The final regional map in Sub-Saharan Africa experiences the same issues with complexity to an even greater extent. Students could not open the Geoinquiry instructions and the map on the same screen as they could on a desktop computer.

There are also limitations which arise from the use of ArcGIS Online itself. All the maps for this application were first created in ArcGIS Pro and then uploaded to ArcGIS as web maps. Although the upload process is very simple, the functionality of ArcGIS Online is not nearly on par with that of ArcGIS Pro. In a practical sense this means that designers could spend hours creating cartographically sound maps in ArcGIS Pro only to have many, or most, of their choices nullified by the decreased functionality of ArcGIS Online. A simple example of this disparity in functionality can be illustrated through an examination of the labeling engines available between the desktop and online services. The two figures below show the differences between the available labeling engines; Figure 27 below shows the results of the ArcGIS Pro Maplex Label Engine. The reader can see that the labels have been deconflicted and configured to align within the polygon boundaries of the feature they represent.

Figure 27: Russia, Eastern Europe and Central Asia ArcGIS Pro Labels

Figure 28 shows the same map within the application after being uploaded to ArcGIS Online. The reader will see that the labels are all uniform, horizontally aligned, and in many cases crowded into areas that are too small for them. In ArcGIS Online some of the conflict can be mitigated by setting the visibility scale so labels only appear as the user zooms, but in that case the map would not display any labels when initially loaded. There are workarounds for this, e.g. creating layers from the labels and adjusting their visibility scale individually (essentially going through and manually deconflicting the labeling). This approach is unattractive, mainly because it is too complicated and time-consuming an approach for educators who wish to implement the Story Map technology.

