WEB-BASED GIS FOR MIDDLE SCHOOL TEACHERS: USING ONLINE MAPPING APPLICATIONS TO PROMOTE TEACHER ADOPTION

by

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Web-based GIS for Middle School Teachers: Using Online Mapping Applications to Promote Teacher Adoption

Thesis directed by Professor Kenneth E. Foote

One factor underlying the use of information and communications technologies (ICT) in schools is the interest and willingness of teachers to learn and adopt these technologies in their teaching. Previous studies of geographic information systems (GIS), as one type of ICT, indicate that the lack of teacher training is one of the key barriers to adoption. This project addresses this issue by employing a user-centered design (UCD) methodology to plan, design, and develop teacher-centered and teacher-friendly web-based GIS training materials for middle school social studies teachers. This three-step method involved a user needs analysis, tutorial development, and evaluation. The user needs analysis used semi-structured interviews to collect input from 23 teachers. They made suggestions about the tutorial topics, their scope and activities, as well as the types of help the teachers would like to have available. The tutorial development step also involved 23 participants. They made a variety of suggestions about content, formats, and terminology. The final versions of the training tutorials were published on the web and evaluated by 55 participants. Of the 55, 11 teachers reported that they implemented web-based GIS technologies in their classrooms with students. The teachers rated the tutorials positively but also made suggestions about factors that might help them adopt GIS more readily, such as context-sensitive help and tutorials designed specifically for teachers with varying levels of ICT ability. This suggests that although the current project, within the limitations of its methodology, was able to address some of the barriers to adoption of ICT in schools, other issues still prevent greater classroom implementation of GIS technologies.

DEDICATION

This thesis is dedicated to

my beloved parents, Soon An Hong and Soo Ya Choi.

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CHAPTER I

INTRODUCTION

This project focuses on how to bring recent web-based geographic information systems (GIS) technologies into middle school classrooms. The broader goal of the project is to analyze and suggest strategies for bridging the digital divide in geography education. Whereas previous efforts to introduce mapping and GIS software into the K-12 curriculum have had mixed results from the standpoints of both teacher adoption and student achievement, the question today is whether the latest web-based GIS applications, including online visualization and mapping tools and virtual globes, have changed this situation by reducing the overall cost of implementation in terms of both time and the cost of needed software and hardware. Not only are applications that I included in this study like Esri's ArcGIS Explorer Online and Google Earth easier to access and use than some previous desktop GIS software, but their Application Program Interfaces (APIs) allow users to more readily add their own data and create customized instructional materials.

In addressing the lack of GIS technologies in classrooms, this study focuses on one particularly critical issue in educational change: teacher adoption. Whereas previous studies of instructional applications of GIS have demonstrated that they can be used at some grade levels and in some areas of the K-12 curriculum to promote geographical and spatial thinking and reasoning (Baker and White 2003; National Research Council 2006), the issue of teacher adoption is one of the greatest barriers to the broader use of new instructional techniques. Teachers serve, to a great extent, as the gatekeepers for these techniques. Unless they are able and willing to bring them into the classroom, student exposure will remain limited. For technologies like GIS, the barriers can be substantial—mastering complex software, acquiring and maintaining expensive software and hardware, and developing teaching and learning GIS-supported materials. Though the latest web-based GIS and mapping applications such as ArcGIS Explorer Online and Google Earth have reduced these barriers substantially, the question remains as to whether these applications are sufficiently advanced to promote greater teacher adoption.

Therefore, this research focuses on training teachers, especially, middle school social studies teachers. There are several reasons to target middle school social studies teachers. First, the curriculum of many middle schools includes wide range of social studies curricula, such as geography, history, economics, and civics. Therefore, pragmatically I had more opportunities to enlist middle school social studies teachers through the national geography alliance network, than I did for other teachers at other age levels. Second, Piaget's model of learning and cognitive development suggests that students older than eleven years are able to think in terms of the abstractions and symbolic representations used in cartography and GIS (Inhelder and Piaget 1958), and typically middle school students are at or older than eleven years of age. Third, some national and state standards for middle school social studies education benefit greatly from using GIS technologies. Through this research, middle school social studies teachers learned how to create and customize classroom materials with web-based GIS technologies to support social studies curricula. With the help of this training, they learned how to teach social studies efficiently and effectively.

1.1 Research Objectives

The key issue explored in this research is whether the latest web-based systems lower the barriers to using mapping and GIS technologies in the classroom. That is, I investigated whether there are ways to help teachers quickly get started with these technologies and to easily customize lesson plans and activities rather than develop their own from scratch. The questions on which I focused were:

1) How would teachers like to use web-based GIS technologies in the classroom?
   Overall, whether teachers have positive or negative attitudes towards implementing GIS technologies as an instructional tool in their classrooms is identified through this research, and reasons that they like or dislike these technologies are also addressed.
2) What barriers do teachers report that limit their use of these technologies?

This research helps identify various barriers that prevent implementing GIS technologies in the classroom and suggests several solutions to remove or lessen those barriers to encourage teacher adoption of these technologies.

3) What sorts of training and help do teachers find most useful in getting started?

   This research finds types of useful teacher training in order to motivate teachers to adopt new technologies in their classrooms without hesitation; this study also finds effective design formats of teacher training.

4) What kinds of mapping tools are most useful to teachers wishing to implement GIS technologies in the classroom?

   This research finds useful mapping tools to help teachers personally explain a certain concept to students and useful mapping tools to support students in the classroom to understand the concepts easily.

1.2 Background

One of the most important challenges currently facing K-12 education in the U.S. is the effective use of information and communications technologies (ICT) in the classroom. Certainly, there are other political and economic issues currently facing K-12 education, but the pace of technological change is also of great concern since it seems to be moving much faster than it can be adopted for instruction. In part, the issue is one of bringing ICT into the curriculum, so students will be prepared for future study and work as 21st century citizens because ICT literacy is one of the most important 21st century skills that today's students need to learn and master to be successful in the world (Partnership for 21st Century Skills 2004a). But perhaps more importantly, ICT offer a number of features that can enhance and enrich learning and teaching and can potentially help students at different age and developmental levels master concepts across many subjects (Partnership for 21st Century Skills 2004b).

Rudenstine (1997) has, for instance, stressed several other good reasons to use ICT in the classrooms. First, ICT allow us to collect infinite sources of information and to use diverse formats of sources, including texts, numerical data, images, videos, and music. Students do not need to go to the library to find certain information; they can access information without having time and spatial constraints. Second, rich, interactive, and effective classroom materials can be developed using ICT. Students are able to learn context meaningfully through various types of materials and activities, such as interactive multimedia and online interviews. Third, ICT can be used to support conversational learning, which is one of the important elements in education. We can mimic and often overcome limitations of traditional face-to-face conversation using several tools and techniques of ICT, such as video conferencing with someone in a different location. Lastly, ICT help promote students' participation to become active learners. Not mere receivers of information and knowledge, students can be active knowledge constructors. Using ICT, students enthusiastically participate in constructing new knowledge by searching for information on the web or providing their opinions on an online discussion forum. These points are especially salient to geography education and the rise of very powerful visualization tools and GIS technologies, which can be used in all the ways noted above.

1.2.1 Background on GIS in K-12 Education

Desktop GIS technologies were introduced into K-12 education in the early 1990s (Sui, 1995; Kerski, 2008). Desktop GIS technologies refer to stand-alone GIS software that requires software installation at each computing machine. Therefore, its processing speed is usually faster, and its operating is more robust and stable compared to other formats of GIS technologies, such as web-based and mobile. Also, it has powerful, complete, and substantial analysis and cartographic functionalities. The contemporary representative desktop GIS software is Esri's ArcGIS for Desktop (Esri 2012b).

1.2.1.1 History of Desktop GIS Technologies in K-12 Education

Desktop GIS software was first incorporated into public education, 4th to 6th grade levels, by Tinker (1992). He tried to find out whether digital maps can help represent data in many curricula. He concluded that desktop GIS technologies act as a bridge to connect field observations at the personal level and comprehensive issues at the global level. Audet and Abegg (1996) continued to research the relationship between desktop GIS technologies and high school students' learning. They observed that desktop GIS technologies support problem-solving skills, but it was not easy to expect reliable accomplishment. However, for high school students, desktop GIS technologies could be an efficient tool to analyze and visualize spatial data at the basic level. Alibrandi and Palmer-Moloney (2001) believed that integration of desktop GIS technologies in K-12 education reflects the information age's networked workplace where contemporary K-12 students spend most of their time studying, social networking, and enjoying a hobby. In addition, Baker and White (2003) argued that capabilities of desktop GIS technologies for expanding data scale and analyzing data extensively helped promote contextually rich student learning and enabled in-depth analysis.

1.2.1.2 Effectiveness of Using GIS Technologies in K-12 Education

In geography, debate over technological innovation has focused on GIScience. Stand-alone GIS software systems have been used with varying results to support primary and secondary education since the early 1990s (Schultz, Kerski, and Patterson 2008; Sui 1995). Effectiveness of using GIS technologies in the K-12 classroom is the subject of ongoing debate among GIS researchers and educators. Many researchers have done various studies to determine the effectiveness of using GIS technologies in the K-12 classroom, and these researchers have discovered that there are three advantages that K-12 students are able to gain from using GIS technologies in the classroom. Using GIS technologies, K-12 students can construct new knowledge, develop spatial thinking skills, and learn new knowledge deeper and remember knowledge for longer periods of time.

Educating students with GIS technologies is one potential method to apply constructivist learning theory in the classroom (Bodzin and Anastasio 2006; Doering and Veletsianos 2007; Kerski 2003; Liu and Zhu 2008; Zerger et al. 2002). Constructivism assumes that knowledge is constructed by active learners who are information constructors (Driscoll 2005). Learners try to make sense of their experiences for new information. In other words, when students accept and construct new information, they make a connection to their prior knowledge, personal experiences, and cultural factors. GIS technologies can be a great tool to allow students to connect new information to their background and experiences. For example, using GIS technologies, students can understand conditions and problems in their communities, and such lessons might be a good opportunity for students to think about possible solutions to pressing local issues (McClurg and Buss 2007). Students often know more information regarding their communities than other areas, and they are familiar with related information such as street names. For this reason, students can be interested in and easily engage in this activity. A project of Association American Geographers (AAG), *My Community, Our Earth* (Association American Geographers 2012) and a published book by Richard Audet and Gail Ludwig, *GIS in Schools* (Audet and Ludwig 2000) are great examples of GIS activities related to students' communities.

Furthermore, in addition to providing an opportunity to construct new knowledge, GIS technologies are good support systems to improve spatial thinking skills of K-12 students (Bednarz 2004; Meyer et al. 1999). Spatial thinking can be defined as "a collection of cognitive skills. The key to spatial thinking is a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning." (National Research Council 2006, 12). Spatial thinking is not a geographical skill, which can be helpful to learn only geographic contexts. Rather it is a more general cognitive skill, which should be taught across the K-12 curriculum in many subjects (National Research Council 2006). The committee of National Research Council identified three requirements to be successful support systems for spatial thinking—functions of data spatialization, data visualization, and other functions such as analyses, operations, and transformations. In order to be great support systems for K-12 students, interface design and availability to be implemented across the curriculum are additional requirements. The committee evaluated that GIS technologies can be good potential tools to be used as a support system for developing spatial thinking skills. Therefore, through GIS technologies, K-12 students can gain higher spatial thinking skills which are helpful to understand knowledge in various subjects.

GIS technologies can also be used as visual aids for multimedia learning to illustrate geographic concepts (Campbell 2007; Meyer et al. 1999). Multimedia learning promotes meaningful learning by allowing students to learn knowledge more deeply than traditional learning modes and remember them longer period of time (Mayer 2003). In other words, introducing a specific concept with words and pictures is more effective than words alone. If texts are served with multimedia such as pictures and videos, students are able to understand more deeply and remember longer because multiple learning modes help to hold knowledge in their long-term memory (LTM). Besides, with a multimedia tool, students can engage in active cognitive processing, which fosters meaningful learning and supports problem-solving transfer. GIS technologies can be actively implemented in the classroom as a type of multimedia learning. Using visualization functions, geographic contents with various formats, including vector data, satellite imagery, and geo-referenced pictures, can be represented to students. In addition, information that has been changed over time is easily visualized with animation functionality in GIS technologies. Learning with the static or dynamic images visualized in GIS technologies facilitates and promotes students to learn and understand new concepts more profoundly and to remember them longer than learning with only textbooks.

1.2.1.3 Limitation of Using Desktop GIS Technologies in K-12 Education

Although many benefits have been found in using desktop GIS technologies, adoption has not been widespread so far. Only a few teachers implemented desktop GIS technologies in their classrooms. Therefore, desktop GIS software had a hard time to have wider users in the education field (Baker and Bednarz 2003). According to Kerski (2003), approximately 1,900 U.S. high school classrooms have desktop GIS software, but less than 15% of them use it for educational purposes. Therefore, many GIS researchers have tried to identify barriers to limit its use in the K-12 classroom (Baker 2005).

The major identified barrier preventing desktop GIS technologies implementation in the K-12 classroom is teachers' lack of time, both learning time and technical preparation time (Baker 2005; Bednarz 2004; Kerski 2003; Patterson 2007; Meyer et al. 1999). Implementing desktop GIS technologies in the classroom requires a substantial commitment of time, which can be divided by two types. One is personal time to learn and practice GIS functions and complex spatial data. Educators who do not have enough GIS background and experiences need to spend significant time to learn and master GIS technologies. For example, one GIS teacher-training workshop exceeded 40 hours to teach GIS skills to K-12 educators (Baker 2005). Even though once they know a certain level of GIS technologies, they have to continuously spend their own time to catch up with the up-to-date GIS technologies because they are developed continuously. Another type is time to develop GIS-supported curricula in the classroom. It takes time to update existing lessons to GIS-based classroom activities and materials. Usually, times that teachers spend more than their official working hours are not paid. Therefore, most teachers are reluctant to spend additional time to upgrade current curricula to GIS-based lessons. This time issue has limited adoption of desktop GIS software in the classroom.

Second, current professional-level and industrial focused desktop GIS software is too complex and difficult for K-12 teachers and students (Doering and Veletsianos 2007; Kerski 2003; Liu and Zhu 2008; Meyer et al. 1999). In the existing desktop GIS software, there are too many tools and functions that are not useful and needed in the K-12 classroom. In order to solve this problem, K-12 educators need to use simple and basic GIS applications. Or, K-12 educators should be able to customize user interface of existing desktop GIS software. However, for educators who do not have proper technical skills to customize user interface, it takes a considerable amount of time to learn user interface customization.

The third barrier to teacher adoption is that different schools have various computing and network systems (Baker 2005; Bednarz 2004; Liu and Zhu 2008; Patterson 2007). There is an obvious digital divide issue in terms of equipped computing facilities at each school in the U.S. Some schools equip up-to-date computing facilities; for example, Apple's iPads are available for every student and SMART Boards are in each classroom of some schools. However, there are also other schools that have only a couple of desktop computers, so that teachers have to share computers with other teachers, or students need to share one computer with other students. Therefore, those schools cannot meet the demands of desktop GIS software, and there is not enough funding from school districts and/or state departments to equip suitable computing and network systems in every school to use desktop GIS software. Also, in order to use desktop GIS technologies, every school has to hire a skilled technician to manage and repair desktop GIS technologies. Without a technician's help, it is difficult to maintain desktop GIS technologies appropriately. However, it is difficult to hire at least one GIS technician at each school due to the financial issues of each school.

The last barrier is inadequate curriculum time at a school (Baker 2005; Liu and Zhu 2008; Patterson 2007; Meyer et al. 1999). Currently, one lesson takes 50 minutes. Many researchers and educators have mentioned that the GIS-based lessons require at least two hours to complete planned activities. Unlike lecture-based lessons, GIS-based lessons require students to spend a certain amount of time to prepare, understand, perform, and analyze tasks by themselves or as a group. Dividing one completed GIS activity into two different class periods is not a feasible idea because students have to spend a certain amount of time to do set-up the activity again at the second period, and sometimes it is not easy to save students' incomplete GIS projects. Often, such activities are a waste of class time and not an effective for both teacher and students. Without cooperation and the help of school administrators and teachers across the disciplines, it is difficult to implement GIS technologies in the K-12 classroom.

1.2.2 Can the Latest Web-based GIS Applications Improve the Situation?

Web-based GIS applications such as ArcGIS Explorer Online and Google Earth are suggested in order to solve the limitations of using stand-alone GIS software systems in K-12 education. Of course, full-function GIS systems are becoming available for use on the web, such as versions of ArcMap, which is used as an application on hand-held devices; however, here I am focusing on the use of free, open-access applications like ArcGIS Explorer Online and Google Earth. These web-based GIS applications can potentially offer easier access to software, simpler interfaces, and access to data and more effective ways for students to map, search, and analyze geospatial data. Therefore, through the Internet, either GIS professionals or novices can utilize some GIS functions without installing desktop GIS software.

There are many advantages to using these sorts of web-based GIS applications in K-12 education. The first advantage is that geospatial data can be accessed and submitted by multiple users anywhere and anytime with web-based GIS applications (Baker 2005). In the case of desktop GIS software, students can submit their data only with a computer that has installed desktop GIS software. Because it is difficult to install desktop GIS software on every student's home computer, not all students can access desktop GIS software at their homes, assuming that students have home computers. However, in the case of web-based GIS applications, student-generated data can be uploaded via the web without temporal and spatial restrictions if they have a computer and Internet connection.

A second advantage is that web-based GIS applications are able to help teachers to focus on teaching with GIS rather than teaching about GIS (Kerski 2008). When educators use desktop GIS software as a teaching tool, they have to explain a particular GIS technique because some of the GIS tools are not easy and intuitive for K-12 students. As a result, students may be focused on learning about GIS technologies rather than learning a particular subject with GIS technologies. Since web-based GIS applications are relatively easy to learn and use, teachers can focus on teaching not a specific GIS technique, but a central concept or topic supported by web-based GIS applications.

Finally, compared to desktop GIS software, web-based GIS applications have an easier user interface design (Rakshit and Ogneva-Himmelberger 2008). K-12 students may be overwhelmed when they first use some desktop GIS software systems because of their difficult user interfaces. Desktop GIS software is developed for a wider audience, including anyone from students to professionals, so the software's user interface may be difficult for K-12 students.

However, in the case of web-based GIS applications, user interface can be designed for a specific user group. If the expected users are K-12 students, user interface can be customized based on K-12 students' background knowledge of GIS. As discussed above, using web-based GIS applications in K-12 education can give many advantages to K-12 educators and students compared to using desktop GIS software.

1.2.3 Lack of K-12 Teacher Training and Resources for Teachers

Certainly, acquiring hardware, software, network connections and staff support are also important factors in implementation of GIS technologies. However, the most important factors to using GIS technologies in education are helping teachers learn to use the technologies and providing GIS-supported instructional resources for teachers. Many researchers have mentioned that most teachers' GIS technological skills are not enough to implement GIS technologies in the K-12 classroom (Bednarz 2004; Kerski 2003; Meyer et al. 1999). Most K-12 teachers, who do not have any GIS educational background and experiences, are still struggling to use web-based GIS technologies in the classroom. Therefore, teacher training workshops should be considered in order to educate K-12 teachers how to use web-based GIS applications effectively in their classrooms (Baker 2000). More teacher-training workshops need to be developed by GIS researchers, so that more teachers can have an opportunity to learn about overall GIS functions and GIS teaching skills.

There are two types of teacher training—pre-service and in-service teacher training. Pre-service teacher training is training college students in teacher certification programs, whereas in-service teacher training is training teachers who are already in the field. Compared to in-service teacher training, pre-service teacher training is a more effective and efficient way of training teachers in GIS. Generally, pre-service teachers are younger than in-service teachers, so pre-service teachers tend to understand and learn new technologies more easily. However, according to Bednarz (2004), less than ten percent of teacher education students in 1999 learned GIS technologies. Moreover, they learned mostly about the field of GIS (teaching about GIS) itself rather than how to use GIS in the K-12 classrooms (teaching with GIS). In order to introduce GIS technologies in the K-12 classroom, students who are preparing to be K-12 teachers need to learn how to use GIS technologies to illustrate lectures efficiently and how to incorporate GIS technologies into existing standards. Therefore, teacher training of GIS technologies should be developed and provided to pre-service teachers.

However, because not many university departments or colleges of education provide GIS courses to their students, the only way to reach teachers is in-service GIS training. These days, there are many opportunities for in-service teachers to learn GIS, including online GIS courses, workshops, GIS certificate programs, and so on. However, even if teachers take those chances to learn about GIS technologies additionally, it is difficult for them to master all of GIS functionalities in a few days. In order to educate teachers' ability to implement GIS technologies into the classroom, in-service teacher training needs to be planned and carried out with a long-term goal. Also, in-service training should be provided to teachers through more various training types, so that a greater number of teachers can take advantage of them.

Also, there should be more available resources for GIS-based pedagogy and lessons for teachers. Many researchers have identified that there is a lack of research regarding pedagogy, resources, and lessons with GIS technologies in the K-12 classroom (Bednarz 2004; Doering and Veletsianos 2007; Kerski 2003; Patterson 2007). Doering and Veletsianos (2007) mentioned that there is a dearth of geographic pedagogical content models with GIS technologies and related curricula. Because we do not have systematic pedagogy and content models based on GIS technologies, K-12 educators have more difficulties to introduce GIS technologies in the classroom. According to Patterson (2007), there is a shortage of GIS-based curricular activities to share with other teachers. If there are plenty of GIS-based curricula, teachers are more willing to use it in their courses. Therefore, to promote teachers' implementation of courses with GIS technologies, it is important to build, collect, and share GIS-based curricular activities. Another issue is insufficient data resources. Even if teachers want to teach a course with GIS technologies, if they have a hard time finding appropriate resources then they might not want to use GIS technologies in the classroom. GIS researchers need to develop and provide sufficient GIS-based resources to teachers, so that they can find and use appropriate data easily.

1.2.4 Impacts of Web-based Mapping Service Applications

In 2005, Google released Google Maps and Google Earth. Currently, a few hundred million users are using Google Maps and Google Earth to find directions, to find locations of businesses, to plan a route by different transportation, to check satellite imagery, and so on. Also, some users have developed their own maps for personal use or business purposes using the APIs. For example, some people have developed the travel diaries using Google Earth, and some businesses have used Google Maps to provide their local stores' locations. However, these types of web-based GIS applications have not been just released to the market lately. Some GIS applications and map servers have been available on the web more than a decade ago.

The phenomenon that people are excited about recent web-based GIS applications and using them on a daily basis can be explained through three reasons—changes in computing and network technologies, changes in virtual globe applications, and changes in technology trends. Because of rapid spread and development of computing and network technologies, most people have personal computers. Besides, computers have become an indispensable daily living tool for learning new knowledge, searching for information, entertaining such as watching a movie or listening to music, meeting or finding people, discussing issues with others, and so on. Also, due to the development of virtual globes, people have been able to use geospatial data, including remotely sensed images, for free. In addition, because of a new, innovative technology trend called Web 2.0, people are enabled to create new information and share information with others easily on the web.

Web 2.0 has impacted web-based GIS applications, too. These online mapping systems are so easy to use. Therefore, recently many people, some who do not have GIS or a mapping educational background, have used and posted these applications as a tool to express their thoughts, ideas, and lives in their web pages or blogs. This trend is known as the neogeography movement. According to Turner (2006, 2-3), "neogeography is about people using and creating their own maps, on their own terms and by combining elements of an existing toolset. Neogeography is about sharing location information with friends and visitors, helping shape context, and conveying understanding through knowledge of place." Besides, many users can use and borrow diverse contents from more than one source. With APIs, they can combine various contents from different sources that are called map mashups (Pietroniro and Fichter 2006). There is some debate about the value of this neogeography movement, but irrespective of its ultimate value, it does indicate that the ease of web-based GIS applications is more empowering to different groups of users than desktop GIS software.

1.2.5 Necessity of Teacher-friendly Design of Web-based GIS applications and Resources

As mentioned the above, there are many useful, powerful, and free web-based GIS applications that K-12 teachers are able to use as an instructional tool. However, the rate of classroom implementation of those technologies is still pretty low. In other words, even though recent online mapping applications like Google Earth have been developed as easy to use for the novice computer users, many K-12 teachers still feel challenged to use them in their classrooms. The main reason for this resistance would be the lack of teacher-friendliness of those technologies even if they offer user-friendliness to the general public.

In order to increase classroom implementation of web-based GIS applications, the user interfaces of the applications need to be designed and developed for not only the general public, but also teachers and students in particular. If developing new applications only for K-12 education is practically and financially challenging, associated resources, including tutorials how to use the applications, should be developed to fit into K-12 education. One of widely used methods to design and develop applications for specific users and circumstances is the user-centered design (UCD) approach. UCD places the user at the center and focuses on the user's needs, goals, and experiences (Garrett 2002). That is, a product/system can be designed for the specific users, and the users' opinions and suggestions can have great influence on the design and developing process of the product/system.

In 1980s, Donald A. Norman and his research fellows at the University of California San Diego coined the term UCD. In his book, *The Design of Everyday Things*, previously titled as *The Psychology of Everyday Things* (Norman 1988), he stressed the importance of the users' desires and interests for the design process. He insisted that a product/system should be designed for users, so that the users can use the product/system as planned without having a steep learning curve. In other words, if a user needs to take such a long time to learn how to use a product/system, and it requires more than minimum efforts, the design of the product/system is failed.

Depending on different intentions and situations, users' influence can only reach certain parts of the designing process as participants, or they can participate as decision-makers or design partners (Abras, Maloney-Krichmar, and Preece 2004). There are various techniques that designers are able to use to collect users' opinions for the UCD approach, including interviews, focus groups, questionnaires, direct observation in the field, direct observation in a controlled environment, and indirect observation (Sharp, Rogers, and Preece 2007). The designers should choose the most appropriate technique, and if required, a set of techniques can be combined for the better design. This UCD approach is one of useful and effective methods to design and develop teacher-centered and teacher-friendly web-based GIS applications and resources for K-12 teachers.

1.3 Research Goals and Chapter Organization

The question then is whether these new web-based GIS applications can help overcome some of the traditional barriers to deploying desktop GIS software in education. They may not be able to address all of the challenges of using desktop GIS software in K-12 education, but they do offer solutions to some of the most pressing problems. The ultimate research goals are improving K-12 educators' capability to develop web-based supported curricula by themselves and increasing the adoption rate of using web-based GIS applications in the classroom.

In order to reach the research goals, I adopted the UCD approach and conducted a three-part, mixed-methods research design—user needs analysis, tutorial development, and evaluation, which will be described in Chapter 2. The results and analysis of each methodology will be introduced in Chapters 3, 4, and 5, separately. The discussion and conclusion will be presented in Chapter 6.

CHAPTER II

METHODOLOGY

Given my research questions, I chose to explore whether teachers might learn web-based geographic information systems (GIS) technologies faster and use them more frequently in the classroom if teachers themselves participated in the process of planning, designing, and developing training tutorials. In other words, by developing teacher-centered and teacher-friendly training tutorials with teachers' participation, other teachers would find the training tutorials useful, learn the materials easily, and use them often as instructional tools with their students in their classrooms.

2.1 User-Centered Design

In order to develop teacher-centered and teacher-friendly web-based GIS training tutorials for middle school social studies teachers, this research adopted the user-centered design (UCD) approach to suit users' specific requests and circumstances. There are various ways to implement the UCD approach, but I chose to use a five-step method adopted from Sharp, Rogers, and Preece (2007) (Figure 2.1). The first step is analyzing users' needs; a researcher should understand who users are and what they need and want by interviewing them. Second, based on the results of the interview data analysis, major requirements for designing teacher-centered and teacher-friendly web-based GIS training tutorials need to be identified. Third, using the identified requirements, the researcher begins to design the user interface of the training tutorials. Fourth, the researcher meets participants again, and asks for their feedback on the user interface. The researcher keeps revising the user interface design based on the participants' feedback. Finally, once the user interface design is satisfied, the researcher evaluates the user interface with a large number of users. If the results of the evaluation are unsatisfactory, the researcher starts over by going back to the first step of analyzing users' needs.

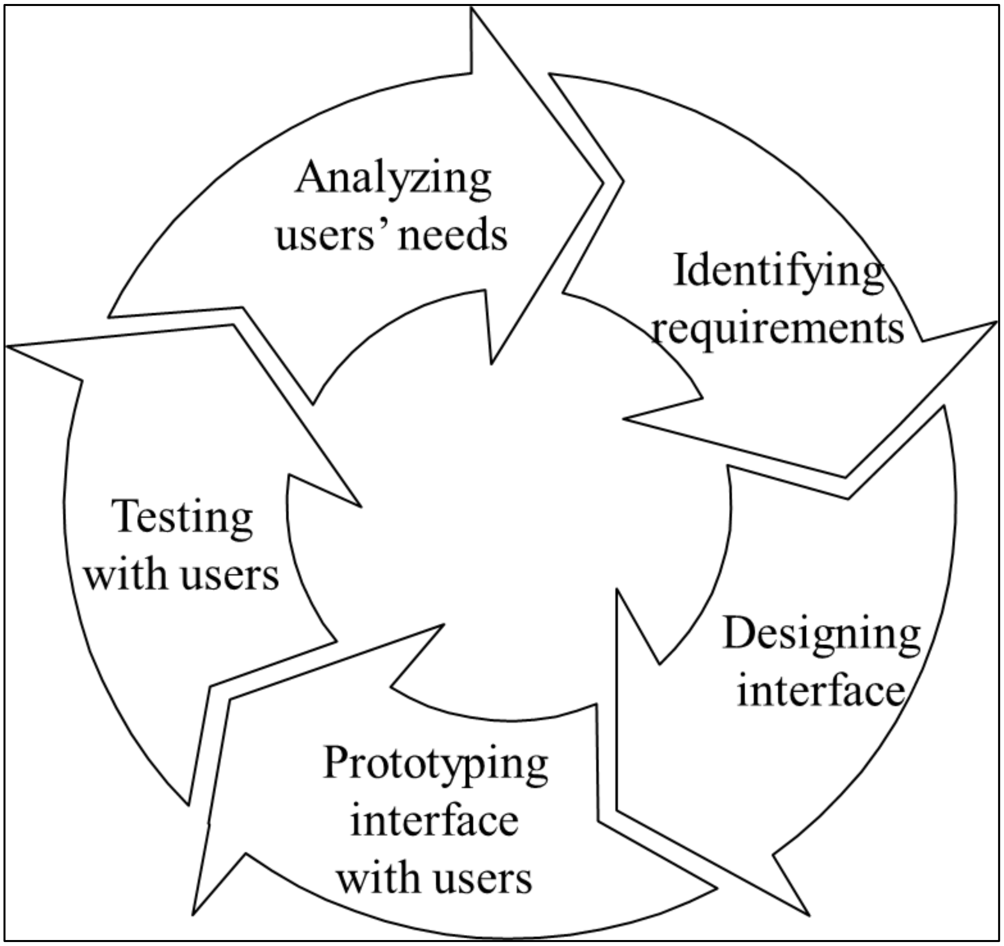


Figure 2.1. The user-centered design (UCD) model (Adapted from Sharp, Rogers, and Preece 2007, p448)

2.1.1 Background of User-Centered Design

2.1.1.1 Human-computer Interaction

The UCD approach is one type of human–computer interaction (HCI) design methodology. HCI is research about "how people design, implement, and use computer systems, the usability of the effectiveness of the interaction between humans and machines, and how computers affect individuals, organizations, and society" (Haklay and Tobón 2003, 577-578). As multidisciplinary research, HCI has been contributed to many other disciplines such as cognitive psychology, computer science, ergonomics, industrial engineering, and so on (Haklay and Tobón 2003). The fundamental significance of HCI is emphasizing the importance of human factors for designing, constructing, and developing interfaces, systems, and structures.

Since personal computers have been widely used by the general public beginning in the 1980s, the usability of single-user computer systems has been highlighted (Haklay and Tobón 2003). Moreover, development of communication technologies between people in different locations using emails, teleconferencing, and videoconferencing has been another contributing factor for the improvement of the field of HCI (Carroll 2001). Today, HCI research is broadly applied for the wide range of user interaction research on hardware, software, input devices, and user interface design. Also, currently many different fields including education, industrial applications, national policy, and international competitions have adopted main theories of HCI in their research (Shneiderman and Lewis 1993).

2.1.1.2 User Interface Design

There are five measurable human factors to be considered for designing user interface—time to learn, speed of performance, rate of errors by users, retention over time, and subjective satisfaction (Shneiderman 1998). Among these five factors, sometimes two factors conflict with each other, so these factors need to be balanced (Shneiderman 1998). For instance, if a designer makes as few errors as possible, speed of performance might be slow. Also, the priority can be different depending on the purpose of a product/system. For example, time to learn may be the most important factor for a certain product/system, but other products/systems do not need to be designed with consideration of the time to learn factor. Therefore, understanding the fundamental objectives of a product/system is the most important to designing its user interface effectively.

In addition, designing an interesting user interface is also another important factor to make a product/system attractive. If people lose interest when they use the product/system, people might not want to use the product/system continuously. According to Shneiderman (2004), there are two general goals for user interface design—task-suitable functionality and usability/reliability. However, in order to design a user interface to be more fun, Shneiderman suggested one more goal, fun-features, which include alluring metaphors, compelling content, attractive graphics, appealing animations, and satisfying sounds (Shneiderman 2004). These five fun-features may help to attract greater numbers of users and make the most successful product/system. For example, in order to appeal to the target users effectively, many instructional technologies for children have been developed and designed under a game-like environment. NASA Kids' Club (http://www.nasakids.com) provides good examples of incorporating fun-features into its user interface design (Figure 2.2).

Figure 2.2. An example of incorporating fun-features in user interface design (source: NASA Kids' Club, http://www.nasa.gov/externalflash/Buzz_Lightyear/web)

2.1.1.3 Usability Testing

Usability can be defined as the effectiveness of the communication and interaction between humans (users) and a product/system to improve users' working processes (Sharp, Rogers, and Preece 2007). In order to evaluate whether interface design of a product/system is usable, usability testing should be mandatorily conducted. Developers and designers are able to guarantee if the design meets the objectives, functionalities, and requirements through usability testing. Usability testing allows developers and designers to have clear ideas about performance and how many planned tasks users can accomplish effectively, efficiently, and enjoyably before launching a product/system into the real world. According to Sharp, Rogers, and Preece (2007), there are six measurements identified as usability goals, including effectiveness, efficiency, safety, utility (having good utility), learnability (easy to learn), and memorability (easy to remember how to use).

There are several methods to evaluate usability such as think-aloud protocols, cognitive walkthroughs, and heuristic evaluation (Sharp, Rogers, and Preece 2007). In think-aloud protocols, users are asked to verbalize their thoughts while performing a task, and the designer must observe and take notes on everything users say. If it is difficult to recruit users as participants, analytical evaluation methods such as cognitive walkthroughs and heuristic evaluation can be used. With cognitive walkthroughs, a designer and one or two expert evaluators perform sample tasks by walking through the action sequences for each task and recording problems and issues that users might face. Lastly, heuristic evaluation can be implemented by answering whether interface design meets ten usability principles developed by Jacob Nielsen (2005). These ten usability principles are "visibility of system status, match between system and real world, user control and freedom, consistency and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, help users recognize, diagnose, and recover from errors, and help and documentation" (Nielsen 2005, under "Ten Usability Heuristics"). Nielsen believed that the above principles provided the general guideline for developing and designing user-friendly interface design.

2.2 Research Design

In this research, a three-part, mixed-methods UCD research design was used. It consisted of a user needs analysis step, a tutorial development step, and an evaluation step. In this chapter, I present the details of these steps (Figure 2.3). The results of each of these methods will be presented in Chapters 3, 4, and 5, respectively. A total of 30 teachers participated in the user needs analysis and the tutorial development parts of the method, and 55 people participated in the evaluation.

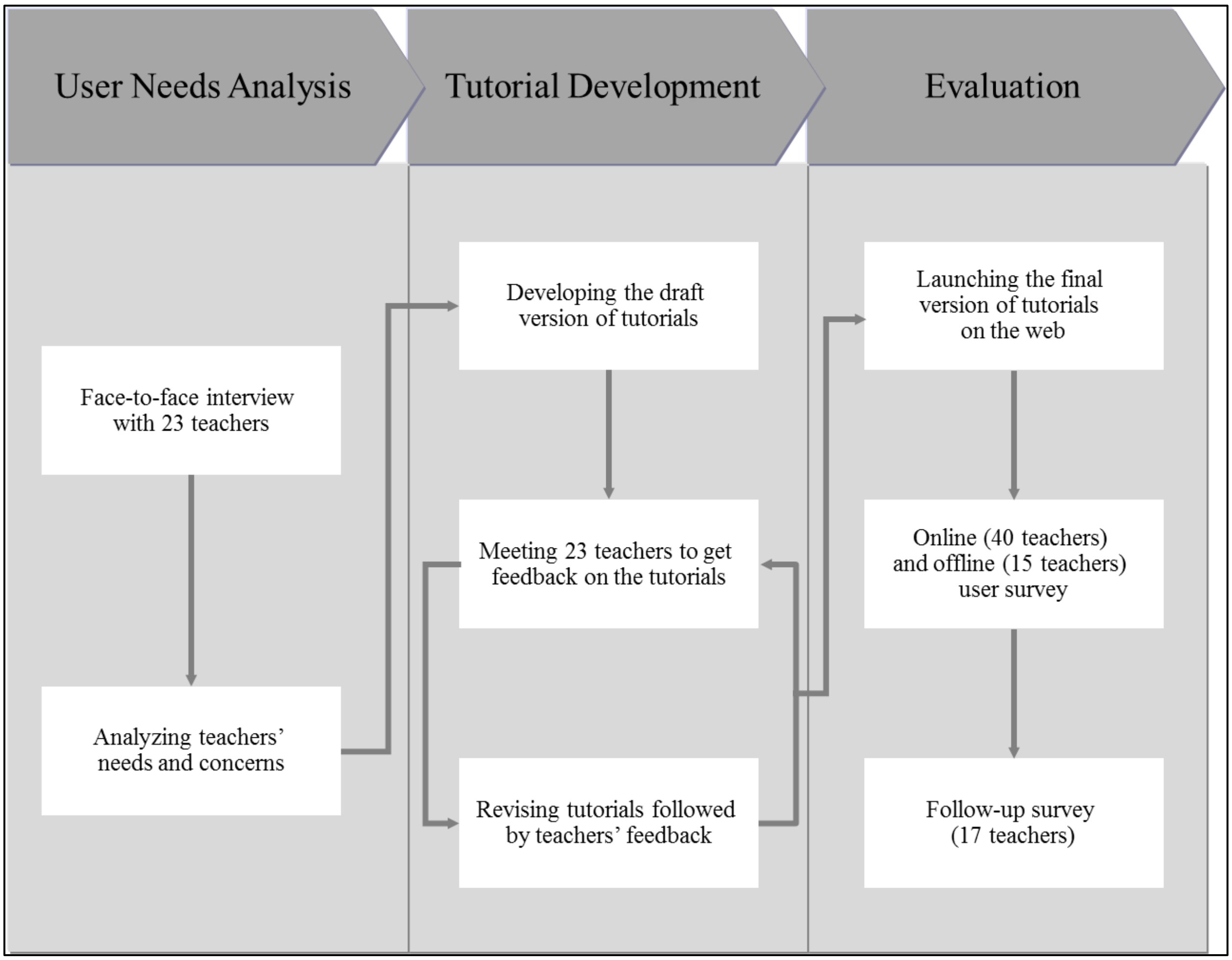


Figure 2.3. Detailed procedures of each method step in this study.

2.2.1 User Needs Analysis

The first step for effective and efficient user-centered interface design was analyzing users' needs. The aim is to understand the potential users of the GIS materials—who they are, what they want, where they come from, what they think, and so on. The target users of this research were middle school social studies teachers. To obtain the detailed information regarding the users of this research, I chose a face-to-face interview method. I thought meeting individual teachers personally and asking questions directly was the best way to understand and analyze my users' needs in terms of designing and developing effective web-based GIS training tutorials for teachers. Compared to questionnaires or surveys, semi-structured interviews are sometimes more useful in exploratory projects like this one in which relatively few user characteristics are understood clearly in advance of the study. The open-ended format of semi-structured interviews allows users to reflect more widely on their experiences and preferences. However, my choice of meeting teachers individually meant that I could only recruit middle school social studies teachers in Colorado.

Of the 30 total teacher participants, 23 teachers participated in the user needs analysis from May 11th to June 7th, 2011. Interviews were held with each interviewee at his/her preferred location such as a local coffee shop in his/her neighborhood. Each interview took about 30 minutes to one hour, and the interviews were recorded using an audio recorder. Participants were asked about their general teaching experience, learning tools and materials that they usually used, their background with computer technology including GIS, and their preferred teacher training styles. There were several reasons to ask these questions. First, I wanted to know how participants saw their strengths and weaknesses as teachers and the opinions they held about implementing information and communication technologies (ICT) in the classroom. Second, I wanted to know about how participants typically developed lesson plans and what kinds of resources they usually used, including paper and digital maps. Also, I wanted to know how much participants already employed ICT in their lesson planning. Third, I wondered about the level of participants' experience with ICT, whether they were expert, intermediate, or novice users. Fourth, I wanted to know how much experience and background participants had about GIS. Lastly, I wanted to ask about what types of teacher training participants liked or disliked. Table 2.1 is sample of interview questions for the user needs analysis. The complete version of the interview questions is available in Appendix A.

Table 2.1. Sample Interview Questions for the User Needs Analysis

Categories	Questions
General teaching	What do you see as one or two of your greatest strengths as a teacher?
	What areas you are trying to improve or change?
	What are the barriers not to use a new technology in the class?
Learning tool/material	How do you develop lesson plans?
	What resources would help you develop lesson plans using online and paper maps?
	What role do computers and the Internet play in your lesson planning?
	Do you enjoy learning and trying new technology for your class?
	What kinds of computing skills do you want to improve for your class?
Experiences of computer technologies	How do you see your proficiency with computers?
	Do you enjoy working with computers and information technology?
	What's the best way to learn computing technology?
	What motivates you to learn computing technology?
Experiences of GIS technologies	Have you ever learned about GIS before?
	Have you used GIS application as an educational tool?
	Have you used web-based GIS applications such as Google Earth in the classroom?
	Do you think which mapping tools are most useful in the classroom?
	What kinds of mapping tools do you want to learn?
	Which course topics (curriculums) do you want to develop with web-based GIS?
Teacher training	What is your favorite way of learning new techniques?
	What wouldn't work for you?

I covered all of the topics with all of the participants, though I used slightly different versions of some questions depending on a teacher's background and experience. If they were expert ICT users, I posed the questions in terms of their level of expertise. If a participant answered that he/she was an expert user, then I asked him/her whether he/she had created websites and had any programming experience. Also, if the situation was necessitated, I asked related follow-up questions. After conducting interviews with 23 participants, I transcribed these recorded interviews into text files using the Express Scribe transcription software. Then I categorized and coded participants' responses and made a table for each question to see clear patterns.

2.2.2 Tutorial Development

In order to design and develop teacher-centered and teacher-friendly GIS training tutorials, I met participants again to get their feedback on content, formats, terminology, and so on. In this step, teachers were not only participants but also collaborators in designing and developing the GIS training tutorials for middle school social studies teachers. Again, as during the first step, I chose to meet teachers in person.

Based on the results of for the user needs analysis, I began developing the first draft of web-based GIS training tutorials for middle school social studies teachers using two free online mapping applications, ArcGIS Explorer Online and Google Earth. ArcGIS Explorer Online is developed by Esri, and it allows users to use various kinds of GIS datasets provided by Esri in combination with users' own local data. It also offers the capability of customizing and sharing maps with others (Esri 2012a). Google Earth allows users to fly over the entire earth and access many types of maps and imagery (Google Earth 2012). Figure 2.4 shows different interfaces of these two online mapping applications.

I developed three different topics for each grade level, so there were a total of nine different tutorial topics. The topics were all based on suggestions made by teachers in the user needs analysis. Each topic included three independent activities, and the contents of these three activities were suggested by participants during the tutorial development step. Once the contents of activities were chosen, I read related chapters of geography and the U.S. History textbooks that many of the middle school teachers used. Then I came up with ideas of various mapping tools and techniques that could be used in either ArcGIS Explorer Online or Google Earth. I also checked to make sure that the topic's activities were aligned with the middle school social studies curricula of Colorado as well as the national geography education standards (National Council for Geographic Education 1994). Some activities required preparing digital map layers, mostly shapefiles, and others used publicly available data that could be downloaded from public websites, such as National Atlas of the United States (nationalatlas.gov) and Esri (esri.com). I also used digital images, photographs, and attribute data downloaded from various web pages such as Wikimedia Commons.

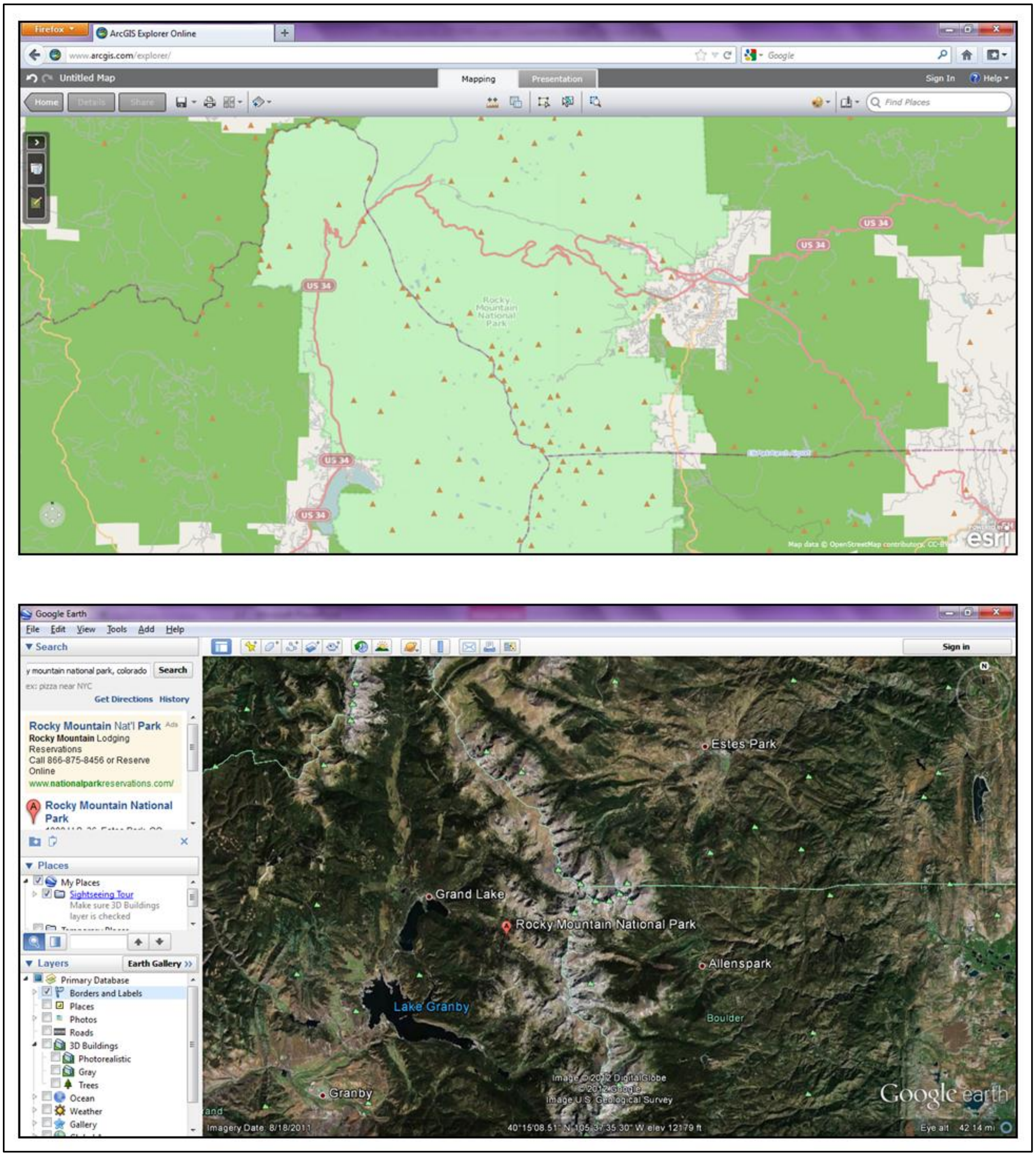


Figure 2.4. Rocky Mountain National Park on ArcGIS Explorer Online (above) and Google Earth (below)

In addition to the three independent activities in a topic, each tutorial topic included three or more mapping tools. Examples of mapping tools are: showing historical imagery, adding a new feature, adding a new map layer, color symbolization, adding a picture with its description, drawing boundaries, creating various charts, and so on. Some mapping tools, such as adding a picture, were used in many different tutorial topics, but other tools were introduced in only one tutorial topic.

During the tutorial development step, 23 teachers were asked to test the draft versions of the training tutorials. I met with individual teachers or small groups wherever they preferred to meet, sometimes at their homes or in local coffee shops. Each testing session took approximately one hour to complete. Among different types of usability testing methods described above, think-aloud protocols were conducted in this step. This think-aloud method allows the researcher to find major and recurring problems that users struggle with in the design (Sharp, Rogers, and Preece 2007). Teachers were asked to test the draft versions of one topic's tutorials. While performing the tasks, they were asked to verbalize their thoughts. I observed how teachers accomplished each step and took notes. If teachers could not complete a step, I asked the reason for their confusion and offered a hint to help them proceed to the next step.

Once the full draft versions of one of the topic tutorials for each grade level were developed, specifically, *Deforestation in the Amazon Rainforest* (6^{th}), *Ancient Greece and Rome* (7^{th}), and *Westward Expansion of the U.S.* (8^{th}), I met a few of the participants. After revising the first three tutorials based on teachers' feedback, I met with other teachers to obtain different responses to the same tutorials. Participants suggested various important ideas such as adding new content, changing the order of activities, and introducing more background knowledge about specific mapping tools. I revised the tutorials to reflect the teachers' suggestions.

When I met with participants, I also solicited suggestions about teaching ideas, materials, and classroom activities to incorporate into the next topics, which were not yet developed. Applicability to actual teaching contexts might increase the teachers' motivation to learn the tutorials, so it was very important to solicit teacher input before developing the tutorials. Participants suggested various ideas and hands-on activities that they were actually using with students. I tried to develop tutorials based on their suggestions to the greatest degree possible. As with the first round of drafts and after developing the second set of topic tutorials, I met with other teachers and asked them to test the tutorials. I followed the same process for the third set of topics for each grade level. Teachers provided valuable suggestions. Again, after each testing, the tutorials were revised based on teachers' feedback and suggestions. Each tutorial topic was tested by two to four different teachers. Specific processes and information regarding how and what kinds of suggestions participants made will be presented in Chapter 4.

2.2.3 Evaluation

There were two parts to the evaluation methodology. A user survey was conducted both online and off-line, asking teachers to use and review one of the nine tutorials. The follow-up survey was employed to ask teachers about their experiences using one or more of the tutorials in the classroom, if they chose to use a tutorial with their students.

2.2.3.1 User-survey

The completed, final versions of web-based GIS training tutorials for middle school social studies teachers were posted on the web on November 9th, 2011 (GIS for Social Studies: http://www.colorado.edu/geography/cartpro/gisedu). Because training tutorials on the web could be accessed from any location, there was no spatial limitation in inviting participants for the user survey. The detailed information regarding the participant recruitment process will be introduced below. The total number of participants for the user survey was 55: 40 participants from online testing and 15 participants from offline testing. For the user survey, I asked participants to test one or more topics' GIS training tutorials. Once participants completed the tasks, I asked them to take my online survey created and employed in the SurveyMonkey web application.

On two occasions the user survey was done off-line. The first of these was on April 14th, 2012 as part of a teacher workshop sponsored by the Colorado Geographic Alliance (COGA). The second off-line testing was employed on April 20th, 2012 via in-service professional development for social studies teachers at Casey Middle School in Boulder, Colorado. Similar to the online testing, 15 total participants tested one of the topics' GIS training tutorials and took the same survey at the end of the testing. The only difference between online and off-line testing was a facilitator's help while testing. The comparison analysis will be presented and discussed in Chapter 5. Table 2.2 shows the sample survey questions for the user survey. The completed version of survey questions is provided in Appendix B. In order to analyze the results of the survey, I coded responses manually for open-ended questions and calculated descriptive statistics such as the rating average of questions with a Likert scale. Then I created either tables or charts to see the overall patterns clearly.