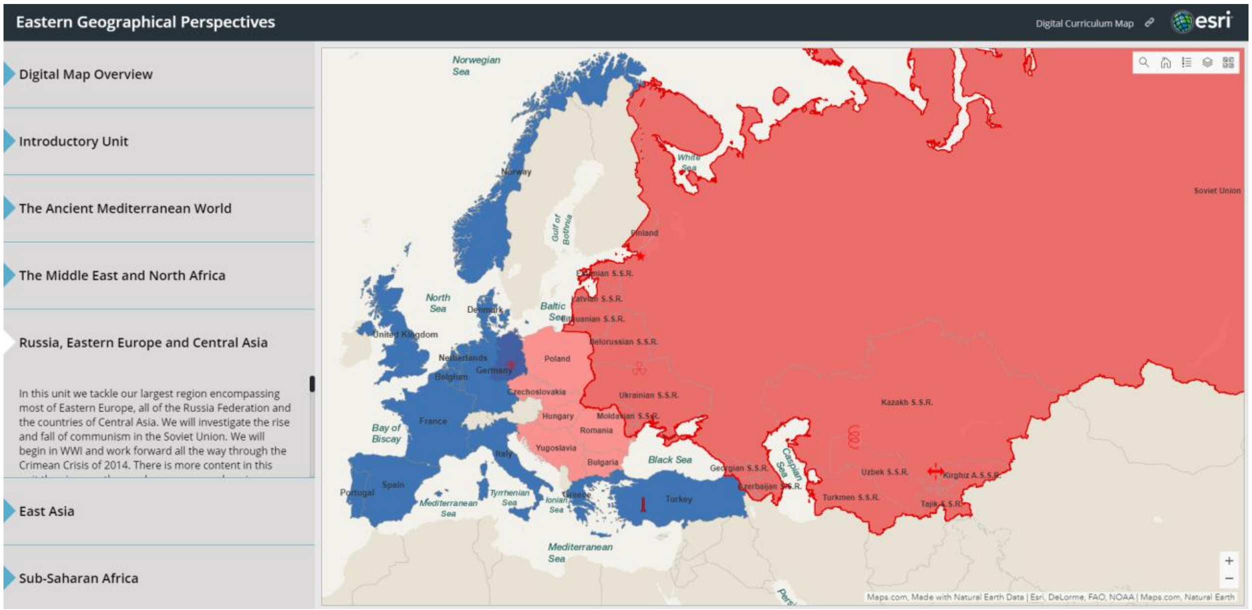

Figure 28: Russia, Eastern Europe and Central Asia ArcGIS Online Labels

There were also limitations within the educator survey for this thesis. Section 3.3.5 outlines the intent and design choices of the survey. The survey did not include demographic data because the method outlined in this thesis is not subject-dependent or based on any one demographic factor. It is limiting, however, in that the interest level gauged through the survey is from a wide variety of educators. Demographic data would allow researchers to pair attitudes with subject taught, however that was outside of the scope of this project. In addition, the survey was closely aligned with a teacher-centric educational model. As a result, the questions and options identified limit the educator to describe themselves only within the framework of a direct instruction classroom. For example, question three outlines how a teacher could use GIS in an educational capacity, but it does not specifically identify student-centered GIS approaches.

In general, this thesis is limited to focusing on a teacher-centered approach to the application and to student learning. Research shows that student-driven, problem-based learning via GIS can lead to “higher order learning outcomes” such as improved analysis and evaluation skills (Liu et al. 2010, 150). This thesis is concerned with providing a model for educators, however those same educators should be aware of the student-centered approach to learning and how that impacts their own pedagogical practices relative to GIS incorporation. These limitations were exacerbated during this thesis, completed during summer break, by the inability to gather quantitative data with regard to student learning outcomes relative to the Story Map that was developed. Despite that, investigation of student-based learning will benefit educators who choose to employ this thesis' model.

5.3. Conclusion

As designed and implemented this project was a success in terms of its development goal and standards-based GIST education design. Future studies of this and similar applications would undoubtedly need to assess the effectiveness of the application, e.g. how student outcomes were impacted by use. Future technologies can and will be incorporated into projects such as these in the same way that ArcGIS Dashboards were incorporated into this Story Map. This model is now available to other educators and provides a roadmap for implementing similar technology in the K-12 classroom. This Story Map will first be used in the fall semester of 2020 and will be continually updated as long as I still teach the class.

The implications for further research on this topic are broad, including teacher training in GIS, student roles when interacting with GIS, the effectiveness of teacher created applications, and the long term impacts of introductory applications such as the one designed in this thesis. One avenue for research is to investigate how to make more teachers proficient in GIS, in terms of their pedagogy, technological skill and content knowledge. This three-part nexus is described as the Technological Pedagogical Content Knowledge, or TPACK, and provides a framework for understanding the teachers' role in GIS education, whether that be teacher or student driven (Mishra and Koehler 2006). Within the discussion of TPACK, there is also an opportunity to research what role the teachers and students play while using GIS in an educational context. How and when do teachers implement direct instruction and how can they transition to student-driven GIS education most effectively; how would this thesis' style of application inform that discussion? The effectiveness of teacher created applications should also be researched, especially within and among networks of educators. Other educators may be best suited to provide meaningful feedback on projects such as this thesis. This research would answer the call of the "Road Map for 21st Century Geography Education" with regard to building relationships among formal and informal educators in order to conduct research (Bednarz 2013). The Road Map also calls for educators to research the learning progressions of students over time. As this thesis was developed as a starting point for high school students, further research to track the growth of students relative to GIS after using an application such as this would be appropriate (ibid., 8).