Table 2.2. Sample Survey Questions of the User Survey

Categories	Questions
Background	What grade are you currently teaching?
	How many years have you been teaching?
	Please rate your knowledge level of GIS, web-based maps, virtual globes, ArcGIS Explorer Online, and Google Earth.
Tutorials	Was the tutorial easy to follow?
	What is the best feature in the tutorial? Why?
	What is your least favorite feature of the tutorial? Why?
	What elements or features of the tutorial need the most improvement? How?
Mapping tools	Please rate (from 1 to 5) the mapping tools you used in terms of their value to you personally.
	Please rate (from 1 to 5) the mapping tools you used in terms of their useful to you as a teacher and to your students in the classroom.
	Besides provided mapping tools in the tutorials, what else tools and techniques do you want to learn?
Teacher training	Do you like this type of teacher training (online training)?
	What are your favorite types of teacher training?
Classroom implementation	Did the tutorials provide enough help for you to create and/or customize web-based GIS by yourself?
	Do you think web-based GIS are useful and effective as an instructional tool?
	Would you use web-based GIS in your class?
	What are possible barriers to limit use of these technologies in the classroom?

2.2.3.2 Follow-up Survey

The main goal of follow-up survey was to identify the adoption rate of GIS technologies among participants. I did this by asking teachers in the user survey if I could contact them again with follow-up questions. Nineteen participants agreed to participate in follow-up survey, and provided their contact information. I contacted these participants via email and asked about their use of the web-based GIS technologies in the classroom. Table 2.3 presents the sample survey questions for the follow-up survey. The follow-up survey was also created and employed using the SurveyMonkey web application. The completed survey questions are provided in Appendix C. Of the 19 volunteers, 17 completed the survey. Through the follow-up survey, I wanted to know whether my GIS training tutorials persuaded teachers to use web-based GIS technologies in the classroom. Also, I was interested in teachers' perceptions of students' responses and the advantages and disadvantages of using web-based GIS in the classroom. The analysis approaches that I used for the follow-up survey were similar to the user survey—coding responses and using descriptive statistics.

Table 2.3. Sample Survey Questions of the Follow-up Survey

Categories	Questions
Rate of GIS adoption	Did you use one of tutorial topics from GIS for Social Studies website and/or create your own materials in your classroom?
Tutorial topics	How many times did you use web-based GIS applications in your classroom?
	To you, was the tutorial easy to use in the classroom?
	To your students, was the tutorial easy to follow?
Description of your materials	Did the tutorials provide enough help, so that you could create and/or customize web-based GIS by yourself?
	What were the topics or learning objectives of the materials?
	What kinds of mapping tools or tasks did you use in your materials?
Students' responses	Did the web-based GIS applications you used encourage student engagement in the classroom?
	Did the web-based GIS applications you used increase the degree of your students' understanding of the topic you presented?
	Did the web-based GIS applications you used help reach the learning objectives of the topic you presented?
	Do you think the web-based GIS applications you used are useful and effective as an instructional tool?
Preventing factors	What factors prevented you from using of web-based GIS applications in your classroom?
Future implementation	In the near future, would you try to use web-based GIS applications in your class?

2.3 Participant Recruitment

In this section, detailed procedures of recruiting participants for each methodology of this study will be presented.

2.3.1 Participants for the User Needs Analysis and the Tutorial Development

Thirty current secondary level school social studies teachers in Colorado participated in the first two steps of this study—the user needs analysis and the tutorial development. First of all, I asked leaders of COGA if they would circulate a call for volunteers, but I only received two responses from the COGA members. Because not all middle school social studies teachers were members of COGA and people tended to pay more attention to an email directly sent to them rather than through group emails, I decided to contact teachers individually. Therefore, in order to recruit teachers, I searched all of the middle school websites in Colorado available from the Colorado Department of Education website first. I then found social studies teachers' email addresses on the individual middle schools' websites, and I sent out invitation emails to these social studies teachers.

Even though participants did not receive compensation or a reward from participating in the research, a total of 30 teachers agreed to participate in the research because they wanted to learn about up-to-date geospatial technologies for themselves and their students. Sixteen teachers participated in both the user needs analysis as well as the tutorial development of the study. Of the rest of the teachers, 14 teachers participated in only one or the other step. Among the 30 teachers, 8 (26.7%) were 6th grade teachers; 15 (50.0%) were 7th grade teachers; and 7 (23.3%) were 8th grade teachers (Table 2.4). One participant was teaching both 6th and 7th grade, and 1 participant was an 11th and 12th grade teacher.

Table 2.4. Job Description of Participation in the User Needs Analysis and the Tutorial Development (Total=30)

Grade	# of Participants	% of Participants
6th	8	26.7%
7th	15	50.0%
8th	7	23.3%
11th and 12th	1	3.3%

Figure 2.5 shows the locational distribution of participants in this study. A majority of participants were from schools in the metropolitan Denver region including Adams County, Arapahoe County, Boulder County, Clear Creek County, Denver County, Douglas County, Elbert County, Gilpin County, Jefferson County, and Park County. These counties are home to approximately 58% of the students from pre-Kindergarten to the 12th grade in Colorado (Colorado Department of Education 2012). However, there were a small number of participants from schools in the Pikes Peak, north central, northwest, and northeast regions of Colorado.

Therefore, I was able to obtain information on different classroom environments, financial support from school districts and the state department, and students' lives in both urban and rural areas in Colorado.

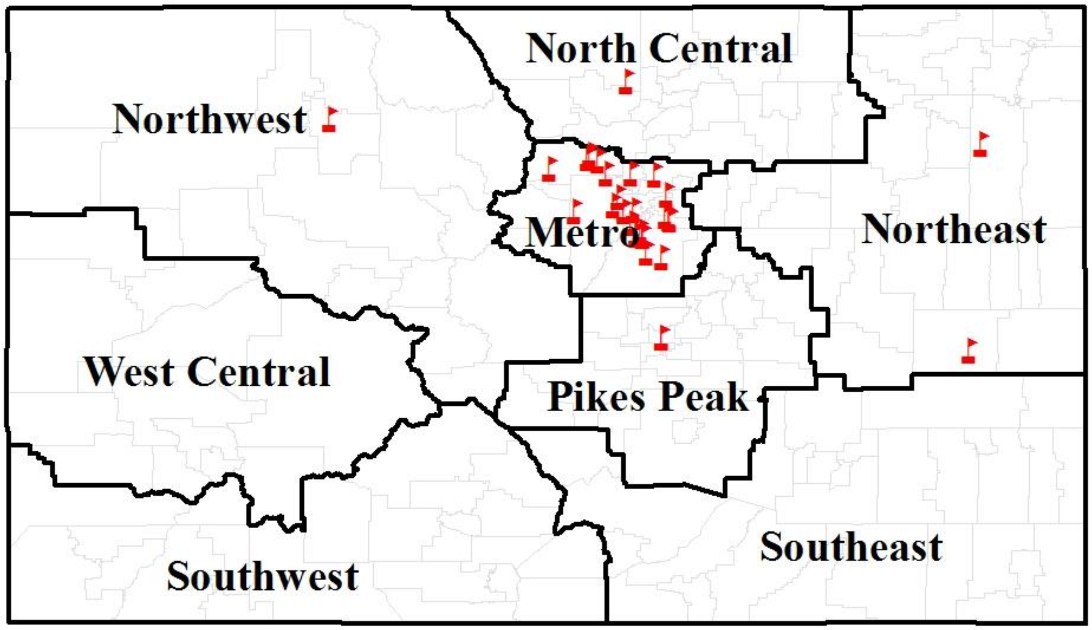


Figure 2.5. Geographical distributions of participants for user needs analysis and tutorial development ()

2.3.2 Participants for the Evaluation

For the evaluation step, I did not limit areas, teaching grade levels, and teaching subjects of participants. Because both the user survey and follow-up survey were conducted online, teachers in any location were able to participate in the evaluation of the tutorials. All of the tutorial topics were in line with the middle school social studies curricula of Colorado, but some topics such as *Deforestation in the Amazon Rainforest*, *Natural Disasters in America*, *Natural Resources*, and *Human-Environmental Interaction* were correspondent topics in science curricula. Also, the 8th grade topics in the U.S. History curriculum could be used in the high school U.S. History classroom. Therefore, to evaluate the tutorials, I invited not only middle school social studies teachers, but also high school social studies and science teachers in locations throughout the U.S.

In order to recruit teachers for the evaluation step, I first contacted coordinators of the 50 state geographic alliances and councils for social studies. Some states' coordinators sent my invitation letter to their teachers. Some posted my invitation letter on their monthly or quarterly newsletters or websites/blogs. The invitation letter for the study was also posted on the GIS Education Research Google Group (http://groups.google.com/group/gisEd) discussion board and was sent to members in the 4-H GIS GPS team. Because I received more responses if I contacted teachers individually than via group emails, I used the same approach that I did for enlisting participants for the first two steps, the user needs analysis and the tutorial development of the study. I contacted individual teachers by searching individual school websites and finding as many social studies teachers' email addresses as I could. In addition, I contacted participants who contributed to the first two steps of the methodology, the user needs analysis and the tutorial development. Although their prior knowledge of the tutorials had the potential to introduce some bias into the evaluation, I chose to do so for two reasons. First, in practical terms, it took several months to recruit teachers willing to evaluate the tutorials. I chose to reinvite the previous participants to provide a margin of safety. Second, I felt that any potential bias either for or against the finished tutorials would be relatively small. Participants in the user needs analysis did not see any of the finalized tutorials before they were asked to review them. And, of the teachers who participated in the tutorial development by testing one of nine topics, they were asked to evaluate a different tutorial if they chose to participate.

CHAPTER III

USER NEEDS ANALYSIS

This chapter provides the results of the interview with 23 participants as part of the user needs analysis. The results are grouped into five categories—participants' background and experience teaching with information and communications technologies (ICT); attitudes towards ICT; their views of barriers that limit the use of ICT; their training experience with geographic information systems (GIS) technologies; and their preferences with respect to their preferred styles of learning about ICT. At the end of the chapter, I will introduce how the results of the user needs analysis were used in the next step of my methodology, the tutorial development.

3.1 Participants' Teaching Experience and ICT Background

3.1.1 Background and Experience as a Teacher

As an ice breaker, I asked participants their great strengths as a teacher first (Table 3.1). The most frequently responded strength was relationship with students (12 participants (52.2%)). The participants mentioned that they were close to their students, which helped create a warm classroom environment. Secondly, 7 participants (30.4%) said that they often used hands-on activities in the classroom compared to other teachers. They believed that hands-on activities helped students learn more effectively and reach meaningful learning because "the more they're interacting, the more they learn" (ID #10). Five participants (21.7%) mentioned that they enjoyed learning something new. Because they liked to learn, "it's easy to pass that enthusiasm to my kids" (ID #8). Four participants said that they brought technology into the classroom more often than other teachers. They said that they were not hesitant to try a new instructional method in the classroom and were not afraid of failing with it.

Table 3.1. Participants' Greatest Strength as a Teacher

	Times Responded	As % of Total Respondents
Relationship with students	12	52.2%
Hands-on activities	7	30.4%
Like to learn	5	21.7%
Use technology	4	17.4%
Try new things	4	17.4%
Connect to students' background	2	8.7%
Make students be critical thinkers	2	8.7%
Focus on reading/writing	2	8.7%
Make safe environment	2	8.7%
Enjoy teaching	2	8.7%
Encourage students to do their best	2	8.7%
Others (12 different responses identified by 12 participants)		

I also asked participants when they felt challenged in explaining a new concept (Table 3.2). Eight participants (34.8%) identified that lack of students' background knowledge was the most difficult to overcome when explaining a new concept or a topic to students. Teachers "have to make an assumption of students' level of background knowledge. If [teachers] make the wrong assumption, the unit/lesson is completely a flop" (ID #13). Seven participants (30.4%) mentioned that they had a difficult time when they did not have background knowledge of a certain concept or topic, to "make sure [they] know what [they're] doing, and [they] have some background before [they] present [it to students]" (ID #17). Five participants (21.7%) also identified that they felt challenged when they used inappropriate levels of vocabulary, reading, and intellectual challenge for their students. One participant said that "a lot of students are English language learners, so they have a lower [level of] reading skill. Many of them speak Spanish at home. I have to spend a lot of time on vocabulary development, in order to make them higher-level critical thinkers, so it takes longer" (ID #11). Also, according to some teachers, generally it was hard to explain a concept to suit all students' cognitive levels because some of the middle school students were still in the concrete thinking phase. Therefore, when teachers talked about abstract things, those students could not understand them easily.

Table 3.2. Situations that Participants Felt Challenged in Explaining a New Concept

	Times Responded	As % of Total Respondents
Lack of students' background knowledge	8	34.8%
Lack of my background knowledge	7	30.4%
Not using appropriate levels of vocabulary, reading, and cognitive skill for students	5	21.7%
When students are not interested	4	17.4%
Not having adequate visual aids/hands-on activities	3	13.0%
Figuring out the best way to present information to make students understand	2	8.7%

3.1.2 Experience of Lesson Plan Development

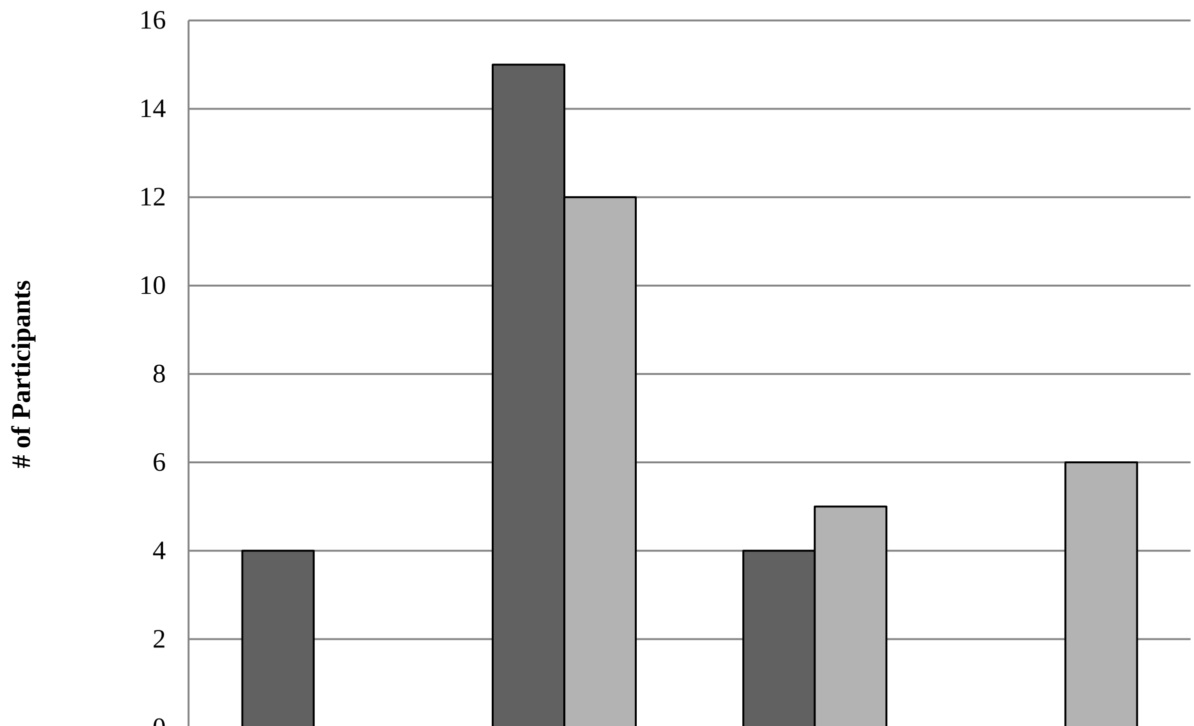
Participants used different ways of developing their lesson plans (Table 3.3). Eight participants (34.8%) mentioned that they started from state or school district standards first. They tried to cover every single standard if possible. To do that, they went through standards and then assigned each standard to the related context. Seven teachers (30.4%) mentioned that they used the backwards design approach. Teachers first "think about the most [important] information that [teachers] want [their] students to walk out of the class knowing. [Teachers] use that [information] to develop the essential questions. Everything else such as lesson and assessment all ties back to answering those essential questions. [And then teachers] develop individual steps to hit those essential questions" (ID #13).

Table 3.3. Participants' Various Ways to Develop Lesson Plans

	Times Responded	As % of Total Respondents
Start from state or district standards	8	34.8%
Backwards design	7	30.4%
Use curriculums developed by districts	6	26.1%
Collaborate with colleagues	6	26.1%
Use textbooks	6	26.1%
Use the Internet to find resources	5	21.7%
Use TCI program	5	21.7%
Focus on planning activities	3	13.0%
Others (2 different responses identified by 2 participants)		

Six participants (26.1%) mentioned that they used curricula developed by school districts. Some school districts provided detailed and specific curricula to teachers, which they followed and used. Also, 6 participants (26.1%) responded that they collaborated with other teachers and used a textbook. One of the interview questions was whether participants shared their lesson plans with their colleagues. All participants answered yes. Through department (vertical) and grade (horizontal) meetings, the teachers discussed and shared plans, tools and information. Even though 6 participants (26.1%) answered that they used a textbook a lot, other participants did not because they thought textbooks limited students' learning and were not always neutral in their perspectives. Those teachers who did not use a textbook created their own classroom materials including reading materials and activities.

When developing lesson plans, many participants used both paper and digital maps (Figure 3.1). Between paper and digital maps, more participants used paper maps more frequently than digital maps. Four participants mentioned that they used paper maps all the time, almost every class hour. Fifteen participants said that they used paper maps often, such as once per unit when they introduced the region of the unit. However, 2 of them said that they preferred digital maps, and if they could use digital version instead, they would not use paper maps that often. Four other participants did not use paper maps often. In the case of digital maps, 12 participants used digital maps often in the classroom. They showed digital maps, mostly static maps, to students using a projector. Or, sometimes they showed Google Earth to students. Five participants did not use digital maps often. They tried once, but they thought that it did not work well at that time, so they went back to paper maps. Six participants did not use digital maps at all. They always used paper maps instead.



	All the time	Often	Not Often	Not at all
Paper maps	4	15	4	0
Digital maps	0	12	5	6

Figure 3.1. Participants' experience of using paper and digital maps in lesson plans

ICT played an important role when participants developed lesson plans (Table 3.4). Eighteen participants (78.3%) mentioned that they used ICT as a research tool to find information and resources, understand material better, and prepare for class. Those participants believed that they "couldn't be an effective teacher without ICT. [Because there are] not a lot of resources at schools, ICT are basically free resource tools and maps that [they] don't have" (ID #16). Fourteen participants (60.9%) used ICT for classroom activities. They used ICT at a teacher station to show some information to students, or they had students use ICT on their own. Five participants (21.7%) identified that they usually used ICT to create lesson plans and classroom materials.

Table 3.4. Participants' Responses to Roles of ICT in Lesson Plans

	Times Responded	As % of Total Respondents
Research to build my knowledge and to find resources for the class	18	78.3%
Classroom activities (for self or students)	14	60.9%
Creating lesson plans and classroom materials	5	21.7%
Assign the Internet required homework	1	4.3%
Upload resources onto my website	1	4.3%
All of the above	2	8.7%

Table 3.5 shows a list of software that participants usually used for their classes. The most frequently used software identified by 20 participants (87.0%) was Microsoft Office such as Word, PowerPoint, and Excel. They also used Microsoft Publisher to make brochures and pamphlets. Ten participants (43.5%) said that they made movies and presentations using tools such as iMovie, iPhoto, Admoto, Prezi, Keynote, Movie Maker, Photo Story, Sliderocket, and so on. Five participants (21.7%) mentioned that they used Google Docs and GIS/mapping tools such as Google Earth.

Table 3.5. Participants' Responses to Software Usage for the Class

	Times Responded	As % of Total Respondents
MS Office	20	87.0%
Various presentational tools	10	43.5%
Google Docs	5	21.7%
GIS/Mapping applications	5	21.7%
SMART Board	3	13.0%
Dropbox	2	8.7%
Others (3 different responses identified by 3 participants)		

For their classes, participants wanted to improve various computing skills (Table 3.6). Twelve participants (52.2%) wanted to improve information retrieval skills—knowing what information is out there, which information is most up-to-date, and how to find the information they wanted to know. Those participants thought that they "did not know what [they] did not know" (ID #8). They wanted "to be a person who knows what is out there" (ID #5), and how to use it. Eight participants (34.8%) mentioned that they wanted to learn GIS and mapping tools.

Some of them used Google Earth, but they just used basic functions such as search location, zoom in-out, and fly-by and wanted to get the benefits of using Google Earth tools for educational purposes. Also, they wanted to learn about GIS technologies and wanted to know what kinds of GIS tools were available for the classroom.

Table 3.6. Participants' Identified Types of Computer Skills to Improve for the Class

	Times Responded	As % of Total Respondents
Information retrieval (knowing what's out there)	12	52.2%
GIS/mapping tools	8	34.8%
General computing skills (including trouble-shooting)	4	17.4%
Google Docs	3	13.0%
Ways to make students to think/understand better and become better researcher	2	8.7%
Creating interactive webpages	2	8.7%
Excel (advanced functions)	2	8.7%
Various presentational tools for students	2	8.7%
Others (6 different responses identified by 6 participants)		

Four participants mentioned that they wanted to improve their general computing skills, including trouble-shooting. Therefore, if something happened, they would know how to deal with and solve the issue without being scared and asking computer teachers and/or technicians. Three participants wanted to learn how to use Google Docs. They said that it was useful because it was available to share with others and could be saved over the cloud. Therefore, students would not need to bring their own flash drives to save their assignments.

3.1.3 Background and Experience as an ICT User

Except two participants, 21 participants identified themselves as intermediate users of ICT (Figure 3.2). No one identified as an expert user. Five participants (21.7%) said that they were high-end intermediate because they could quickly learn new things about ICT by themselves. These 5 participants were mostly in their 20s to 30s. Fifteen participants (65.2%) identified themselves as intermediate users and knew how to use a computer in general. Also, 1 participant identified as a low-end intermediate user, and 2 participants said that they were novice users. Once participants knew how to use basic functions of a computer such as using the Internet and Microsoft Office, they tended to rate themselves as an intermediate user. Also, some participants, who I would have judged to be advanced or experts, still rated themselves as intermediate users. They compared themselves to IT professionals like computer programmers and judged their own skills as intermediate. For this reason, there was a very large range of skill levels represented in the intermediate level.

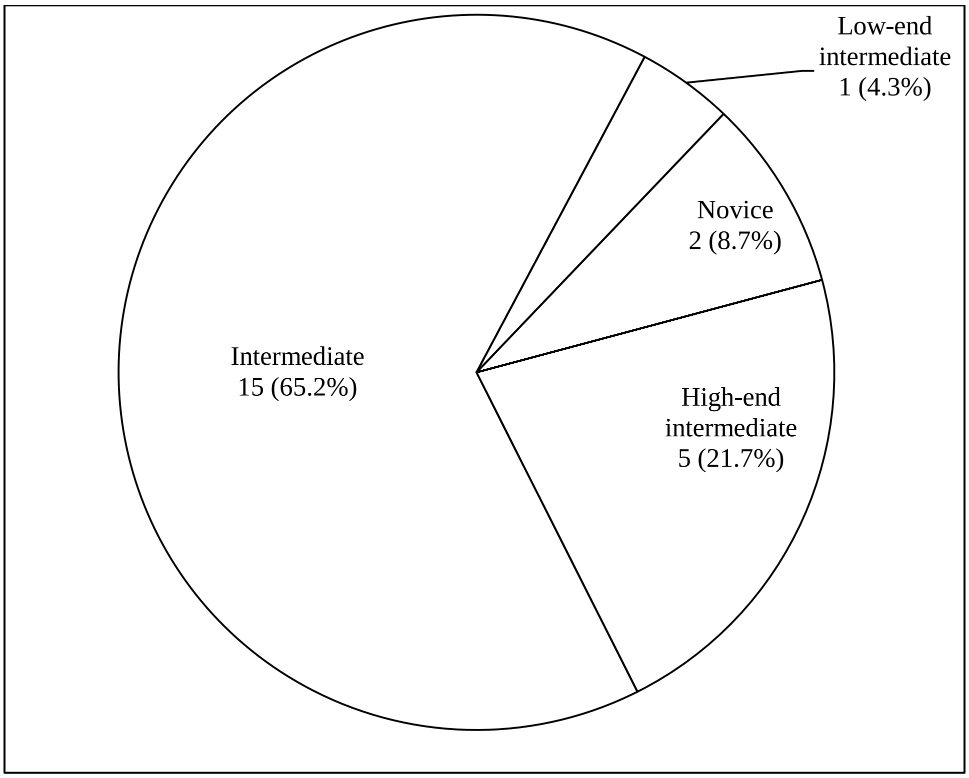


Figure 3.2. Participants' level of proficiency with ICT

Figure 3.3 shows participants' weekly and daily usage of ICT. Except for 1 participant, who used ICT 5 to 6 days a week, the rest of the participants (22 participants (95.7%)) said that they used ICT every day, including weekends. In the case of daily usage of ICT, 2 participants used ICT mostly during planning periods (0 to 2 hours), and 6 participants (26.1%) used ICT for 2 to 4 hours a day. Five participants (21.7%) mentioned that they used ICT for 4 to 6 hours a day, and other 5 participants used ICT for 6 to 8 hours.

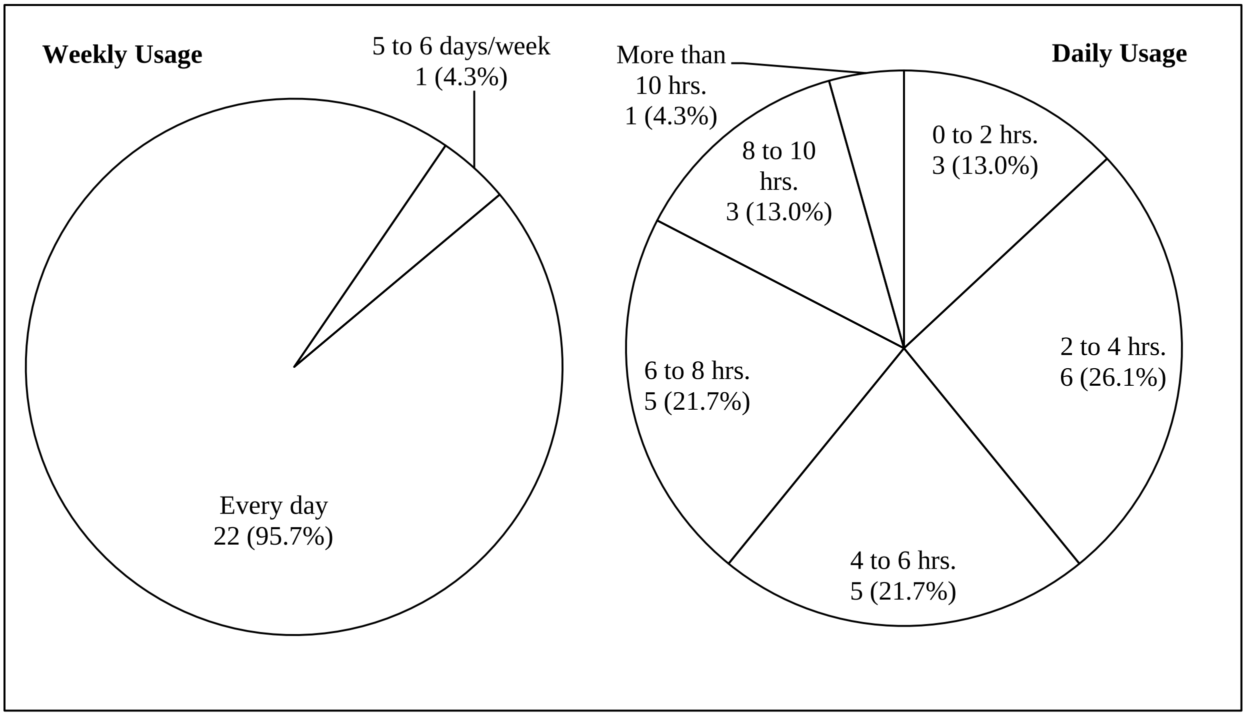


Figure 3.3. Participants' weekly and daily ICT usage

Apart from teaching, participants used ICT for diverse personal activities (Table 3.7). The two most frequent activities were checking emails (20 participants (87.0%)) and web surfing (18 participants (78.3%)). The next three identified activities were watching movies, television, and sports using the Internet (11 participants (47.8%)), social networking, such as Facebook and Twitter (10 participants (43.5%)), and doing office work (9 participants (39.1%)).

Table 3.7. Participants' Types of Personal Activities using ICT

	Times Responded	As % of Total Respondents
Email	20	87.0%
Web surfing	18	78.3%
Watching movies/TVs/Sports	11	47.8%
Social networking	10	43.5%
Office work	9	39.1%
Playing games	2	8.7%
Contacting people	2	8.7%
Creating videos	1	4.3%

Of the 23 participants, 9 (39.1%) had experience creating websites (Figure 3.4). Of these, 7 created websites using templates and 2 designed using HTML. Only one of the 9 participants with website development experience had advanced programming experience. Another 4 participants rated themselves as beginners in programming, although 3 had taken introductory programming courses in high school or college. They said that they were able to customize programming scripts.

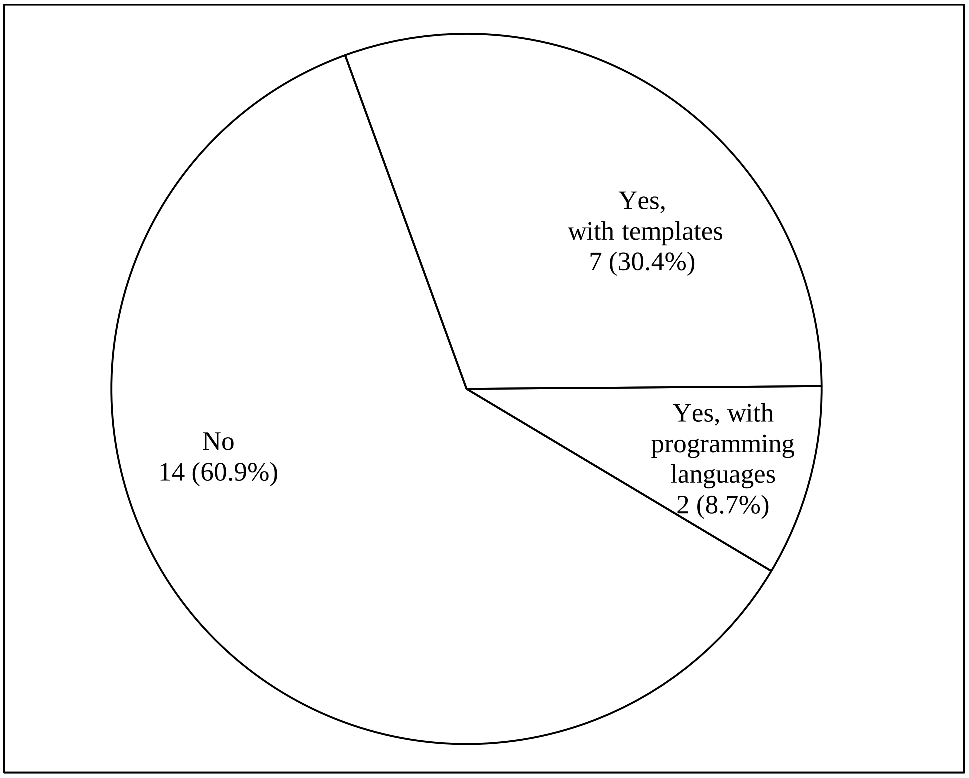


Figure 3.4. Participants' website development experience and programing levels used for developing website

3.2 Attitude towards ICT

Apart from 1 participant, all the rest reported that they enjoyed working with ICT. They valued the ability to learn, teach, and share information with ICT (10 participants (43.5%)), its speed (8 participants (34.8%)), and the wealth of information available (5 participants (21.7%)) (Table 3.8). Participants liked ICT for effective instructional tools and as a resource bank for their teaching. They said that they could learn and teach new knowledge quickly with its multimedia functionality. Also, they could find useful resources and information for their classrooms rapidly and discover various ways to teach course materials to students through ICT.

Also, some participants mentioned that both they and their students had used ICT since they were young and, as a consequence, that using ICT was a familiar way of learning new knowledge.

Table 3.8. Participants' Attitudes of Working with ICT

Attitudes	Reasons	Times Responded	As % of Total Respondents
Enjoying 22 (95.7%)	Powerful availability	10	43.5%
	Fast accessibility	8	34.8%
	Wealth of information	5	21.7%
	How I and/or students have been raised	4	17.4%
	Fun and engaging	4	17.4%
	Automatic and efficient	4	17.4%
	Interactive	2	8.7%
	Current trend	1	4.3%
Not enjoying 1 (4.3%)	Not comfortable	1	4.3%

Although many participants enjoyed working with ICT, some teachers mentioned that "not all good teaching includes the use of ICT" (ID #10). In other words, depending on the topic or unit being taught, ICT might not help teaching and learning. As one person remarked, ICT "should be used at the right times and for the right reasons to enhance the lesson or the learning" (ID #10). However, many participants believed that the advantages of using ICT as an educational tool compensated for the disadvantages.

Ten participants (43.5%) identified incorporating more ICT in their classrooms as one of the major areas to improve or change in their daily teaching (Table 3.9). Participants wanted to learn new ways of using ICT to teach classroom materials to their students through this research and this seemed to be the main reason they wished to participate in this research project.

Table 3.9. Participants' Identified Areas to Improve or Change in Daily Teaching

	Times Responded	As % of Total Respondents
Incorporate technology including GIS	10	43.5%
Differentiation	3	13.0%
Develop new classroom materials	3	13.0%
Know current events	2	8.7%
Increase student engagement	2	8.7%
Make better technology accessibility at schools	2	8.7%
Others (7 different responses identified by 7 participants)		

3.2.1 Reasons to Learn and Use ICT

Table 3.10 shows various factors to motivate participants to learn ICT. The major motivation for learning ICT was that teachers felt it was a current trend (12 participants (52.2%)). Participants were also motivated to learn ICT out of personal interest (8 participants (34.8%)) and for their careers (7 participants (30.4%)). In addition, they believed that using ICT would give benefits to their students (4 participants).

Table 3.10. Participants' Motivation to Learn ICT

	Times Responded	As % of Total Respondents
Current trend	12	52.2%
Personal interests	8	34.8%
For my career	7	30.4%
Benefits to students	4	17.4%
Due to school districts	1	4.3%

3.3 Major Barriers to Using ICT

Participants identified various barriers to implementing ICT in their classrooms (Table 3.11). The barriers fall into four categories—economic/social issues (15 participants (65.2%)), lack of teacher background or time (10 participants (43.4%)), technological issues (8 participants (34.7%)), and additional issues (4 participants (17.4%)).

Table 3.11. Participants' Identified Barriers to Limit Using ICT in the Classroom

		Times Responded	As % of Total Respondents
Economic/Social issues 15 (65.2%)	Low availability	14	60.9%
	Costs of software	1	4.3%
Teacher related issues 10 (43.4%)	Lack of my knowledge	7	30.4%
	Lack of my time	3	13.0%
Technological issues 8 (34.7%)	Unreliability	5	21.7%
	Long set-up time	3	13.0%
Additional issues 4 (17.4%)	No technical support	2	8.7%
	Huge gaps of students' level	2	8.7%

3.3.1 Barriers due to Economic and Social Issues

Among economic and social barriers, the most commonly identified was low availability of ICT (14 participants (60.9%) in Table 3.11), which is directly related to the digital divide issue in education. The digital divide refers to differences between who uses, has access to, and has knowledge of ICT and who does not, and it has been considered significantly in education since the late 20th century (Hargittai 2002). Based on the interviews for the user needs analysis, ICT are still not available every day for every student in the U.S. classroom. Many teachers seemed to suggest that the digital divide starts in the classroom (ID #3). Some schools have computers for every student, but other schools have only a few numbers of computers. Some teachers said that they had computer labs and laptop carts to be used for classroom purposes. However, there were limited quantities of computing facilities at their schools, so teachers needed to share with other classrooms. "There is always high demand" (ID #13), so "teachers need to fight to use [computers]" (ID #15). If teachers wanted to use computers, they needed to sign up in advance. Therefore, "it's difficult to have lessons with ICT every day" (ID #13), and teachers "can't count on always having computers" (ID #3). If they had computers in the classroom, they might use them more often.

3.3.2 Barriers Relating to Teacher Background, Confidence, and Time

Barriers involving teacher background were of two types. The first type is teachers' lack of knowledge about and comfort with ICT (7 participants (30.4%) in Table 3.11). Teachers, who do not have enough background and experience with ICT are not comfortable using ICT with students because they "don't want to mess up with computers" (ID #5) in front of students. Therefore, teachers are "hesitant [and reluctant] to use ICT" (ID #5) in the classroom. In other words, less experienced teachers with ICT have anxiety and confidence issues in terms of incorporating ICT as instructional tools. Because of this reason, one participant mentioned, "I think the biggest barrier [against using ICT in the classroom frequently] is me. If I knew better, I could advocate what I need. And a technological barrier is still me. If I understood what I was doing more, I would be able to advocate better. I think the district will support me if I said I need this, this and this, but I don't know enough to do [it]" (ID #1).

Participants said that they did not want to and would not use any types of teaching or learning tools with students unless they had full confidence in their ability to use the tool effectively. Participants felt they should learn the tools before bringing them to the classroom. Teachers would like to use only "foolproof and guaranteed" (ID #8) tools and materials with students. Some teachers said that they were scared and sometimes "it's too intimidating" (ID #8) that something would go wrong when they used ICT in the classroom. Once they failed the trial, they "got frustrated" (ID #23), and did not want to try anymore. Also, to prepare for a possible failed situation, they always needed to have a back-up plan, which required double the amount of preparation time.

The other type of teacher issue is the lack of their time to learn and practice technology (3 participants in Table 3.11). Most participants mentioned that they were busy during school hours teaching and preparing classes. When participants went back home, they had their own lives, such as taking care of their own children, enjoying their hobbies, or cleaning house. There are some motivated teachers who eagerly invest their time to learn and test ICT for their students.

However, in general, many teachers do not have enough time, and do not want to spend their personal time to learn and practice ICT.

3.3.3 Technological Issues

Several technological issues were identified as barriers. The first was the unreliability of the technology (5 participants (21.7%) in Table 3.11) in that sometimes a network server goes down unexpectedly or a website freezes. When this happens, many teachers who are novice ICT users are scared and do not know how to solve the above technical issues.

The second identified issue in this category is long set-up time (3 participants in Table 3.11). Compared to traditional textbooks or paper maps, using ICT takes more time to start class, and there are a lot of things to be controlled. For example, all computers should be turned on, software or websites should be accessible, and all computing hardware and software should be turned off when a class is done. Also, teachers need to check availability and accessibility of every machine before class. Therefore, a certain amount of class time is used for setting up to use ICT, but many teachers do not like spending class time to set up ICT.

3.3.4 Additional Barriers

There were two important barriers that did not belong to the above three categories—the lack of helpful technical support, especially from the IT department at school (2 participants in Table 3.11) and huge disparity in students' level of technological background (2 participants in Table 3.11). Two participants said they had an IT department at their schools, but the main task of the IT department was mostly checking machines and installing hardware/software. According to these participants, their IT staff did not know instructional tools specifically. Once a teacher "requests specifically [a certain tool that he or she] wants to implement in the classroom" (ID #1), the IT staff might help the teacher to find and use the tool. However, they said that, most of time, teachers do not know about appropriate teaching tools. Because IT people were "not educators" (ID #1), they have a lack of knowledge about instructional technologies. "If [teachers] ask [IT people] which software [teachers] need to use to teach a certain topic to students, [IT people] have no clue" (ID #1). Therefore, IT people "wouldn't help [teachers] to figure out which technologies [teachers] can use" (ID #1).

Another identified additional barrier is the disparity in students' levels of ICT knowledge and experience. These days, some students have advanced levels of ICT knowledge and experience. Generally, those students with high levels of ICT have had more time to be exposed to ICT since they were young, and/or they have been interested in ICT personally more than other students with low levels of ICT experience. For advanced students, ICT that teachers use in the classroom might be easy, and sometimes those students might know how to use and manage ICT better than teachers. However, less experienced students with ICT might have difficulty following the teachers' instruction. In order to make students engage in the classroom activities using ICT regardless of their experience levels, teachers need to determine the right level of differentiation using ICT for all students, to provide advanced tasks for more experienced students, and to spend extra time for less experienced students.

3.4 GIS Teacher Training

From the interviews with participants, I found out that a lack of teacher training in GIS was a fundamental reason to obstruct teacher adoption of GIS technologies in the classroom. Among 23 participants, only 9 participants (39.1%) had been exposed to GIS before (Table 3.12). Among them, 5 participants (21.7%) learned GIS by taking teacher training workshops, but these were one-time events. Also, some GIS teacher workshops were not intended for teaching how to use GIS technologies. Rather, the workshops had a purpose to introduce basic information about GIS technologies to teachers. One participant "attended a [GIS] workshop, [but only obtained] a list of websites about GIS" (ID #21). It is difficult to learn how to use GIS technologies by taking those workshops. Once some teachers took the workshops, they thought they knew how to implement GIS technologies. However, after a while, teachers forgot how to use GIS technologies, and they had no one to ask further questions to.

Table 3.12. Participants' Experience of Learning GIS

	Learning sources	Times Responded	As % of Total Respondents
Yes 9 (39.1%)	Workshops	5	21.7%
	A GIS course at college	3	13.0%
	An introductory geography course at college	2	8.7%
	Experiences from working	1	4.3%
No 14 (60.9%)			

Also, 3 participants took an introductory GIS or mapping course when they attended a college. Among them, 1 participant in her late 40s took a mapping course when she was at a college in the early 1990s. However, the current versions of GIS technologies were not yet introduced at that time, so she drew maps using a paper and a pencil rather than by computer. Two participants had a chance to learn about GIS technologies when they took an introductory geography course at a college. However, GIS was only one of the course topics, so an instructor only briefly explained basic information about GIS technologies. One participant did self-study of GIS when he worked at a company. Out of 9 participants who had learned about GIS, only 1 participant had taken a current, semester-long GIS course. Of the 9 participants that had some exposure to GIS, 8 participants mentioned that they barely remembered what they had learned about GIS. They were aware of GIS but did not know how to use it.

Lack of GIS experience and background seems to be linked to low teacher adoption rate. Among the 23 participants, only 1 had implemented GIS technologies in her classroom (Table 3.13). Nineteen participants (82.6%) mentioned that they did not use GIS technologies in the classroom because they did not know about it. They did not know how to use GIS technologies, or of course, how to create lesson plans with GIS technologies. Also, they did not know what kinds of GIS software/applications were appropriate and applicable for educational settings.

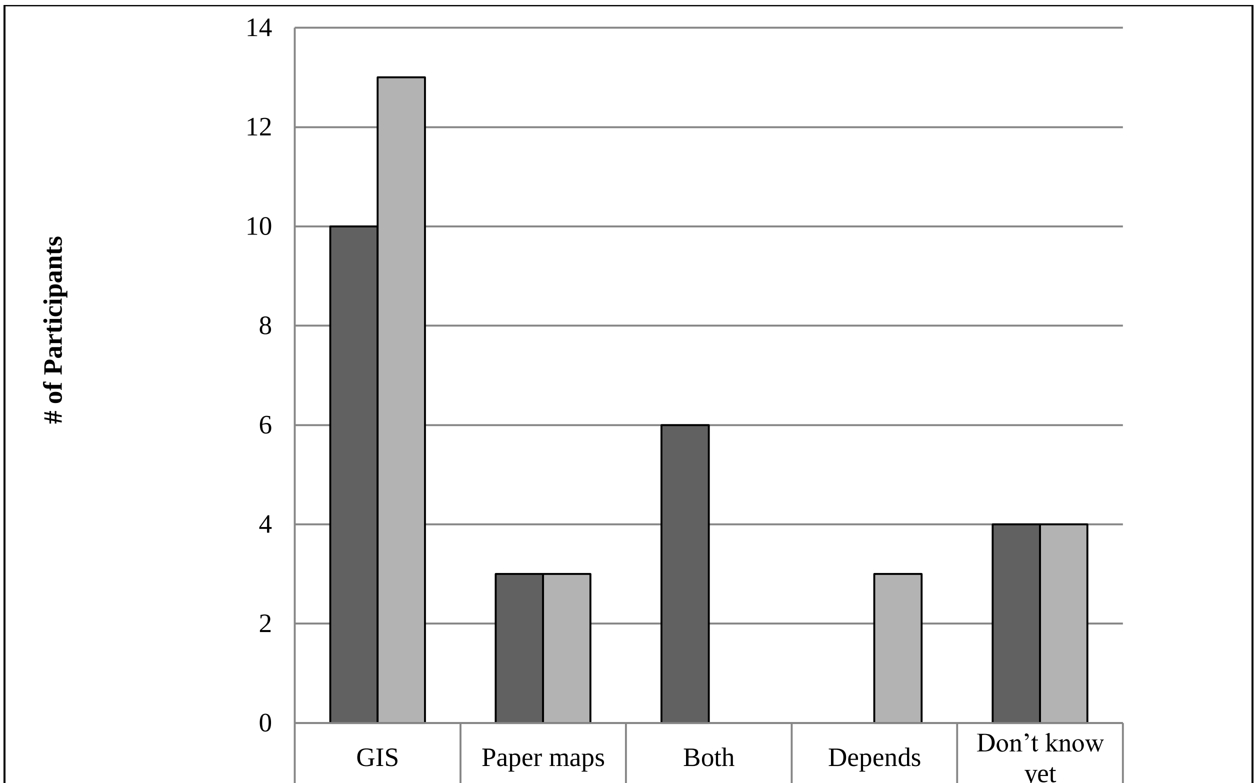
Teachers who do not have GIS knowledge and experience are not aware of how to start using GIS technologies with students. Even they do not think that GIS can be used as an instructional tool: they "haven't thought about using it in the classroom" (ID #7). However, some participants mentioned that they would "figure it out once [they] get experience [with GIS]" (ID #6).

Table 3.13. Participants' Experience on GIS Implementation in the Classroom

	Reasons	Times Responded	As % of Total Respondents
No 22 (95.7%)	Not knowing about it	19	82.6%
	Limited accessibility to computers	3	13.0%
	Scared and hesitant	2	8.7%
	Expensive software	2	8.7%
Yes 1 (4.3%)			

Even though most participants did not use and know about GIS technologies, they still held positive attitudes toward it (Figure 3.5). Ten participants preferred GIS technologies over paper maps. Those participants believed that GIS might be a better tool than paper maps because students might learn more effectively, and it might help them to prepare class more easily than with paper maps. However, 3 participants preferred paper maps. One of those 3 participants said that she had no choice at this moment, so she had to use paper maps no matter what: "I don't prefer paper maps, but that's what I have, so that's what I use" (ID #2). Also, 1 participant preferred paper maps at this moment, but acknowledged she might change her mind once she learned about GIS technologies later on. Six participants said both; they thought both of them have advantages, and could not be replaced by the other one. Four participants said that they could not answer this question because they did not know about GIS technologies yet. Therefore, they could not compare GIS technologies with paper maps.

For the helpfulness in the classroom question, 13 participants thought that GIS technologies were more helpful than paper maps for the class because "it would be much more visually appealing to students" (ID #11), and GIS technologies "have more options" (ID #14) than paper maps. Three teachers said that paper maps were still more helpful than GIS in the classroom. The reasons were “because of the hardware issue, paper maps might be more useful” (ID #6), and “physical activities with paper maps were helpful to kids” (ID #15). Another participant said that she might change her mind once she knew about GIS and how to implement it in the classroom. Three participants said that it depended on different students’ characteristics and different circumstances. Four participants could not choose one of them because he/she did not know about GIS technologies yet.



	GIS	Paper maps	Both	Depends	Don’t know yet
Preference	10	3	6	0	4
Helpfulness for class	13	3	0	3	4

Figure 3.5. Participants’ responses to personal preference and helpfulness of GIS and paper maps

3.5 Preferred and Non-preferred Training Styles

The most frequent response to the question of the best way to learn ICT was “doing it” (15 participants (65.2%)), such as hands-on activities and trial and error (Table 3.14). Participants mentioned that they were “not able to learn [a new technology] until [they could] do it [themselves]" (ID #7). When participants learned a new technology, they wanted to follow up and test the instruction. Otherwise, they felt they would quickly forget how to use the technology. Many participants liked a trial-and-error approach because they saw it as a way to improve their computing skills. One participant mentioned that "I think [we] really have to get in dirty with [the technology]. The reason [we] don't know how is [we] don't try it" (ID #9). Participants were asked to choose their preferred and non-preferred training styles at the end of the interviews. I selected the top three training styles that many teachers liked and disliked.

Table 3.14. Participants' Identified the Best Ways to Learn ICT

	Times Responded	As % of Total Respondents
Doing it	15	65.2%
Direct instruction	11	47.8%
Follow-up in-person support	3	13.0%
Materials to refer later on	1	4.3%
Step-by-step written instruction	1	4.3%

3.5.1 Top Three Preferred Training Styles

The top three preferred training styles were one-on-one coaching, any types of published lesson plans, and in-service workshops (Table 3.15). Interestingly, all three training styles were in the scope of "doing it." Eleven participants (47.8%) identified one-on-one coaching as their favorite training style. They liked one-on-one coaching because "everyone has different pace" (ID #16). With one-on-one coaching, participants could learn new knowledge at their own pace. According to participants, if someone is a fast learner, he or she does not need to wait for others to catch up, or vice versa. If a teacher's school has only a few computers, the teacher could ask a coach how to use ICT in his or her school environment, which "makes better sense to [teachers]" (ID #15). One participant wanted to have a coach "who [can] go over and over again until [the participant] get[s] it" (ID #15). Another participant mentioned that "I need to be coached while I'm learning it cause sometime there's the slightest a little thing you don't get. It doesn't take a long if I'm coached during" (ID #6). However, the participants who liked one-on-one coaching realized that in reality, one-on-one coaching was not always feasible.

Table 3.15. Participants' Preferred Training Styles

		Times Responded	As % of Total Respondents
One-on-One coaching		11	47.8%
Any types of published lesson plans/manuals/books/tutorials		7	30.4%
In-service workshops		5	21.7%
In-district professional development (excluding a workshop type)		4	17.4%
Anything		4	17.4%
Direct instruction	With small number of people	4	17.4%
	With having time to practice at home	4	17.4%
	Meeting regularly (sequential learning)	4	17.4%
	With in-service credits/hours	3	13.0%
	With hands-on activities	3	13.0%
	With many people	1	4.3%
	Without hands on activities (lecture type)	1	4.3%
	With back-up support	1	4.3%
Any digital materials		2	8.7%
Customizable templates		1	4.3%

The second most popular training type was using published lesson plans. Seven participants (30.4%) liked to learn new knowledge with any types of published lesson plans, including manuals, books, and tutorials. They liked this because they could learn anytime and anywhere based on their availability. This response was common among the younger participants (in their 20s and 30s) who identified themselves as fast learners with an existing level of background in ICT.

The third preferred form of training style was in-service workshops. Five participants (21.7% of the participants) liked in-service workshops because they could learn, share, and discuss their work with other teachers. A further reason they liked it was because they could obtain professional development credit hours when they attended the workshops.

3.5.2 Top Three Non-preferred Training Styles

I also asked participants to identify training styles that they did not like. The top three non-preferred styles are lectures without hands-on activities, in-district professional development, and any type of published lesson plan (Table 3.16).

Table 3.16. Participants' Non-preferred Training Styles

		Times Responded	As % of Total Respondents
Nothing (Liked all)		7	30.4%
Direct instruction	Without hands on activities (lecture type)	4	17.4%
	With many people	2	8.7%
	With hands-on activities at the same time	1	4.3%
	Without back-up support	1	4.3%
In-district professional development (excluding a workshop type)		3	13.0%
Any types of published lesson plans/manuals/books/tutorials		3	13.0%
Any digital materials		2	8.7%
Any paper materials		2	8.7%
One-on-One coaching		1	4.3%
In-service workshops		1	4.3%

The participants who disliked lecture-style training felt that they would forget what they learned if they did not have an opportunity to try the techniques during the training session. Three participants who did not like in-district professional development felt that such sessions usually mixed together too many teachers with different knowledge levels from too many different settings.

From the results of preferred and non-preferred training styles, I found that the responses seemed to be related to personal preferences regarding learning styles. Kolb's (1984) research suggests that most people have preferences for how they like to learn new concepts and skills. These have been characterized as feeling, watching, thinking, and doing, but they relate to Kolb's idea that learning can arise from concrete experience, reflective observation, abstract conceptualization, and active experimentation. He argues that the most effective learning experiences involve all four organized together into what he terms a "learning cycle." But individuals often prefer to start their learning at one of the four basic styles. Some teachers like to learn by doing activities; some want to learn by watching how others are doing. And, apart from Kolb's ideas, training has to be linked to a teacher's background and level of expertise. If training is intended to introduce basic information of a certain technology, a teacher who has a high level of knowledge about the technology might not need training. Therefore, there is no one training style that every teacher likes, and depending on the situation, teachers prefer different training styles.

3.6 Implications of the User Needs Analysis

The results of the user needs analysis were very helpful in beginning the design and development of the web-based GIS training tutorials for middle school social studies teachers. Through the interviews, I gained some confirmation that web-based GIS technologies would be more suitable to be used in the middle school classroom than desktop GIS software because it was free, required no installation, and had an easy-to-use interface. Also, from the questions regarding participants' preferred and non-preferred training types, I decided to design tutorials that would include hands-on activities, step-by-step instruction, and could be used in both digital and printed versions. For teachers with less experience using ICT and GIS technologies, I decided to provide additional information as much detail as possible. The goal of designing training tutorials was helping teachers follow the instruction without having to rely on an instructor or some type of technical support. In other words, I wanted teachers to learn how to use, customize, or create classroom materials with web-based GIS technologies by themselves through my tutorials.