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Appendices

Appenix A: List of Linked Standards

Theme:	History	Culture	Government	Economics	Physical Geography	Spatial Thinking
Unit:	The Ancient Mediterranean World	The Middle East and North Africa	Russia, Eastern Europe and Central Asia	East Asia and India	Sub-Saharan Africa	ALL
C3 Framework Standards						
	D2.His.1.9-12	N/A	D2.Civ.1.9-12	D2.Eco.1.9-12	D2.Geo.4.9-12	D2.Geo.1.9-12
	through		through	through	through	D2.Geo.2.9-12
	D2.His.17.9-12		D2.Civ.14.9-12	D2.Eco.15.9-12	D2.Geo.12.9-12	D2.Geo.3.9-12
			Note: D2.Civ.4 omitted; U.S. Const.-Specific			
National Geography Standards						
	Standards 9-15	Standard 6	Standard 9-16	Standard 9-16	Standard 4-5	Standard 1
	and	Standard 10	Standard 18	Standard 18	Standard 7-10	Standard 3
	Standards 17-18	Standard 13			Standard 12	
		Standard 15			Standard 14-16	
		Standard 17-18				
Idaho Content Standards: Geography-Eastern Hemisphere						
	6-9.GEH.1.8.1	6-9.GEH.1.8.4	6-9.GEH.4.5.1	6-9.GEH.3.1.1	6-9.GEH.2.1.1	6-9.GEH.2.1.1
	through	6-9.GEH.1.8.5	6-9.GEH.4.5.2	6-9.GEH.3.2.1	through	through
	6-9.GEH.1.8.5	6-9.GEH.2.4.2	6-9.GEH.5.1.4	through	6-9.GEH.2.1.4	6-9.GEH.2.1.4
		6-9.GEH.2.4.3		6-9.GEH.3.2.6		
	6-9.GEH.2.5.3	6-9.GEH.2.5.4		6-9.GEH.5.1.4	6-9.GEH.2.2.1	
	6-9.GEH.5.1.4	6-9.GEH.5.1.1		through	through	
		through		6-9.GEH.5.1.6	6-9.GEH.2.2.6	
		6-9.GEH.5.1.6				
					6-9.GEH.2.3.1	
					through	
					6-9.GEH.2.3.3	
					6-9.GEH.2.4.1	
					6-9.GEH.2.4.4	
					6-9.GEH.2.5.1	
					6-9.GEH.2.5.2	
					6-9.GEH.2.5.5	
West Ada School District Curriculum Guide: EGP						
	Unit 1: Priority Standard 3	Unit 2: Priority Standard 1	Unit 5 Priority Standard 1	Unit 4 Priority Standard 2	Unit 3 Priority Standard 2	N/A
	Unit 3: Priority Standard 1	Unit 2 Priority Standard 2	Unit 5 Priority Standard 2	Unit 4 Priority Standard 3		
		Unit 2 Priority Standard 3				

Appendix B Modified Geoinquiry

A river runs through it: from the Esri GeoInquiries collection for Earth Science

Activity: Discover how water is gathered and travels to larger and larger watersheds to meet the sea.

Learning Outcomes:

- Students will explore local water features in order to better understand the concept of watersheds.
- Students will familiarize themselves with the hydrography of Sub-Saharan Africa by identifying the watershed of one of the region's major rivers.

Map URL: http://www.esriurl.com/earthgeoinquiry10

- This is the same map that is embedded in the Story Map, use this link if you would like a separate tab to display the map.

Engage

Where does your water come from?

Run water from any tap into a glass. Do you know from where this water comes?

- In the upper-right corner, click the link, Modify Map.
- With the Details button underlined, click the button, Show Contents of Map (Content).
- In the Find Address Or Place box at the top right of the map, search for your school address. (1900 W Pine Ave, Meridian, Idaho, 83642)

What is the largest lake or river near your school? (Create a Word DOC, start a numbered list and enter your answer to this question after number 1.)

- Looking at the water nearest you on the map, trace how it flows eventually to a sea, ocean, or bay. (Zoom in and out to see where the water body flows.)

- Make a list of the other streams and rivers your local creek flows into before making it to the bay, sea, or ocean. (You may need to turn layers on and off to get all of the names.) (Number 2: List the streams and rivers in order from closest to farthest away ending with the Pacific Ocean (if you don't end in the pacific, you made a mistake))

Explore

How removed are you from the ocean?

As rivers split farther upstream, each side-branching stream or tributary is assigned a higher stream "order" number.

- Using the list created above, count backward from the farthest tributary to determine which stream order a local creek outside your school is considered to be.

Explain

What makes up an entire watershed?