3.6.1 Online Mapping Applications and Tools Selection

When participants were asked about usage of online mapping applications such as Google Earth, 14 participants (60.9%) responded that they used these applications in the classroom. Figure 3.6 shows usage of online mapping applications. Nine participants (39.1%) said that they did not use any online mapping applications. Six participants (26.1%) used 2 to 4 times per year, and other 6 participants (26.1%) used 6 to 8 times per year. Fourteen participants implemented online mapping applications for various course topics, such as religious sites, types of maps and map making skills, movement, conflicts, and so on. Eleven participants used online mapping applications to find and show locations and places to students. They did not use many of the mapping tools offered by the applications such as adding push pins, time change, fly-by, measuring, and drawing a boundary.

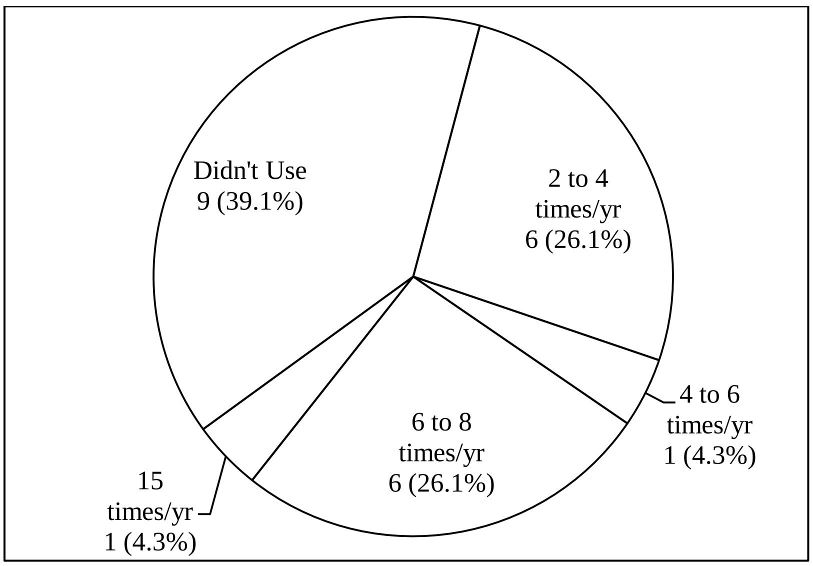


Figure 3.6. Participants' responses to usage of online mapping applications

Therefore, I also decided to provide instruction how to use various mapping tools available in the applications, so that teachers could have the ability to choose the most appropriate mapping tool for classroom activities. From one of the interview questions, 17 participants (73.9%) wanted to learn both basic and advanced mapping tools, all of which I tried to include in the tutorials.

3.6.2 Training Format Selection

Participants were also asked about types of resources that helped them to develop lesson plans (Table 3.17). Eight participants (34.8%) responded that websites or software were suitable as long as they could be customized based on their needs. On the other hand, three participants wanted to have ready-made lessons or activities for all course topics because they did not want to spend too much time preparing lesson plans. Based on the above results, I decided one format for the training—mainly tutorials with step-by-step instruction of how to create and customize lesson plans, but also providing ready-to-use examples.

Table 3.17. Types of Resources that Participants Wanted to Have

	Times Responded	As % of Total Respondents
Customizable mapping resources	8	34.8%
Training/support	4	17.4%
Other teachers' lesson plans	3	13.0%
Ready-made lessons/activities for each unit	3	13.0%
Anything	2	8.7%
Others (3 different responses identified by 3 participants)		

3.6.3 Topic Selection

One of the questions that I asked participants was what kinds of course topics they wanted to develop with GIS technologies. Participants responded with a variety of suggestions (Table 3.18). For each grade level, the three most popular topics were used (Table 3.19). These course topics followed the Colorado state curriculum. In Colorado, the 6th grade students learn about the Western Hemisphere, North and South America (except the U.S.) as a social studies curriculum, and the 7th grade students learn about the Eastern Hemisphere, all continents except North and South America. In the 8th grade, students learn about the U.S. History as a social studies curriculum.

Table 3.18. Topics that Participants Wanted to Develop with GIS Technologies

6^{th} Grade	Times Responded	7^{th} Grade	Times Responded	8^{th} Grade	Times Responded
Migration (Mexico to US)	3	Ancient Civilization	5	Westward Expansion	4
Deforestation in Amazon	2	Distributions of natural resources	4	The Civil War	3
All units are applicable	2	Human-environment interaction	2	Early Migration	3
Any type of disaster	1	All units are applicable	2	Native Americans	2
Various landforms	1	Current events in the Eastern Hemisphere	2	American Revolution	2
Latitude and longitude	1	Population density in Japan	1	Lewis and Clark Expedition	2
Others	4	Others	9	Others	6

Table 3.19. The Selected Topics for the Training Tutorials

6^{th} grade (Western Hemisphere)	7^{th} grade (Eastern Hemisphere)	8^{th} grade (U.S. History)
Deforestation in the Amazon Rainforest	Ancient Greece and Rome	Westward Expansion of the U.S.
Immigration to the U.S.	Natural Resources	The Civil War
Natural Disasters in America	Human-Environmental Interaction	Native Americans

CHAPTER IV

TUTORIAL DEVELOPMENT

This chapter presents the results of the second part of the method, tutorial development. Twenty-three teachers participated in this step from July 28th to October 28th, 2011. For this part of the study, I used a think-aloud protocol; participants were asked to test a draft version of one topic's tutorial and to comment and raise questions as they went along. I observed how participants completed the task while taking notes but did not make an audio recording because many of the comments involved tasks and graphics on the screen. Their feedback was very useful, and I redesigned the tutorials extensively in response to the suggestions made by the teachers. The detailed procedures of the tutorial development step are described in Figure 4.1.

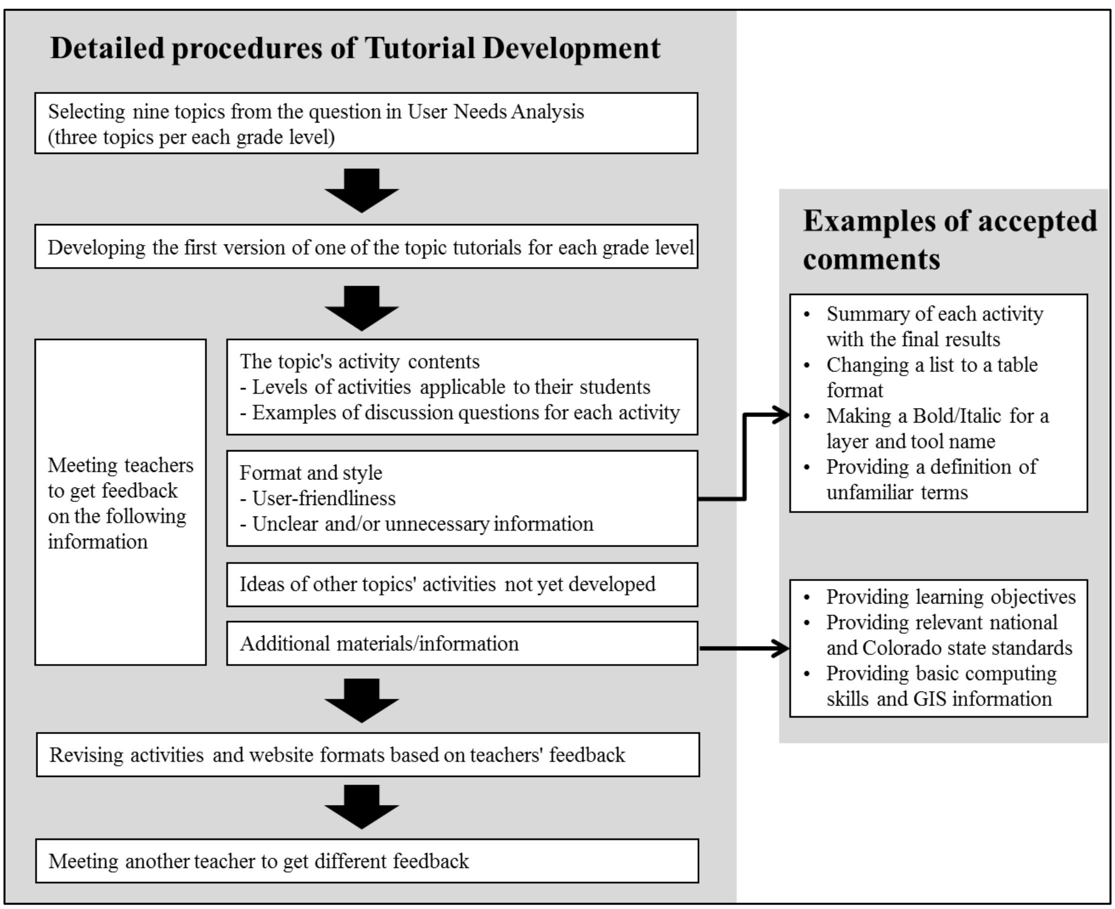


Figure 4.1. Detailed procedures of the tutorial development step and examples of accepted participants' comments

Participants' suggestions can be divided into three categories—tutorial activity content, technical support, and additional suggestions. Detailed description of each category will be introduced in this section.

4.1 Tutorial Activity Content

The tutorial activity content has four sub-categories—revising content, suggesting new content, adding discussion questions, and revising terms.

4.1.1 Content Revisions

I made three major content revisions based on the suggestions of participants. The first involved questioning the certainty of one of the steps in the third activity of the *Deforestation in the Amazon Rainforest* topic. The learning objective of this activity was finding evidence of factors contributing to deforestation. In step 5, I provided an image that showed evidence of deforestation due to cattle ranching in Rondonia, Brazil. However, a participant (ID #18) questioned the image; she mentioned that cattle ranching might not be the cause of the appearance of the landscape. In order to find reliable evidence of deforestation due to cattle ranching, I contacted the researcher, Trent Biggs, whose study area was the Amazon Rainforest. He sent an article that included the latitude and longitude location (10°30' S, 62°30' W) of a large cattle ranch that had landscape that were caused by cattle ranching. The above image of the Figure 4.2 is the original location, and the below image is the correct location of the evidence in Rondonia, Brazil.

Figure 4.2. The original location (above) and the correct location (below) of the cattle ranch in Rondonia, Brazil

The second example of content revision was providing an efficient way of drawing Alexander's campaign of conquest across the ancient world, the second activity in the *Ancient Greece and Rome* topic. The original step was drawing the conquest course followed by a given reference map. However, a participant (ID #1) suggested providing a list of major cities of Alexander's empire on the tutorials and then asking teachers to mark these cities on a map as a point feature. The next step was drawing the line on the map to connect the cities in order. Compared to the original method, the suggested technique made the final map easier to understand and allowed teachers and students to be aware of the major cities at that time. See Figure 4.3: the above map created with the original method, and the below map created with the suggested method.

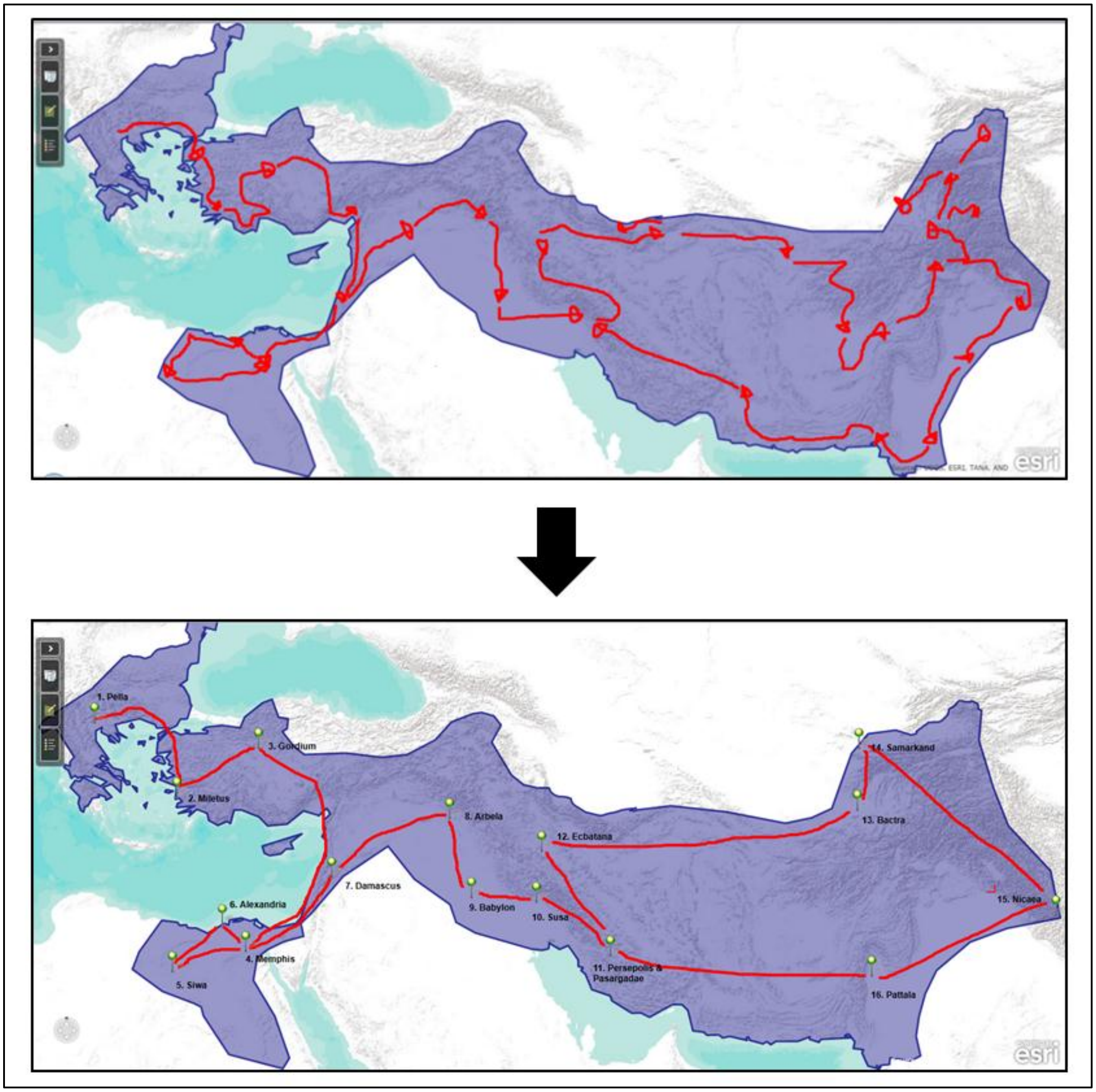


Figure 4.3. Drawing a map of Alexander's conquest of the ancient world the reference map (above) and locations of major cities (below)

The third suggestion was of creating a choropleth map of the percentage of the slave population in the second activity of *The Civil War* topic. I originally had teachers create a choropleth showing the total number of the slaves in each state in 1860. In testing the activity, a participant (ID #10) suggested creating a map to show the percentage of the slave population compared to the total population instead. She mentioned that a map of the percentage of the slave population made more sense to understand the distribution of the slave population in the 1860s and to compare proportions of the slave population among different states. Figure 4.4 is an original map with a total number of the slave population, and the below image is the revised map with the percentage of the slave population in the 1860s.

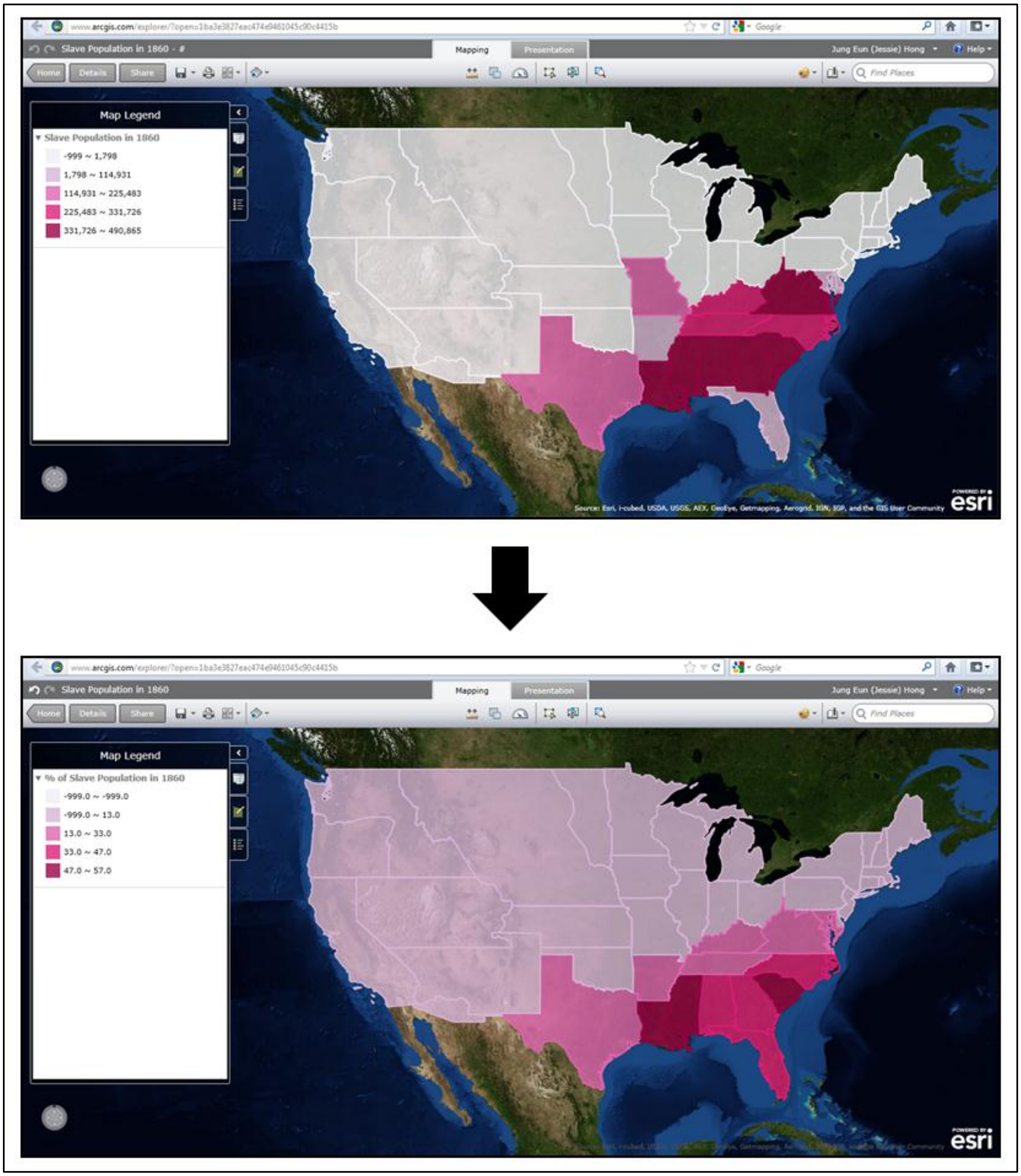


Figure 4.4. Creating a choropleth map with a total number (above) and the percentage (below) of the slave population

4.1.2 New Content Suggestions

In addition to asking participants to provide feedback on the existing tutorials, I also asked them to suggest teaching ideas, classroom activities, and materials for new content for training tutorials that were not yet developed. As I mentioned in Chapter 2, I believed that more teachers would learn the tutorials and use them in the classroom if the content of training tutorials were matched to actual teaching contexts. In this section, I consider some of these suggestions.

One of the tutorial topics for the 6th grade is *Immigration to the U.S.* One participant (ID #8) provided various ideas of what she usually covered in this course topic. She mentioned that she always started from the idea that we were all immigrants to the U.S. except Native Americans, and she made a connection to past immigration history such as immigrants from Western Europe in the 17th and 18th centuries. Then she talked about the reasons to make people move in terms of pull and push factors. Next, she introduced two opposite concepts—legal vs. illegal immigration, and focused on today's illegal Mexican immigration. She then discussed the advantages and disadvantages of illegal Mexican immigrants based on the U.S. government's perspective, and also made students think about issues facing Mexico as a country losing some of its population to emigration. Her suggestions helped develop and construct three activities in this topic. The final three activities in this topic were about early immigration, major sources of legal and illegal immigration to the U.S., and the foreign-born population in the U.S.

For the 7th grade, a few of the participants suggested detailed ideas in the *Natural Resources* and *Human-Environmental Interaction* topics. For the *Natural Resources* topic, one participant (ID #9) suggested various teaching ideas such as comparing major oil producing versus consuming countries, identifying OPEC countries, comparing geographical distributions of renewable and non-renewable energy sources, and analyzing GNP and GDP of major oil producing countries to understand that there are some rich countries producing oil, but not all of the major oil producing countries are rich. I accepted most of these suggestions to develop three activities in this topic. Also, one participant (ID #1) requested an activity about the distribution of the Australian population. This participant mentioned that it was not easy to find classroom activities about Australian population density. Therefore, I included one activity on this topic in the *Human-Environmental Interaction* tutorial connecting Australian population distribution and climate zones.

For the 8th grade topics, participants provided valuable teaching ideas and classroom activities. Three participants discussed the topics they usually taught students in the *Westward Expansion of the U.S.* topic, and two (ID #13 and #18) mentioned that understanding the border lines of each territory and their position with respect to Canada and Mexico were important factors in understanding this topic. I addressed their suggestions in the first activity, “Territories.” One participant (ID #13) commented that understanding what happened in each territory was important, but knowing why and how was also significant. He suggested introducing reasons why each territory was added to the U.S. by marking important locations in each territory; this became part of the second activity, “Important Locations.” For the third activity, “Statehood,” one participant (ID #14) suggested that knowing when each state entered the union was important, so I developed the activity to help students understand this concept.

In the case of *The Civil War* topic, one of the participants (ID #10) helped create the second activity “Major Products of North and South in 1820 to 1860.” The aim was to make a map of major products and resources so students could compare the North and South in terms of the economic value of the slavery system in the South. For the *Native Americans* topic, one participant (ID #2) suggested focusing on the displacement of Native Americans and, in particular, the Cherokee nation's Trail of Tears. Also, she suggested including two reservations in Colorado—Ute Mountain and Southern Ute—to allow students to connect the context to their lives in Colorado. There were some suggestions that were not used, but most suggestions were adopted to develop training tutorials.

4.1.3 Discussion Questions

One participant (ID #8) suggested adding discussion questions for each activity. This participant said that some teachers might develop good questions on their own, but others might have difficultly. Therefore, I provided several discussion questions for each activity. Some questions can be answered directly from the activity, but others require additional research and knowledge to answer.

In order to offer valuable discussion questions, I also asked participants to suggest some questions for each activity. For example, one participant (ID #8) suggested questions in the *Deforestation in the Amazon Rainforest* topic to make students think about the influence of deforestation on the forest, animals, and people in the future. For the "Foreign-born Population in the U.S." activity in the *Immigration to the U.S.* topic, two participants (ID #11 and #25) suggested the question of why some states are not attractive to immigrants. For the "Hurricane Katrina in 2005" activity in the *Natural Disasters in America* topic, a participant (ID #7) suggested a role play question, in which students assume a role at Federal Emergency Management Agency (FEMA) to decide on the areas needing individual and public assistance first, and then have students compare their answers with what FEMA actually did.

One of the participants (ID #29) suggested making students compare and contrast the expansion of Alexander's empire and that of Ancient Rome and think about those causes in the tutorial in *Ancient Greece and Rome* topic. The participant (ID #29) also suggested discussion questions regarding whether renewable energy is cost effective, and if people are getting benefits from using renewable energy for the *Natural Resources* topic. One participant (ID #15) provided many good discussion questions for the "Indian Removal" activity in the *Native Americans* topic. Based on her suggestions, I developed the following discussion questions:

- For the Cherokee, how was the experience of taking the land route different from that of taking the water route?
- What challenges might all tribes have faced on their journeys? What was the climate during the season they traveled? What food and supplies did they have for their journeys?
- If you had been a member of one of these tribes, what would you have chosen to

pack?

- What challenges did the tribes face in the new lands? How did they adjust to this environment and to the other Native Americans who lived there?

Some teachers mentioned that the level of some of the discussion questions was suitable for middle school students, but other questions were too difficult because they involved higher-level thinking (ID #16 and #28). According to the participants, in order to answer these more difficult questions, students would need to understand the context fully, and it would be the teachers' task to provide background information to students. One of the participants (ID #16) liked discussion questions related to students' lives, an approach to authentic learning. This participant believed that students were able to understand concepts well if they could be connected to their lives. Also, one participant (ID #30) mentioned that she taught a language arts class, too, and she thought she could use some of the discussion questions as persuasive writing assignments, for example, "What would we do to stop deforestation?" in the *Deforestation in the Amazon Rainforest* topic.

4.1.4 Terms and Language Revisions

Participants also suggested revising some of the terms of language that I used. For example, in the *Ancient Greece and Rome* topic, before Christ (BC) and Anno Domini (AD) needed to be changed to before the Common Era (BCE) and Common Era (CE) because the previous terms were religious in origin (ID #1). One participant (ID #2) commented that history teachers usually used the terms westward expansion or manifest destiny rather than territorial expansion. She also suggested using Mexican cession rather than Mexican-American War. In addition, one of participants (ID #15) recommended calling Cherokee, Chickasaw, Choctaw, Creek, and Seminole tribes as the Five Civilized Tribes.

Some participants also suggested changes of wording and vocabulary. For instance, one participant (ID #5) recommended using verbs, such as "observe," "compare," and "contrast," in listing the learning outcomes. Also, the participant pointed out that some of discussion prejudged their answers, for example “why do people not use renewable energy?” He suggested writing the questions with a neutral tone, such as “Why is renewable energy being considered, or why do some people advocate renewable energy?”

4.2 Technical Support

While meeting with teachers for the tutorial development step, I realized that other teachers might be confused about how to use the training tutorials if they used the tutorials without my direct support. Therefore, in order to provide clear instruction of how to use the training tutorials, I created a separate webpage to explain the overall steps of using the training tutorials (http://www.colorado.edu/geography/cartpro/gisedu/addtional/start.html). Also, one participant (ID #8) suggested adding a webpage to introduce basic information about web-based geographic information systems (GIS) applications to help teachers prepare for the tutorials. Therefore, I developed a preparation page for each tutorial topic and provided basic steps that teachers could complete in advance of beginning to using the tutorials such as application sign-in, map navigation, and map tool-tip information. I cover these issues in more detail below.

4.2.1 Learning Online Mapping Applications

A majority of participants suggested adding detailed information on how to use online mapping applications, especially ArcGIS Explorer Online. Most participants had experience using Google Earth, but except one participant, no one else had used ArcGIS Explorer Online. Therefore, they asked for step-by-step instruction of how to use ArcGIS Explorer Online.

Also, many participants wanted more information about how to move around a map in ArcGIS Explorer Online. Its navigation style is similar to other online mapping applications, but several participants had difficulty understanding how to zoom in and out and how pan around a map. Also, two participants (ID #1 and #18) did not know how to use a mouse wheel for navigating a map in online mapping applications. Therefore, I added instruction how to navigate using a mouse button and a wheel with the screen captured image (Figure 4.5).

3. The navigator is at the bottom left of the map. Once you move your mouse cursor over the navigator, you can see it. With the navigator, you can zoom in and out, pan, get coordinates, and see the whole map with "Full extent." If your mouse has a wheel, you can use the wheel to zoom in (scrolling up) and out (scrolling down).

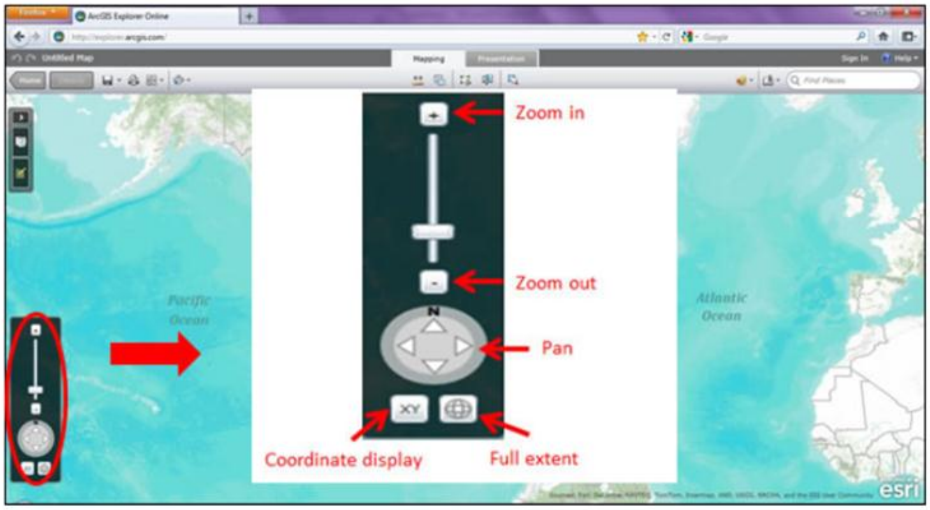


Figure 4.5. Instruction for navigating a map with a mouse button and a wheel

In addition, a few of the participants (ID #5 and #25) wanted to know how to add legend information on a map in ArcGIS Explorer Online. There is the map legend function in ArcGIS Explorer Online, but it does not update automatically when users add new features. The user needs to be told to create a new legend by adding a text box and a rectangle. For this reason, I created an additional webpage (http://www.colorado.edu/geography/cartpro/gisedu/addtional/legend.html) with step-by-step detailed instruction (Figure 4.6).

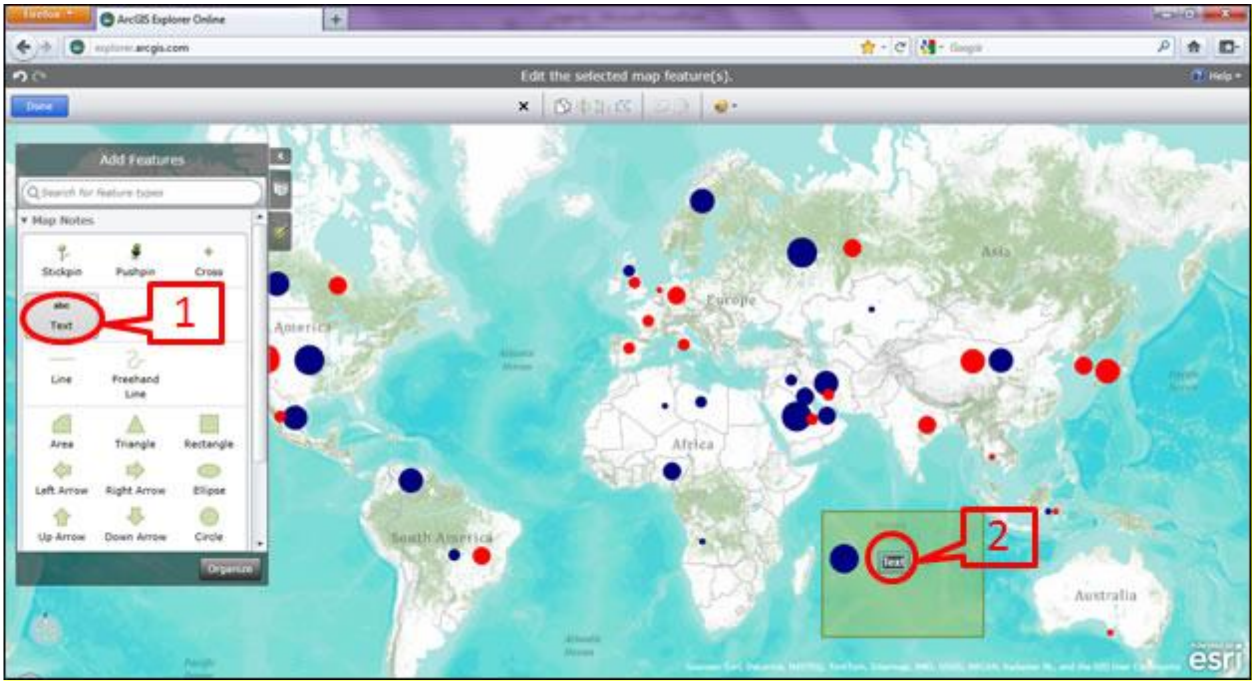


Figure 4.6. Instruction for creating a legend

Additionally, participants suggested adding information about how to use the measurement and dashboard tools. One of the participants (ID #9) had experience with ArcGIS Explorer Online, and she mentioned that other teachers might find the measurement tool useful to explain an approximate size of Alexander the Great's empire to students. Also, another participant (ID #4) recommended adding information on how to use the dashboard tool. Based on the participants' suggestions, I included extra steps to explain how to use the measurement and dashboard (Figure 4.7) tools.

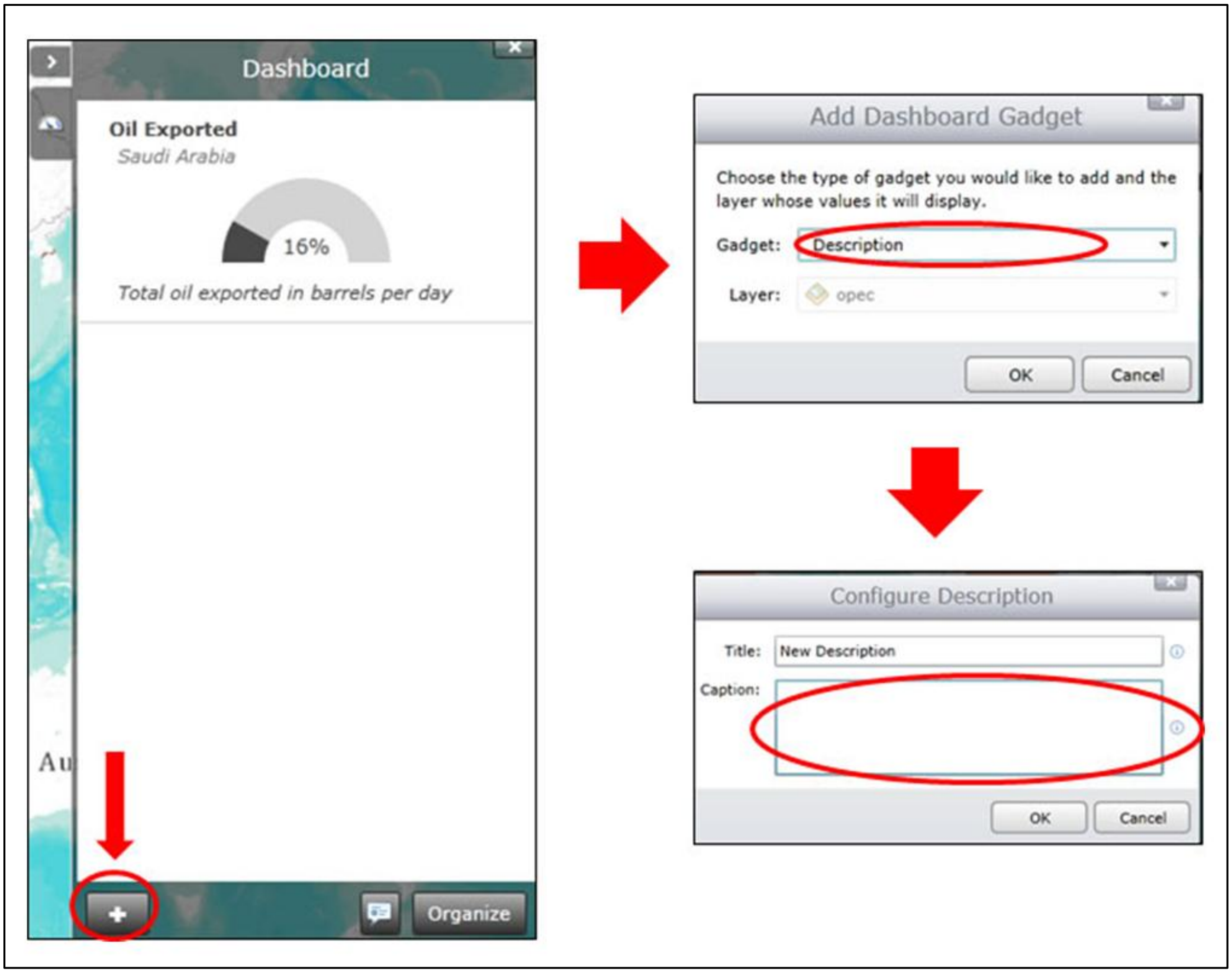


Figure 4.7. Instruction for using a dashboard tool

Some of the participants were also interested in how to set up ArcGIS Explorer Online for use in the classroom with students. Participants wanted to have clear instruction on how to create a new user account (ID #5) and how to use the application with students (ID #4). Participants were confused whether they could create one class account and share the account with all of the students in the class, or whether each student needed an individual account. After consulting with an Esri employee, I found that the easiest way of using ArcGIS Explorer Online in a classroom setting is to have each student to create a user account, with the teacher creating a group for the classroom as a whole. Then the teacher can then give students permissions for joining the group. Also, some of the participants (ID #4 and #7) wanted to know how to search and navigate other maps in ArcGIS Explorer Online and how to add these maps on their map as additional layers. I created additional webpages for providing these three settings' information, respectively—how to create a new user account (http://www.colorado.edu/geography/cartpro/gisedu/addtional/creating_account.html), how to share maps with students (http://www.colorado.edu/geography/cartpro/gisedu/addtional/group.html), and how to search other maps (http://www.colorado.edu/geography/cartpro/gisedu/addtional/search.html).

4.2.2 GIS Technologies and Principles

From the interviews for the user needs analysis, I found out that a lack of GIS teacher training was one of the major barriers to limit its use in the K-12 classroom, and only a few of the participants knew about GIS technologies. One of the participants (ID #7) wanted to see the information about GIS technologies, examples of useful GIS applications that could be used in the K-12 classroom, and the purposes of these GIS applications. Therefore, I created a separate webpage to explain about GIS technologies (http://www.colorado.edu/geography/cartpro/gisedu/addtional/gis.html). I also provided a list of GIS resources, including GIS-based lesson plans and classroom materials that would be useful for teachers.

Some of the participants recommended providing additional information about terms used in GIS technologies and mapping tools. For instance, one participant (ID #26) wanted to know definitions of a map layer and shapefile, and another (ID #10) asked me to explain several classification methods and a role of number of classes. Also, two participants (ID #1 and #8) wanted to know general information about remotely sensed imagery including how to read these images. Therefore, whenever I mentioned terms and tools in GIS technologies, I provided links to other websites where teachers could find detailed information about those terms and tools.

Furthermore, two participants (ID #9 and #26) suggested providing information about general principles of cartography. For example, for a task to create a map with a single value symbol, I could mention that the same color and size of a symbol should be used in this case. Because some of the teachers had not learned about cartography as a field of study, those teachers might not have basic knowledge about how to make a map. Therefore, I added explanations of general cartographic principles on the training tutorials.

4.2.3 Basic Computing Skills

From the interviews for the user needs analysis and the tutorial development steps, I found out that the gap of technology experience and knowledge level between participants was considerable, and many teachers were novice computer users. Therefore, remedial support was necessary for teachers with less technical experience. I decided to provide step-by-step instructions for basic computing skills such as how to search a digital image on the web and how to find its uniform resource locator (URL) on a separated webpage (http://www.colorado.edu/geography/cartpro/gisedu/addtional/finding_url.html). Also, I created a webpage to provide instructions to teachers on how to create an animated image (http://www.colorado.edu/geography/cartpro/gisedu/addtional/making_gif.html). The participants in the tutorial development step liked these additional help webpages for general and basic computing skills. One participant (ID #8) mentioned that these help pages were helpful for older teachers who were not members of the computer generation.

4.3 Additional Suggestions

In addition to comments on tutorial content and technical support, participants also provided several valuable suggestions. They recommended revising some of the formats to make a user-friendly interface design, and they also suggested adding information directly related to their interests—learning objectives and national and state standards.

4.3.1 User-Friendly Interface Design

Many participants suggested revising the format and style of the training tutorials. In order to make a user-friendly interface design, I accepted most of their suggestions, and revised the user interface based on their comments. The most frequently pointed out issue was using a different text style for a step number, tool/function names, and map layer names (ID #1, #4, #5, and #26). For example, when I referred to a specific step on the body of tutorials, I added the "#" sign, like "step #1," so that teachers could find the specific step easily. Also, teachers suggested changing the font style for a tool/function and a map layer to bold, italics, and/or with double quotation marks. Two participants (ID #1 and #5) also recommended numbering a list of information or providing it in a table format to make it readable.

The second suggestion was providing detailed step-by-step instructions with self-explanatory screen captures, which should be big and clear enough to see the instruction easily (ID #15 and #18). Explaining a step in detail in a text was not enough support for teachers to follow the instruction without direct personal support. Originally, I only provided screen captures for some of the complex steps because I thought other steps were straightforward. Contrary to my expectations, I observed that some of the participants had difficulty following the instructions without screen captures. In the end, I provided screen captures for most of the steps to make the tutorials easier to follow.

The third issue commented on by two participants (ID #2 and #27) was providing simpler ways of explaining some steps. According to the participants, making a customized icon in the Google Earth was a great idea, but it took too much time and space in the tutorials. Therefore, they wanted a simpler way of doing the step on a separate webpage. The fourth suggestion was adding an arrow or a circle sign with red to indicate a specific place where teachers needed to pay attention (ID #26). Based on the participant comments, I circled red, added an arrow sign, and/or added a text box to give clear instruction, if needed, on a button or place that teachers should use at each step (Figure 4.8).

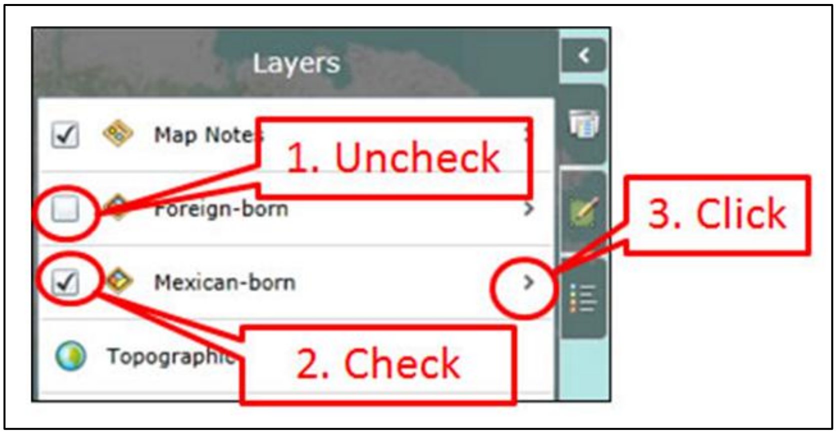


Figure 4.8. Providing clear instruction with a text box

Lastly, one participant (ID #6) wanted to have a printable version of the tutorials. She mentioned that she was not practiced at learning with online materials, and she preferred working with a printed copy on which could make notes. Therefore, I decided to provide both formats and gave teachers a choice between electronic and printed versions. On the top of each activity page, I made a link for a PDF version of the tutorials, so that teachers could download the PDF version and print out if they wanted to (Figure 4.9).

Figure 4.9. Providing PDF versions of training tutorials

4.3.2 Learning Objectives

A few teachers also suggested adding learning objectives for each tutorial topic. One participant (ID #16) wanted to see the learning objectives of tutorials first. When teachers design lesson plans, they usually think about the learning objectives first, and then develop classroom materials and activities based on the learning objectives. Most teachers write the learning objectives of the course topic every day on the physical classroom board. For teachers, having an understanding of the learning objectives of the training tutorials is important and natural when they learn new information and knowledge. Therefore, on the main topic page, I provided learning objectives of each activity in the tutorial topics (Figure 4.10).

Natural Disasters in America

Learning objectives

- To understand locations of major earthquakes in the U.S.
- To analyze the epicenter of the Haiti Earthquake, and research the reasons for the high death toll
- To gain knowledge of Hurricane Katrina by tracking its path and by analyzing the locations that were declared disaster areas

Figure 4.10. Providing the learning objectives of each topic

4.3.3 National and State Standards

One participant (ID #13) recommended providing corresponding national and Colorado state standards for each topic. He mentioned that he and his colleagues try to cover as many standards as possible not only in social studies, but also in science, math, and language arts because teachers, school districts, and the state education department are focused on cross-curricular issues these days. By providing corresponding national and state standards, more teachers might be interested in learning and using the tutorials in their classrooms. Although my tutorials were already keyed to national geography standards and Colorado social studies standards, based on his suggestions, I searched national and state standards in other subjects and listed them for each tutorial. Figure 4.11 is a list of national and state standards related to the *Deforestation in the Amazon Rainforest* topic.

National and Colorado Standards

National/CO	Content Area	Standards
National	Geography	The World in Spatial Terms 1. How to use maps and other geographic representations, tools and technologies to acquire, process and report information from a spatial perspective.
		Places and Regions 4. The physical and human characteristics of places.
		Physical Systems 8. The characteristics and spatial distribution of ecosystems on Earth's surface.
		Environment and Society 14. How human actions modify the physical environment.
		Uses of Geography 18. How to apply geography to interpret the present and plan for the future.
	History	Historical thinking - 1. Chronological Thinking C. Establish temporal order in constructing their [students'] own historical narratives.
	Life Science	4. Populations and ecosystems
Colorado	Geography	1. Use geographic tools to solve problems.
		2. Human and physical systems vary and interact.
	Life Science	1. Changes in environmental conditions can affect the survival of individual organisms, populations, and entire species.

Figure 4.11. National and Colorado Standards for the *Deforestation in the Amazon Rainforest* tutorial. Standards in geography, social studies, and other subjects are listed for each tutorial.

4.4 Participant Responses

When I showed the draft versions of training tutorials to participants, I generally received positive responses. Many participants mentioned that the instruction was easy to follow and easy to use. One participant (ID #30) said that the tutorial website interface was very much user friendly, and it was a great and remarkable resource. Another participant (ID #26) said that when he went to other GIS related websites, he did not know where to begin. However, my tutorial website was very straightforward, and it fit its educative purpose very much. Two other teachers (ID #3 and #6) said that once they spent time practicing alone, they were sure that they could use it in the classroom with students.

Also, many participants liked the tutorial topics and activities, the online mapping applications, and the mapping tools chosen for use. One participant (ID #28) mentioned that the topic of the tutorial she reviewed was a good choice because it covered important concepts in the curriculum. A participant (ID #5) liked ArcGIS Online Explorer very much. He said that it seemed better than Google Earth because its background map was clearer and easier to use than Google Earth. Another participant (ID #30) mentioned that she used Google Earth, but she did not know that there were so many tools that could be used in the classroom, such as historical imagery and place markers.

Two participants pointed out the difficulties of using some mapping tools with middle school students, but they recognized the potential. One participant (ID #6) mentioned that the level of some tools was a bit high for the average middle school student, but these tools might be useful for the advanced students in the gifted and talented programs at schools. Another participant (ID #26) said that if he provided clear instructions, the online mapping would be useful for middle school students.

Two participants (ID #16 and #27) talked about the possibility of using the tutorials in a wide range of subjects. One participant (ID #16) mentioned that some of the topics would fit into an interdisciplinary curriculum that might combine science, geography, and history. According to another participant (ID #27), the tutorials could also be used with high school students. Two participants (ID #7 and #16) said that while following the tutorials, they could think of many other new ideas they could develop for students using web-based GIS. In the long run, I hope that tutorials like these will help teachers develop their own classroom activities and materials using web-based GIS technologies.

Also, two participants (ID #29 and #30) mentioned that they wanted to introduce the training tutorials to their colleagues. They said that the tutorials were very helpful, and they would share the information with other teachers at their schools. Their comments made me think of a different way of promoting teacher adoption for implementing web-based GIS technologies in the classroom. If teachers who participated in this study act as early adopters and pioneers, they may be able to introduce the training tutorials to their colleagues and encourage other teachers to use web-based GIS technologies. More and more teachers would use and implement web-based GIS technologies in the classroom, and it would create a collaborative atmosphere for teachers to help each other develop new ideas and share them with each other.

CHAPTER V

EVALUATION

On November 9th, 2011 the tutorials were released on the web (GIS for Social Studies: http://www.colorado.edu/geography/cartpro/gisedu). Samples of training tutorials are available in Appendix D. As part of the evaluation of their use, I used Web Analytics to collect and analyze website traffic including the number of visitors, their geographic locations, and the amount of time they spent on each page. The evaluation method step of this study was conducted mostly with middle school social studies teachers but included educators who taught social studies at other grade levels, other subjects such as science, and people whose interests and occupations were directly related to this study such as social studies curriculum developers or coordinators at the state level. The teachers came from Colorado and many other states.

There were two steps in the evaluation: a user survey and a later follow up. In the user survey, after completing one or more tutorials, participants were asked to take a survey to collect information about their technology background, the training tutorials, online training, and web-based geographic information systems (GIS) applications as instructional tools. The complete list of survey questions is available in Appendix B. In order to participate in this user survey, teachers did not need to test the tutorials with students. The user survey was conducted both online and off-line. Of the 55 total survey respondents, 40 participants were from online testing, and 15 participants were from off-line testing.

In late April 2012 to mid-May 2012, I conducted a follow-up survey by email asking participants whether they used the training tutorials with students in the classroom. This follow-up query helped me judge whether teachers used web-based GIS technologies in real classroom situations. Among 55 participants who completed the user survey, 19 agreed to participate in the follow-up survey; 17 participants took the follow-up survey completely.

5.1 Web Analytics of *GIS for Social Studies*

In order to examine website traffic such as the number of visitors, geographic locations, and time spent for each page, the website was examined using Google Analytics. Google Analytics provides tools to gather and analyze Internet data of personal or business-related web applications (Google Analytics 2012). The results of web analytics presented in this section were the duration from November 9th, 2011 to May 23rd, 2012. The total number of visitors was 2289 during that period of time. Among the visitors, there were 1526 unique visitors (66.7% of total), while 763 (33.3%) visited the website more than once. These visitors were from 39 different countries (Table 5.1) but mainly from the U.S. (95.1%).

Table 5.1. Website Visitors from Various Countries

Country	# of Visitors	% of Visitors
United States	2177	95.1%
Canada	15	0.7%
Australia	12	0.5%
Trinidad and Tobago	10	0.4%
United Kingdom	10	0.4%
Netherlands	8	0.4%
Belgium	4	0.2%
Portugal	4	0.2%
South Korea	4	0.2%
Ethiopia	3	0.1%
Germany	3	0.1%
Others	39	1.7%
Total visitors	2289	

In the U.S., except Delaware and Hawaii, there was at least 1 visitor from each state. The largest numbers of visitors were from Colorado (1187 visitors (54.7%)), California (108 visitors (5.0%)), and New Hampshire (104 visitors (4.8%)) (Figure 5.1). The average visit duration was 4.9 minutes. Ninety visitors (3.9%) spent more than 30 minutes, but 1017 visitors (44.4%) spent less than 10 seconds. A total number of pages that visitors viewed were 9,041 pages. The average number of pages per each visitor was 4.0 pages.

Figure 5.1. Website Visitors from the United States

5.2 Results of the User Survey

5.2.1 Background of Participants

Table 5.2 shows participants' description of their jobs. Among the 55 people who completed the survey, the largest participant group was 7th grade teachers (21 participants (38.2%)). Also, 8 6th grade (14.5%) and 13 8th grade (23.6%) teachers participated in the study. There were 12 teachers (21.8%) who taught other grade levels such as elementary and high school levels. Eight pre-service teachers (14.5%) also participated in this study. Lastly, there were 6 participants (10.9%) who had education and/or GIS related jobs or activities, like a GIS analyst and a 4-H GIS club member. Some of the participants taught more than one grade level, so the total number of responses (68 responses) was larger than the total number of participants (55 participants).

Table 5.2. Participants' Job Description

	# of Participants	% of Participants
6^{th}	8	14.5%
7^{th}	21	38.2%
8^{th}	13	23.6%
Other grades	12	21.8%
Pre-service	8	14.5%
Related jobs	6	10.9%
Total participants	55	

Participants were also asked to provide the years of their teaching experiences (Figure 5.2). The average years of teaching experience were 10.9 years. Out of 55 participants, 20 participants (36.4%) had less than five years of teaching experience, which included pre-service teachers who did not have any teaching experience. There were 10 participants with 6 to 10 years, 9 participants with 11 to 15 years, 6 participants with 16 to 20 years, 9 participants with 21 to 25 years, and 1 participant with more than 26 years of teaching experience. Therefore, based on participants' years of teaching experience, I assumed that participants' ages were distributed from the 20s to the 60s.