As part of the global water cycle, water evaporates from oceans, lakes, or rivers (or from plants or soil) and falls across continents. Because water is a fluid, it flows along a downhill path that eventually leads back to the ocean. All the areas draining into a single river system are known as that river's watershed.

- Click the Edit button, and then click Areas to draw around each of the major rivers mentioned below.
- Draw around the Mississippi River, including all rivers draining into it as part of the watershed. Draw around the watershed of the Columbia River in Washington.
  Draw around the watershed of the Colorado River in the southwestern United States.
- Discover how water is gathered and travels to larger and larger watersheds to meet the sea.
- Draw around the watershed of the Rio Grande River along the border of Texas and Mexico.
- To check your work, zoom in two clicks to see the smaller regional river watersheds.

Elaborate

Can you find watersheds through the network of connected rivers?

Turn on the layer, World Shaded Relief.

Where do most rivers start? (Number 3: record your answer to this question; be as general as possible)

Click the Hudson Bay Watershed bookmark.

- Click the button, Edit.
- Click the map at the upper edge of the Mississippi watershed (between Canada and the states of North Dakota and Montana), and continue drawing around the area of all rivers that drain into the Hudson Bay. You can use multiple smaller lines to create the boundary. Simply choose the Areas tool again for each section of line you want to draw on your current view of the map before panning.
- Continue drawing lines north along the Rocky Mountains to find the edge of where the rivers drain into the Hudson Bay and those that drain north into the Arctic through the Mackenzie River system.

– For a solution to the major North American watershed boundaries, turn on the layer, Watersheds. (Number 4: Now that you have worked through this activity, define a watershed in your own words using examples)

Evaluate

What do other watersheds look like?

- Choose one of the large river systems in Sub-Saharan Africa. If you need to identify the area of Sub-Saharan Africa turn on the World Shaded Relief layer in the contents pane; you will be able to clearly see the Sahara Desert. Make sure the river system you choose is south of the Sahara (a.k.a Sub-Saharan)
- With the World Shaded Relief layer still on, make sure that you also enable the World Rivers and Boundary Markers layers.

- Select “Edit” just above the contents pane and click the “Boundary Markers – Areas” option.
- Now, using the skills you have gained through the previous steps of this Geoinquiry, draw a polygon around the watershed of the river system that you chose. Note: You have to hold down the left-button on your mouse to trace the boundary.
- Once you are done drawing a Pop-up will appear on screen. Enter what you think the river system should be called (how did they name the river systems in North America?) in the Title field. Then click “Close,” and “Edit” to finish the editing tool.

(Number 5: Click on the watershed you created so the Pop-up displays. Take a screenshot of this map view)

Appendix C Metadata Example

MENA_Region (Winkel Tripel)

Overview | Usage | Settings

Edit Thumbnail

Add to Favorites

The MENA region projected in Winkel Tripel for use with the EGP Story Map. Edit

Tile Layer (hosted) by Misajet

Created: Aug 5, 2020 Updated: Aug 5, 2020 View Count: 0

Description

Edit

This layer outlines the Middle East and North Africa region which is covered in the Eastern Geographical Perspectives high school course in Meridian, ID. This layer was created on August 5th and is used in the "Eastern Geographical Perspectives" Story Map. It is projected in the educational standard Winkel Tripel projection with the central meridian set to 80 degrees east to center the eastern hemisphere on the projection. For further details, please contact Craig Misajet: misajet@usc.edu

Layers

MENA_FeatureClass_Project

Terms of Use

Edit

There are no restrictions on use for this item. If applicable, to cite this item it was created by Craig Misajet in August of 2020 and is hosted by the Meridian HS organization. It is used within the Eastern Geographical Perspectives Story Map.

Open in Map Viewer

Open in Scene Viewer

Open in ArcGIS Pro

View style

Share

Replace Layer

Item Information

Learn more

Low High

Top Improvement: Add a thumbnail

Details

Source: Vector Tile Service
Created from: MENA_FeatureClass_Project, Vector Tile Package
Size: 2 MB