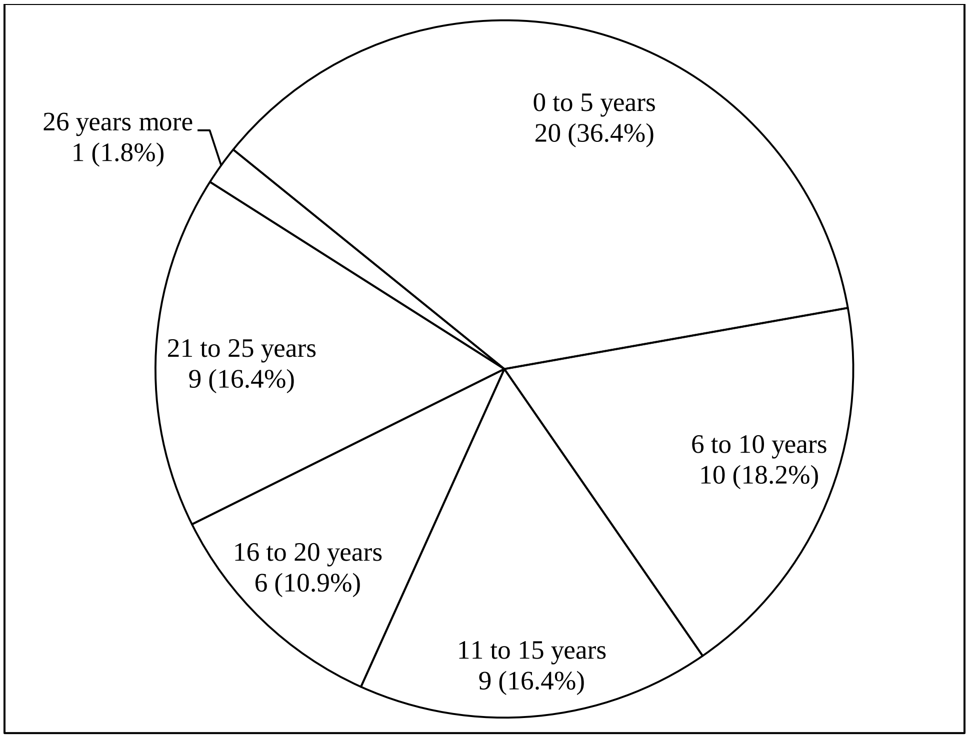


Figure 5.2. Participants' years of teaching experiences

In order to know participants' level of GIS related technology background, I asked them to rate their knowledge level of five different terms, including GIS, web-based maps, virtual globes, ArcGIS Explorer Online, and Google Earth. I provided five category levels that participants could choose from, and I scored each category with a numeric number: none (1), beginner/just a little (2), some (3), moderate (4), and advanced (5). I provided clear definitions of each category level like the following:

- None: Have neither heard of nor used.
- Beginner/Just a little: Have heard of and tried to use recently.
- Some: Have used occasionally (4 to 5 times per year), or just know the basic functionality such as finding location and zoom-in/out.
- Moderate: Use frequently (more than once a month), or can follow the tutorials without direct assistance.
- Advanced: Use very often (2 to 3 times per week), have done professional training/course work, and know the advanced functionality such as analysis.

Participants were most familiar with the term web-based maps (3.2) (Figure 5.3). The average rate of all five terms was 2.8, and no term had an average rating above 4, the "moderate" level. Overall, participants' knowledge level regarding GIS related technology was between the "beginner/just a little" and "some" levels.

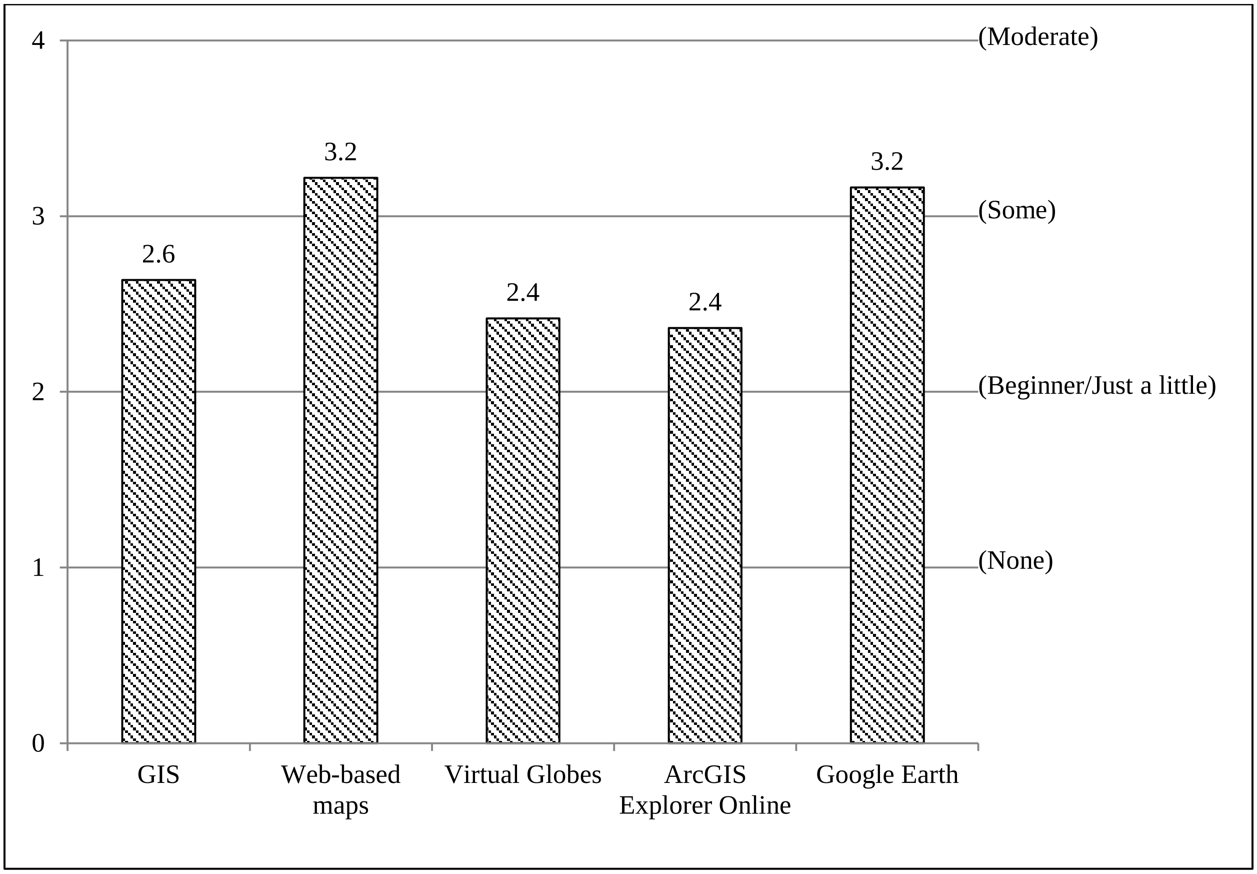


Figure 5.3. Participants' knowledge levels of GIS technologies

5.2.2 Ease of Use and Following Training Tutorials

There were nine different tutorial topics that participants could select to test. Participants were allowed to choose any of these topics to review. Figure 5.4 shows numbers of participants for each tutorial topic. The most frequently tested tutorials were the 7th grade's *Ancient Greece and Rome* (11 participants) and *Natural Resources* (10 participants) and the 8th grade's *Westward Expansion of the U.S.* (9 participants). No one tested the 6th grade's *Immigration to the U.S.* topic.

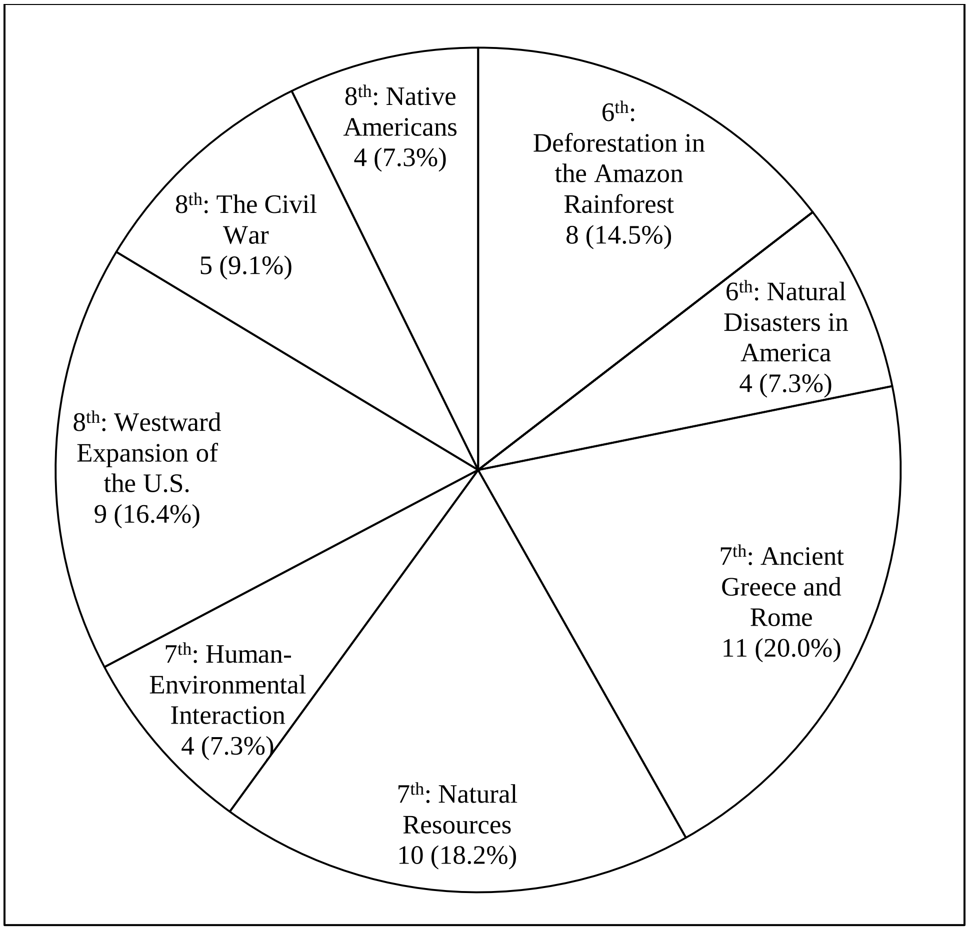


Figure 5.4. Participants' tutorial topic selection

Participants were asked to rate whether the tutorials were easy to follow. Using a five-level Likert scale, participants chose one of five categories, and each category was scored from one to five: strongly disagree (1), disagree (2), neither agree nor disagree (3), agree (4), and strongly agree (5). As a result, the average rate score was 4.1, which was a slightly above the "agree" level. Figure 5.5 shows the distribution of participants' responses. Among 55 participants, 31 participants (56.4%) chose the "agree" category, and 16 participants (29.1%) chose the "strongly agree" category. Only 1 participant answered that he or she strongly disagreed with the tutorials' ease of use.

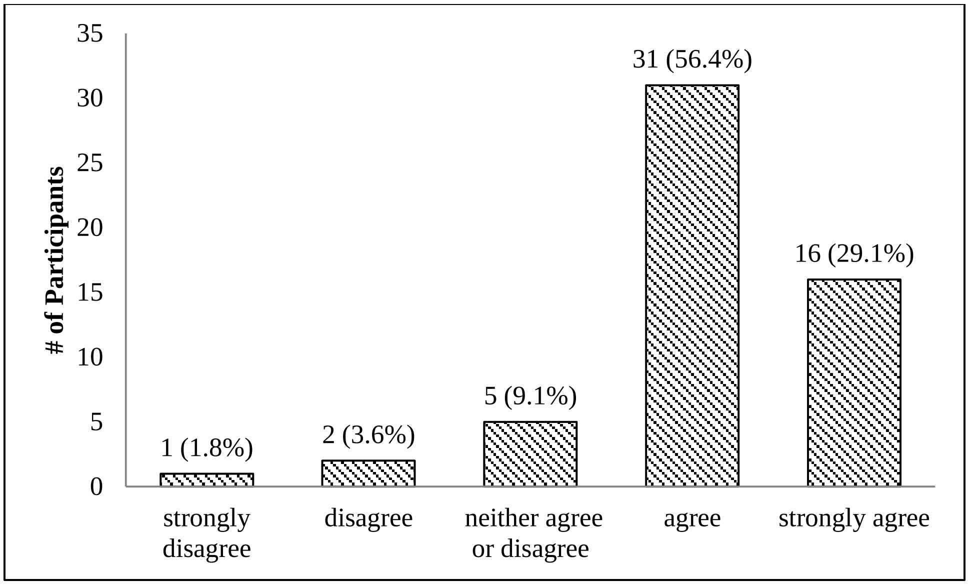


Figure 5.5. Distribution of participants' responses of tutorials' easy-to-follow (rating average = 4.1)

Participants identified the best features and their least favorite features in the training tutorials (Table 5.3). Out of 55 participants, 39 participants (70.9%) answered that step-by-step instruction with captured images and circles and arrows showing steps was the best feature of the tutorials because "it made the tutorials much easier to follow." Also, the user-friendly instructions allowed them to be "completed without direct support" and to have "little prep time to implement lessons in [the] classroom." The captured images helped participants "be able to see what it should look like [and] know whether or not [they were] being successful." One participant commented that "the more you show and the less you write makes the tutorial better."

Five other participants (9.1%) identified specific activities or tools as the tutorials' best features, such as the activity 2 in *Deforestation in the Amazon Rainforest* because of its "easy illustration of deforestation over time." Another participant chose the map presentation tool because it provided "the ability to make a slideshow." In addition, 4 participants liked various GIS functions such as overlay and visualization. One participant who tested *The Civil War* mentioned that GIS showed "how students can visually identify the different states and economics or slave population; this makes it easier for students to understand the complex differences between the North and the South."

Table 5.3. Participants' Responses to the Best and Least Favorite Features of the Tutorials

Best features	Times Responded	As % of Total Respondents
User-friendly instruction	39	70.9%
Specific activities/tools	5	9.1%
GIS functionality	4	7.3%
Topic selection	2	3.6%
Discussion questions	2	3.6%
Online mapping applications/data	2	3.6%
Everything	1	1.8%

Least favorite features	Times Responded	As % of Total Respondents
Like everything	18	32.7%
Too long instruction	11	20.0%
Online mapping applications/data	9	16.4%
Specific activities/tools	5	9.1%
Need more specific instruction	4	7.3%
User interface design	3	5.5%
Required computing skills	2	3.6%
Difficulties of implementation	2	3.6%
Discussion questions	1	1.8%

In the case of participants' least favorite features in the tutorials, the most frequent response was "none" (18 participants (32.7%)). One of them mentioned that "I could honestly not think of something I didn't like!" and another said that "all parts of the tutorial were useful and well done." Next, 11 participants (20.0%) identified that instructions were too long to complete and time consuming. Because of the length of tutorials, some of the participants found it difficult "to find the time to go all the way through it." Also, there were many steps to create a map in some tutorials, and some steps were "too repetitive." One participant commented that "it just seems a bit wordy. Is there a way to have fewer steps to get to the map?" Some of the steps were too complex and long, so 1 participant suggested that "it would have been easier to have some of the multiple steps in one step broken down into smaller steps."

The third most frequent response (9 participants (16.4%)) was online mapping applications and data that were used in the tutorials. They took issue with some of the error messages produced in using ArcGIS Explorer Online when creating a user account and thought the system took too much time to load a map. Also, 1 participant did not like "the vast extent of ArcGIS Explorer Online because it seems daunting to explore more of this in my already limited time." For some participants, unfamiliar terms used in ArcGIS Explorer Online were problematic.

Table 5.4 shows elements and features that needed the most improvement in the tutorials. Sixteen participants (29.1%) mentioned that no element or feature needed improvement because they thought everything worked fine. Eight participants (14.5%) wanted to have "more detailed instructions for teachers with little technological knowledge." One participant suggested using different methods such as video clips for explaining a difficult tool. Five other participants (9.1%) wanted to know more about online mapping applications, for example, "more basic Google Earth tips in tutorials to help share presentation/tour with students" and additional tutorials on ArcGIS Explorer Online to understand "where to find all of the features."
Also, 5 participants (9.1%) suggested that the user interface design of the tutorial website should be improved. One suggested revising layout of instructions with links because:

> while the directions are awesome and give excellent detail, it might be easier to navigate if each step were presented as a link rather than scroll down a long, long page. Each step could be listed with a brief description of the task, then a link for the details. The reason I suggest this is that [once learned] it was easy to remember, so I didn't need such specific directions…again. If all the steps were listed and the user could just click on each step…[and] use the more detailed information if necessary.

Four participants said that they could not suggest anything due to their lack of knowledge. Three participants wanted to have more background information and explanation about topics, for example, "more history for the subject of *Ancient Greece and Rome* by adding extra links with more topics to explore."

Table 5.4. Participants' Responses to the Elements/Features in Need of Improvement

	Times Responded	As % of Total Respondents
Everything is fine	16	29.1%
More detailed instruction	8	14.5%
More information for online mapping applications	5	9.1%
User Interface Design	5	9.1%
Cannot suggest	4	7.3%
More background information about topics	3	5.5%
Problems of online mapping applications	3	5.5%
More GIS training	2	3.6%
Use different activities/steps	2	3.6%
Explain purpose of study/design	2	3.6%
Others (5 different responses by 5 participants)		

5.2.3 Usefulness of Mapping Tools

There were a total sixteen mapping tools introduced across the set of tutorials. Some tools were used in only one topic, but others were used in up to seven different topics. Participants were asked to rate these tools in terms of how useful they were to them personally and how useful these tools would be to students in the classroom (Table 5.5). Using a five-level Likert scale, participants chose one of five categories: strongly disagree (1), disagree (2), neither agree nor disagree (3), agree (4), and strongly agree (5).

The most highly rated useful mapping tool to teachers was the historical imagery (4.9) in Google Earth. This tool allowed participants to see landscape changes over time. The second most useful tool for teachers was the time navigator (4.7) in ArcGIS Explorer Online, again because it helped participants see changes in geographical patterns through time. The third most popular tool was the map presentation feature (4.6) in ArcGIS Explorer Online. With this tool, participants were able to create a slideshow like using Microsoft PowerPoint. Interestingly, although these three top tools were not used often in the tutorials, users still rated them highly.

This suggests that tools able to illustrate any changes over time are helpful to teachers. In the case of features that teachers rated as useful to students, the results were somewhat similar. Historical imagery (4.8) in Google Earth was ranked most highly followed by the map presentation tool (4.6) in ArcGIS Explorer Online. After that, the adding a picture tool (4.5) in both ArcGIS Explorer Online and Google Earth was ranked third.

Table 5.5. Useful Mapping Tools Rated and Ranked by Participants

Mapping Tools	Useful to Teachers Personally		Useful in the Classroom with Students		# of used in the Tutorials	# of Participants who used
	Rate	Rank	Rate	Rank		
3D Trees	3.5	16	3.5	16	1	8
Adding a picture	4.4	5	4.5	3	6	46
Adding a point symbol	4.4	7	4.3	8	7	47
An animating picture	3.6	15	3.9	13	1	8
Dashboard (Gauge)	4.4	6	4.1	12	2	14
Dashboard (Pie Chart)	3.7	14	3.6	15	1	5
Drawing a line	4.1	11	4.3	9	3	25
Finding land use	4.5	4	4.5	4	1	8
Graduated colors	4.3	9	4.4	6	7	47
Graduated symbols	4.4	8	4.5	5	2	14
Historical Imagery	4.9	1	4.8	1	1	8
Map presentation	4.6	3	4.6	2	2	20
Measure	4.3	10	4.3	10	1	11
Multi-colored dot map	4.0	12	4.2	11	1	5
Time Navigator	4.7	2	4.3	7	1	4
Unique values	4.0	13	3.8	14	3	13

Whereas I asked participants to rate all the tools they used in Table 5.5, I asked participants to pick out a tool that was their favorite and another tool that was their least favorite (Table 5.6). I used this question to try to get a clear comparison of the strengths and weaknesses of the tools. Not unexpectedly, historical imagery in Google Earth was the most useful tool to teachers personally (75.0% of those participants who used) and the most useful tool in the classroom with students (62.5% of those participants who used). One of the participants mentioned that "it shows that actual impact of land use over time in a primary source way. I believe it will be very useful throughout my curriculum in all parts of the western hemisphere. I believe I will teach kids this feature using our local area." Also, another participant said that "we are looking at trends, human environmental interaction, regions and place. This [tool] will be good analyzing the economics of the region and using geo tools to solve problems."

The second most useful tool for both categories was the multi-colored dot map in ArcGIS Explorer Online. This tool was selected by 3 out of 5 participants who used it. They liked its "visual representation that showed the different economic components." One of the participants commented that "I think that if students could only learn one skill, or were starting at the beginning, this would be the place to have them start. So when I would introduce GIS, this is where I would have them start and I could do the rest, or not, and the map would still make sense."

The graduated colors tool in ArcGIS Explorer Online was the third most useful tool to teachers (36.2% of those participants who used) and a useful tool in the classroom with students (29.8% of those participants who used). Even though the percentage of participants who chose this tool were lower than the previously mentioned mapping tools, many participants chose graduated colors as the most useful to teachers (17 participants) and useful in the classroom (14 participants). They liked this tool because it "allows [for] visually understanding the map" and is "a clear and concise way to present information to kids." One participant mentioned that "kids need to be able to have the skill set to read many types of maps. Color is an easy visual tool to accomplish this."

Table 5.6. The Most and the Least Useful Mapping Tools Selected by Participants

Mapping Tools	Most Useful to Teachers Personally		Most Useful in the Classroom		Least Useful to Teachers Personally		Least Useful in the Classroom		# of Participants who used
	Times Selected	As % of Participants who used	Times Selected	As % of Participants who used	Times Selected	As % of Participants who used	Times Selected	As % of Participants who used	
3D Trees	0	0.0%	1	12.5%	4	50.0%	5	62.5%	8
Adding a picture	5	10.9%	13	28.3%	8	17.4%	9	19.6%	46
Adding a point symbol	9	19.1%	8	17.0%	6	12.8%	6	12.8%	47
An animating picture	0	0.0%	0	0.0%	3	37.5%	2	25.0%	8
Dashboard (Gauge)	1	7.1%	3	21.4%	4	28.6%	2	14.3%	14
Dashboard (Pie Chart)	0	0.0%	0	0.0%	0	0.0%	0	0.0%	5
Drawing a line	0	0.0%	0	0.0%	10	40.0%	10	40.0%	25
Finding land use	2	25.0%	2	25.0%	0	0.0%	0	0.0%	8
Graduated colors	17	36.2%	14	29.8%	7	14.9%	8	17.0%	47
Graduated symbols	4	28.6%	1	7.1%	4	28.6%	4	28.6%	14
Historical Imagery	6	75.0%	5	62.5%	0	0.0%	0	0.0%	8
Map presentation	5	25.0%	4	20.0%	1	5.0%	1	5.0%	20
Measure	0	0.0%	0	0.0%	4	36.4%	5	45.5%	11
Multi-colored dot map	3	60.0%	3	60.0%	0	0.0%	0	0.0%	5
Time Navigator	1	25.0%	0	0.0%	1	25.0%	0	0.0%	4
Unique values	2	15.4%	1	7.7%	3	23.1%	3	23.1%	13

The least useful mapping tools to participants were 3D trees in Google Earth (50.0% of those participants who used), drawing a line in ArcGIS Explorer Online (40.0% of the participants who used), and an animating picture (37.5% of those participants who used this tool). The least useful mapping tools for classroom use were 3D trees (62.5% of those participants who used), measure (45.5% of those participants who used), and drawing a line (40.0% of those participants who used). The reasons that the 3D trees in Google Earth ranked so poorly was because they were "too unrealistic," and "it might not play a huge role in the overall learning objective or lesson." One participant also suggested that "a YouTube video might work better." In the case of the line drawing tool, teachers said it was "a useful tool, but not as important and valuable as the other mapping tools" and "not as fun." One participant commented that "in my class we have SMART Boards that can do the same thing."

5.2.3.1 Other Learning Tools

One of the survey questions asked what kinds of tools, techniques, or information participants would like to learn besides those provided in the tutorials (Table 5.7). Fourteen participants (25.5%) wanted to learn basic GIS technology skills including creating a map layer (shapefile), combining source information into a map layer, reading map layer information, and creating maps for presentations and reports. One participant mentioned that "I would like to learn how to easily access data myself and be able to build a map from scratch." The second most frequent response was learning various mapping tools and techniques in Google Earth and ArcGIS Explorer Online for the classroom implementation (12 participants (21.8%)). For example, participants wanted to learn "how students can use Google Earth to make their own trips, as well as how to make Google Earth more accessible to middle school students," "how to use graduated symbols in the classroom," "how to make a buffer," and so on. Also, another participant wanted to learn how to create "a rubric for scoring the maps so students can do self-assessment."

Table 5.7. Tools, Techniques, Information about which Participants Wanted to Learn More

Topic	Times Responded	As % of Total Respondents
Basic GIS technology skills	14	25.5%
Various tools in online mapping applications	12	21.8%
Provided mapping tools are enough	11	20.0%
Don't know yet	7	12.7%
GIS-based pedagogy/lessons	4	7.3%
Videos/flash/3D	4	7.3%
Related resources	2	3.6%
Anything	1	1.8%

5.2.4 Preferred Method of Teacher Training

Participants were asked about the kinds of training they preferred. With respect to online training, the rating average was 3.8 from one (strongly disagree) to five (strongly agree) on the rating scale with forty-one participants (74.6%) responding to the question positively (Figure 5.6). Seven participants (12.7%) chose the “neither agree nor disagree” category. They benefitted from online training, but preferred a “hands-on in a classroom environment because it is easier in case there are questions.” However, they agreed that online training was more convenient. Seven other participants responded negatively about online training. One participant who answered “strongly disagree” commented that “I really feel like I needed a person to coach/talk me through and help me figure out the purpose.” Another said that “I prefer to interact with people. I needed some help and if I were doing the whole thing online I would have gotten too frustrated and quit. It was helpful to have a real person.” One participant mentioned that “it’s super hard to find the time” to do online training.

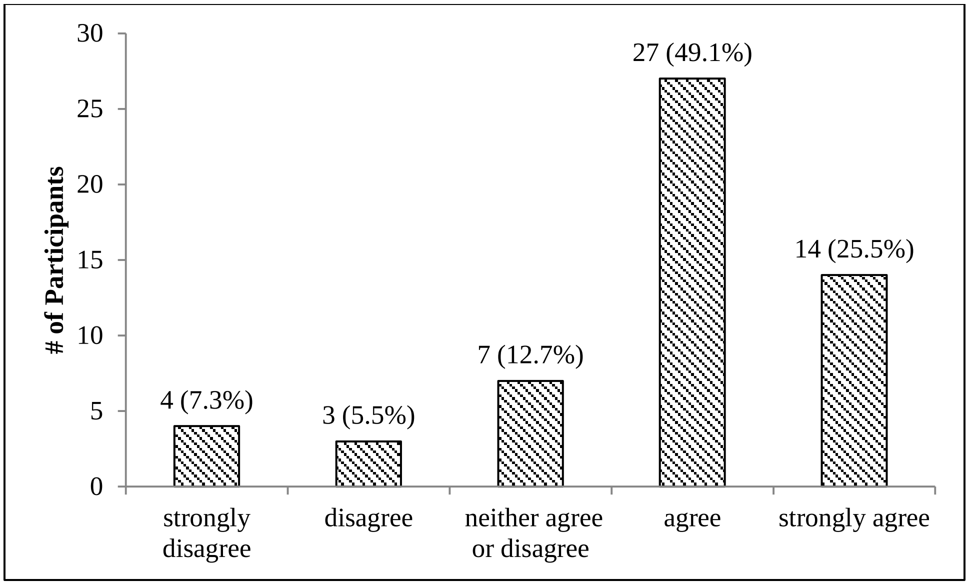


Figure 5.6. Distribution of participants' preference for online training (rating average: 3.8)

The other question that I asked participants was their preferred training types. Table 5.8 shows types of training that participants preferred. Out of 55 participants, 30 participants (54.5%) selected in-service workshops. Twenty-seven participants (49.1%) chose digital-versions of published lesson plans, and 25 participants (45.5%) picked one-on-one coaching. The fourth preferred training type was professional meetings (20 participants (36.4%)), and the fifth one was in-district professional development (18 participants (32.7%)). Five participants chose paper-versions of published lesson plans. Also, there were four additional responses, such as "not sure yet," "small groups that are focused on a topic of interest," and "training by other teachers."

Table 5.8. Participants' Preferred Training Types

Type of Training	Times Responded	As % of Total Respondents
In-service workshops	30	54.5%
In-district professional development	18	32.7%
Professional meetings	20	36.4%
One-on-one coaching	25	45.5%
Digital-versions of published lesson plans	27	49.1%
Paper-versions of published lesson plans	5	9.1%
Other	4	7.3%

5.2.5 Possibilities of Web-based GIS as an Instructional Tool in the Classroom

Knowing whether the training tutorials helped and promoted participants to implement web-based GIS technologies in the classroom was one of the key research questions. In order to investigate this question, I asked four questions. The first was whether the tutorials provided enough help for participants to create and/or customize web-based GIS by themselves. The average rating score was 3.6 out of 5.0, which was in between the "neither agree nor disagree" category and the "agree" category (Figure 5.7).

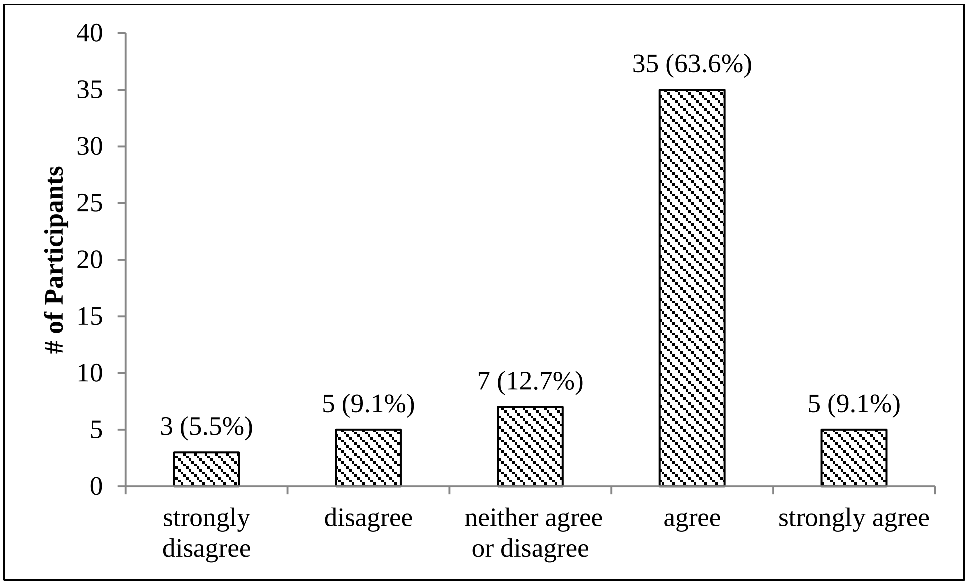


Figure 5.7. Participants' responses to the tutorials' help for classroom implementation (rating average: 3.6)

There were 7 participants (12.7%) who responded neutrally because they "needed more time to experiment with the different options." One of those participants commented that "I agree that they got me started, but I do not know where to put them outside the program." However, 8 participants (14.5%) chose negative responses: 3 for "strongly disagree" and 5 for "disagree." The reasons for negative responses were that they "needed a lot more practice and time" to implement web-based GIS in their classrooms. One participant who selected "disagree" mentioned that "[I am] still not sure how to compile and enter data and create my own maps."

The next question was whether they thought web-based GIS was useful and effective as an instructional tool (Figure 5.8). The average score was 4.4 out of 5.0. Among 55 participants, 27 (49.1%) answered "strongly agree." One participant who answered "strongly agree" mentioned that "these are FANTASTIC tools for students! I find my students have a hard time visualizing other parts of the world. Using this technology in combination with an interactive whiteboard is engaging and powerful for students." Another participant commented that "in a digital world, these types of maps provide the opportunity to study a multitude of scenarios that can be connected to any content area. For visual and spatial learners, this is ideal to support understanding of many concepts in social studies and most other subjects."

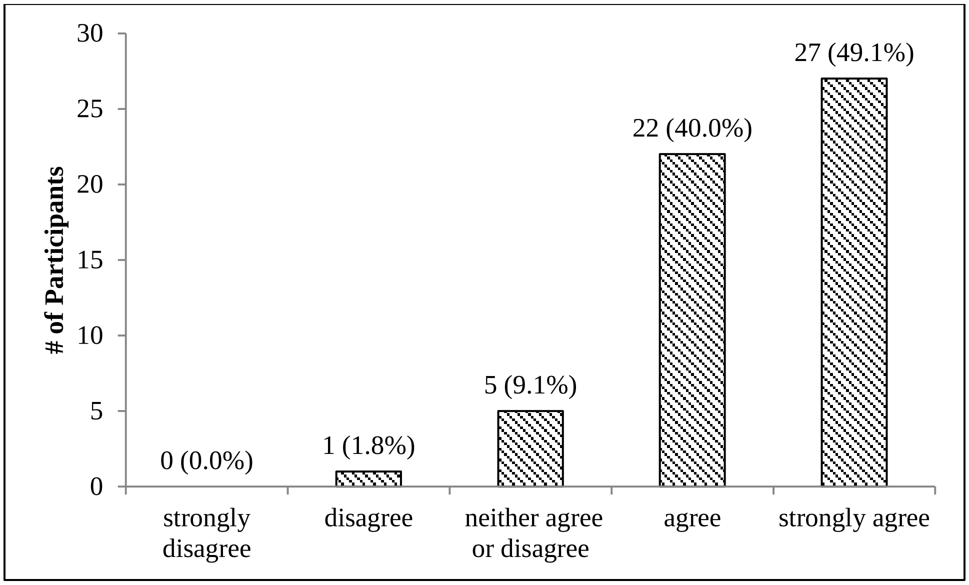


Figure 5.8. Participants' responses to the web-based GIS' usefulness and effectiveness as an instructional tool (rating average: 4.4)

Next, participants were asked to answer whether they would use web-based GIS in their classrooms (Figure 5.9). The average score of this question was 4.4 out of 5.0, which was in between "agree" and "strongly agree." Twenty-eight participants (50.9%) responded "strongly agree," and 23 participants (41.8%) answered "agree." Therefore, 92.7% of the participants responded to this question positively that they would use web-based GIS in their classrooms.

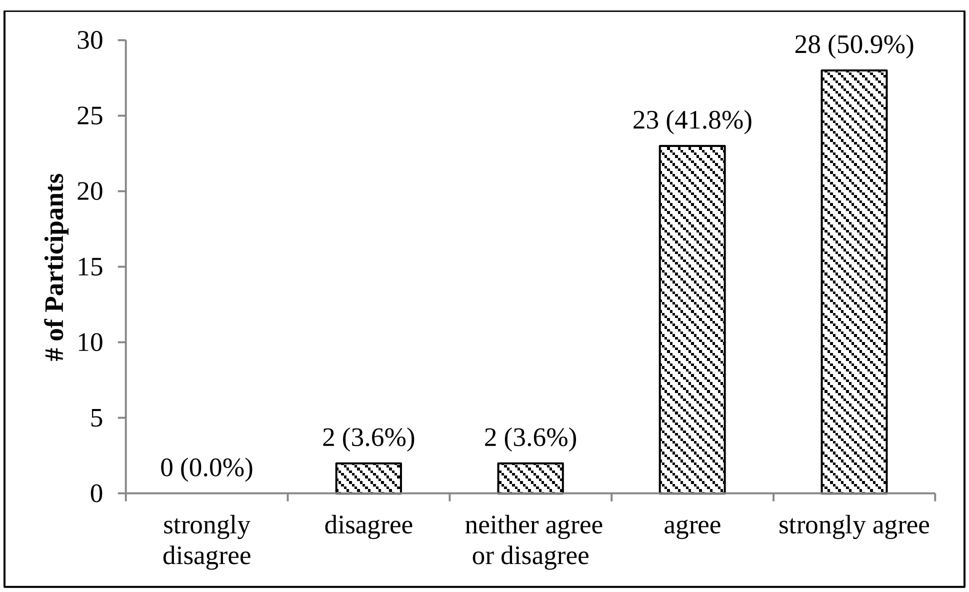


Figure 5.9. Participants' tendency of implementing web-based GIS in the classroom (rating average: 4.4)

As the last question, participants were asked to identify possible barriers to limit the use of these technologies in the classroom (Table 5.9). As I grouped barriers in the Chapter 3, these identified barriers were divided by four groups, including economic/social issues, teacher related issues, technological issues, and additional issues. Five participants mentioned that there was no possible barrier in terms of using web-based GIS in the classroom. The most frequently identified barrier was low availability of technologies (22 participants (40.0%)). According to one participant, “with the devastating budget cuts that schools are facing, these kinds of highly valuable resources may not be available if there is any cost involved.” The next frequently identified barrier was lack of teachers’ time to learn and practice web-based GIS technologies and develop GIS-based lesson plans (16 participants (29.1%)) in teacher related issues. The third barrier was unstable Internet connections (13 participants (23.6%)) in technological issues. One participant commented that “bandwidth at our school is awful. They are slowly improving it. As of right now anything with download time or layers (like maps) takes forever and often times teachers just give up and get frustrated. So it is strictly on our end.”

Table 5.9. Participants’ Identified Possible Barriers to Limit Use of Web-based GIS

Categories	Barriers	Times Responded	As % of Total Respondents
Economic/Social issues	Low availability of technologies	22	40.0%
	Costs of software	2	3.6%
Teacher related issues	Limited time to learn/practice/develop	16	29.1%
	Lack of my knowledge	3	5.5%
Technological issues	Unstable Internet connection	13	23.6%
	Different types of computers	3	5.5%
	Long set-up time	1	1.8%
Additional issues	Huge gaps of students' level	2	3.6%
	Difficult classroom management	2	3.6%
	Administrating issue	2	3.6%
	No barrier	5	9.1%

5.3 Group Comparison of the User Survey

Based on three criteria—different testing environment (online vs. off-line testing), years of teaching experience, and self-rated GIS technology background levels—participants' responses were grouped and compared each other to see significant differences between groups. In order to test the differences, two-sample difference of means t-test was conducted because the sample sizes were less than 30 (McGrew and Monroe 2000). The null hypothesis for the tests was that there was no difference in two independent sample means (H_O: $\mu_1 = \mu_2$). The direction of difference was not necessarily considered, so the two-tailed format was used. The alternative hypothesis of the tests was that there were significant differences in two independent sample means (H_A: $\mu_1 \neq \mu_2$). I chose an alpha level of 0.05. Therefore, if the p-values were less than 0.05 ($p < \alpha = 0.05$), the null hypothesis was rejected, and the alternative hypothesis was accepted. However, if the p-values were greater than 0.05 ($p > \alpha = 0.05$), the null hypothesis was retained. The question about participants' preferred training type was analyzed with a filled radar chart to show different patterns between two groups.

5.3.1 Online vs. Off-line Testing

The first group comparison was testing from online and off-line. There were 40 participants from online testing and 15 participants from off-line testing. Table 5.10 shows statistical descriptions of the two groups and the results of the t-test for seven questions. The first two questions were about their teaching and technical background. Except the first question, years of teaching experience, the response range of all six questions were one to five. Based on the p-values, the means of seven questions' responses in online and off-line testing groups did not have significant differences. In other words, the means of two groups' responses for the seven questions were similar. Participants at two groups' years of teaching experiences were similar, and their GIS related technical background levels were also similar to each other. Their responses regarding tutorials, online training, and implementation of web-based GIS were similar even though their testing environment was different.

Table 5.10. Descriptive Statistics and t-test for Online and Off-line Testing

Questions	Online			Off-line			Results	
	n	x	s	n	x	s	p-value	Decision
Years of teaching experiences	40	10.7	9.1	15	11.5	9.1	0.8	Not significant (no difference in means)
Self-rated GIS technology background level		2.9	0.9		2.6	0.7	0.2	
Tutorials' ease of following		4.2	0.7		3.8	1.1	0.2	
Preference for online training		3.8	1.1		3.7	1.2	0.8	
Tutorials' help for classroom implementation		3.7	0.9		3.3	1.1	0.2	
Web-based GIS's usefulness and effectiveness		4.3	0.8		4.5	0.5	0.2	
Tendency of web-based GIS implementation in the class		4.4	0.8		4.4	0.5	1.0	

Figure 5.10 shows different patterns of participants' preferred training types from online and off-line testing. The obvious dissimilar results were from digital-versions of published lesson plans. Twenty-five participants (62.5% of the online testing participants) from online testing identified that they preferred digital-versions of published lesson plans while only 2 participants (13.3% of the off-line testing participants) from off-line testing preferred this type of training. In addition, differences in between in-service workshops and in-district professional development were greater in off-line testing than in online testing. In-service workshops are school-based training while in-district professional development is based on a school district. There were 12.5% of differences in online testing: in-service workshops (50.0%) and in-district professional development (37.5%). However, in the case of the off-line testing, their differences were 44.7%: in-service workshops (66.7%) and in-district professional development (20.0%). The results mean that more numbers of participants in off-line testing liked training in the range of their schools rather than school districts.

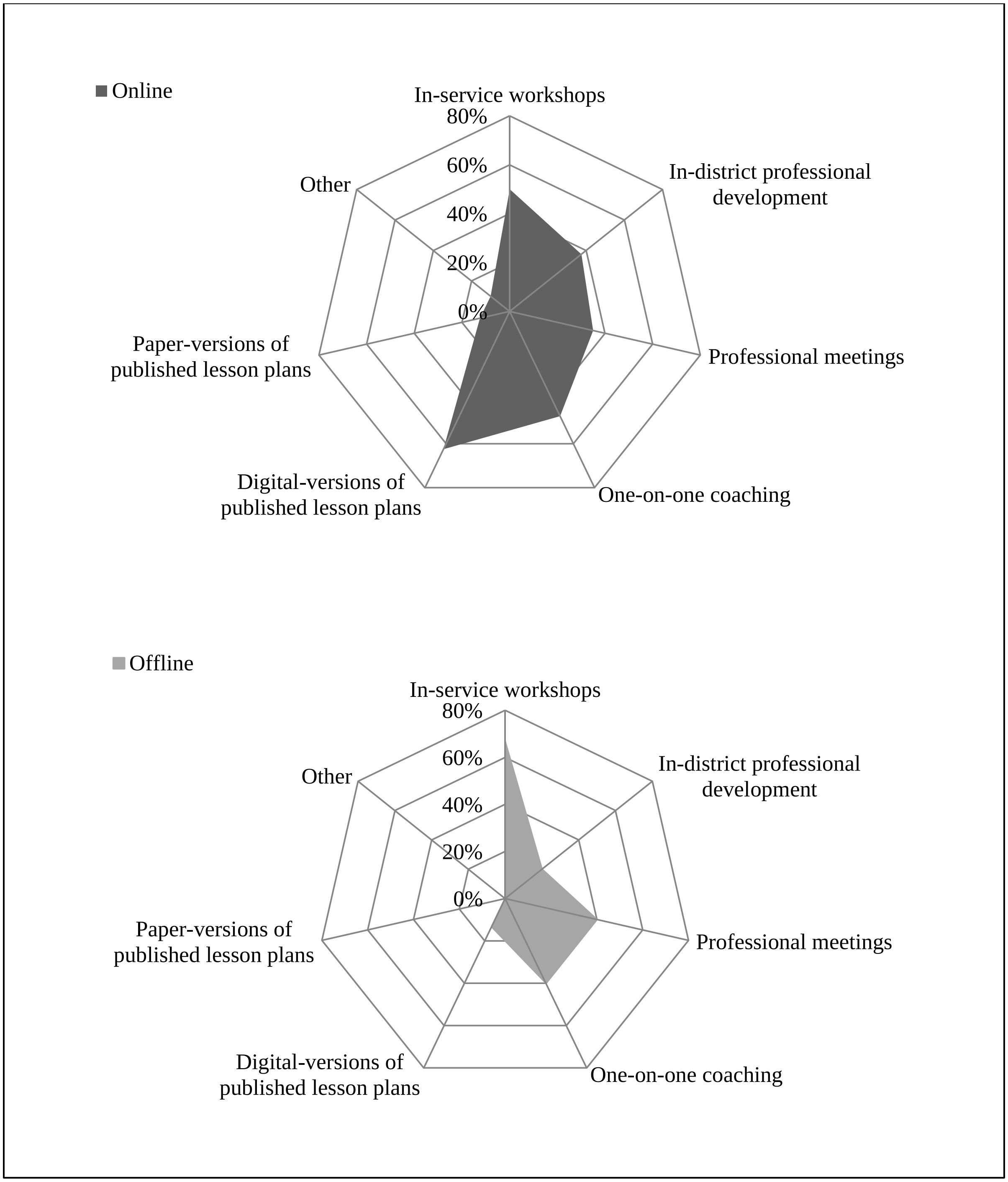


Figure 5.10. Comparison between online and off-line testing participants' preferred training types

5.3.2 Participants with Less vs. More Teaching Experience

Conveniently, participants were divided between those with less than five years of teaching experience and those with more. Twenty participants had five or fewer years of teaching experience. Thirty-five participants had more than five years' experience. Table 5.11 shows the results of descriptive statistics and t-test for two groups, less (≤ 5 years) and more (> 5 years) teaching experiences, for six questions. Interestingly, I found that the means of the two groups' responses regarding tutorials' ease of following were significantly different. The mean of less teaching experiences group was 4.4 while the more teaching experience group was 3.9, so the difference was 0.5. Its p-value of the t-test was 0.0, which was less than the alpha level 0.05. Therefore, participants with less teaching experience felt the training tutorials were easier to follow than participants with more teaching experience. The responses to the other five questions did not show statistical differences based on participants' years of teaching experiences.

Table 5.11. Descriptive Statistics and t-test for Participants Based on Teaching Experiences

Questions	≤ 5 years			> 5 years			Results	
	n	x	s	n	x	s	p-value	Decision
Tutorials' ease of following		4.4	0.6		3.9	0.9	0.0	Significant (difference in means)
Self-rated GIS technology background level		2.6	1.0		2.9	0.8	0.3	
Preference for online training	20	3.8	1.0	35	3.8	1.2	1.0	Not significant (no difference in means)
Tutorials' help for classroom implementation		3.8	0.9		3.5	1.0	0.3	
Web-based GIS's usefulness and effectiveness		4.3	0.7		4.4	0.8	0.6	
Tendency of web-based GIS implementation in the class		4.3	0.7		4.5	0.8	0.4	

Figure 5.11 shows the patterns of the two groups in terms of preferred training types. Except for one-on-one coaching and professional meetings, responses for other training types were similar between groups. Approximately half of the participants in both groups preferred in-service workshops and digital-versions of published lesson plans. However, only a few participants preferred paper versions of the lesson plans. The differences between groups could be seen in terms of one-on-one coaching and professional meetings. Of the participants, 54.3%

of those with more teaching experience preferred one-on-one coaching, while only 30.0% of the participants with less teaching experience chose it as their preferred training type. Professional meetings had the similar patterns. Of the participants, 17.9% more of the group with more teaching experience liked training at professional meetings than did the group with less experience. The results suggested that participants with more teaching experience liked to learn alone with direct support, and they also liked teacher trainings offered outside of their schools and school districts.

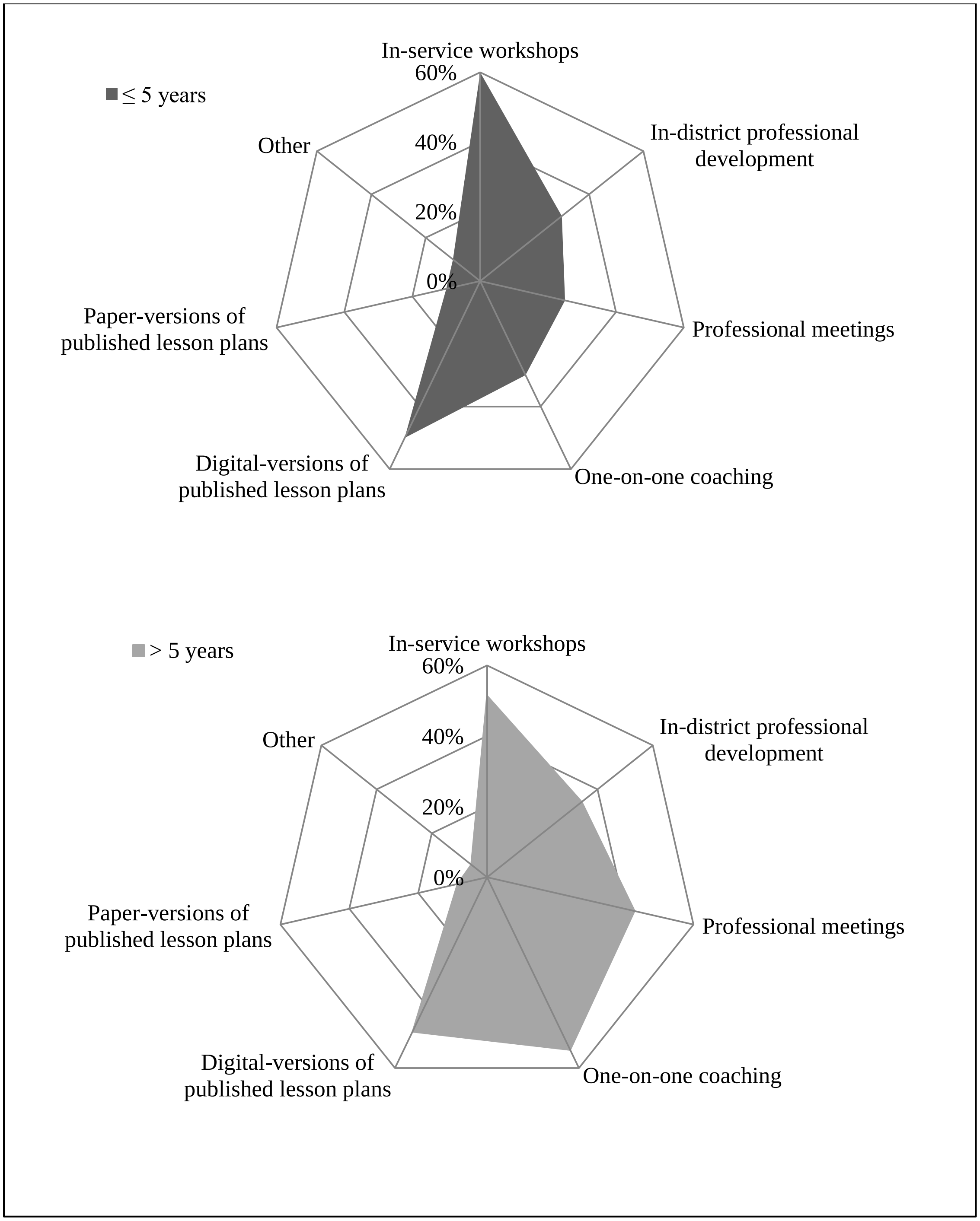


Figure 5.11. Comparison between participants with less and more teaching experiences' preferred training types

5.3.3 Participants with Higher vs. Lower GIS Technology Background Levels

The third group comparison was between participants with higher and lower GIS technology background levels. Participants were asked to self-rate ("none" to "advanced") their background and knowledge levels of five GIS related technologies such as web-based GIS and Google Earth. The averages of their self-rating for five different technologies were calculated. Then participants were grouped into two categories by the rating average as 3.0 ("some"). Therefore, participants who had higher than a 3.0 rating average were grouped as the higher GIS level, and participants who had lower than a 3.0 rating average were grouped as the lower GIS level.

Table 5.12 shows the results of descriptive statistics and t-test for participants with higher and lower GIS levels. The first question was about their years of teaching experience. There were about two years of difference between the two groups, but there was no significant difference in means. The means of the five questions about tutorials, online training, and web-based GIS were also compared between the two groups. The means of all of the questions' responses were not significantly different in the two groups. One of the questions, preference for online training, had a low p-value (0.1). If the alpha level was set to 0.1, it might be concluded that there was significant differences between two groups. However, because I set the alpha level at 0.05, the results were not a significant difference.

Table 5.12. Descriptive Statistics and t-test for Participants with Higher and Lower GIS Technology Background Levels

Questions	Higher GIS level			Lower GIS level			Results	
	n	x	s	n	x	s	p-value	Decision
Years of teaching experiences	27	12.0	9.6	28	9.9	8.6	0.4	Not significant (no difference in means)
Tutorials' ease of following		4.2	0.8		3.9	0.8	0.2	
Preference for online training		4.1	0.9		3.6	1.2	0.1	
Tutorials' help for classroom implementation		3.7	0.8		3.5	1.1	0.4	
Web-based GIS's usefulness and effectiveness		4.4	0.7		4.3	0.8	0.7	
Tendency of web-based GIS implementation in the class		4.5	0.6		4.3	0.9	0.2	

Preferred training types of two groups' participants were also compared (Figure 5.12). Unlike the above group comparisons, there was not a great difference between the two groups. From the results, I could say that regardless of GIS technology background levels, participants preferred in-service workshops, digital-versions of published lesson plans, and one-on-one coaching. Only a few more participants with higher GIS levels preferred in-district professional development and digital-versions of published lesson plans than participants with lower GIS levels.

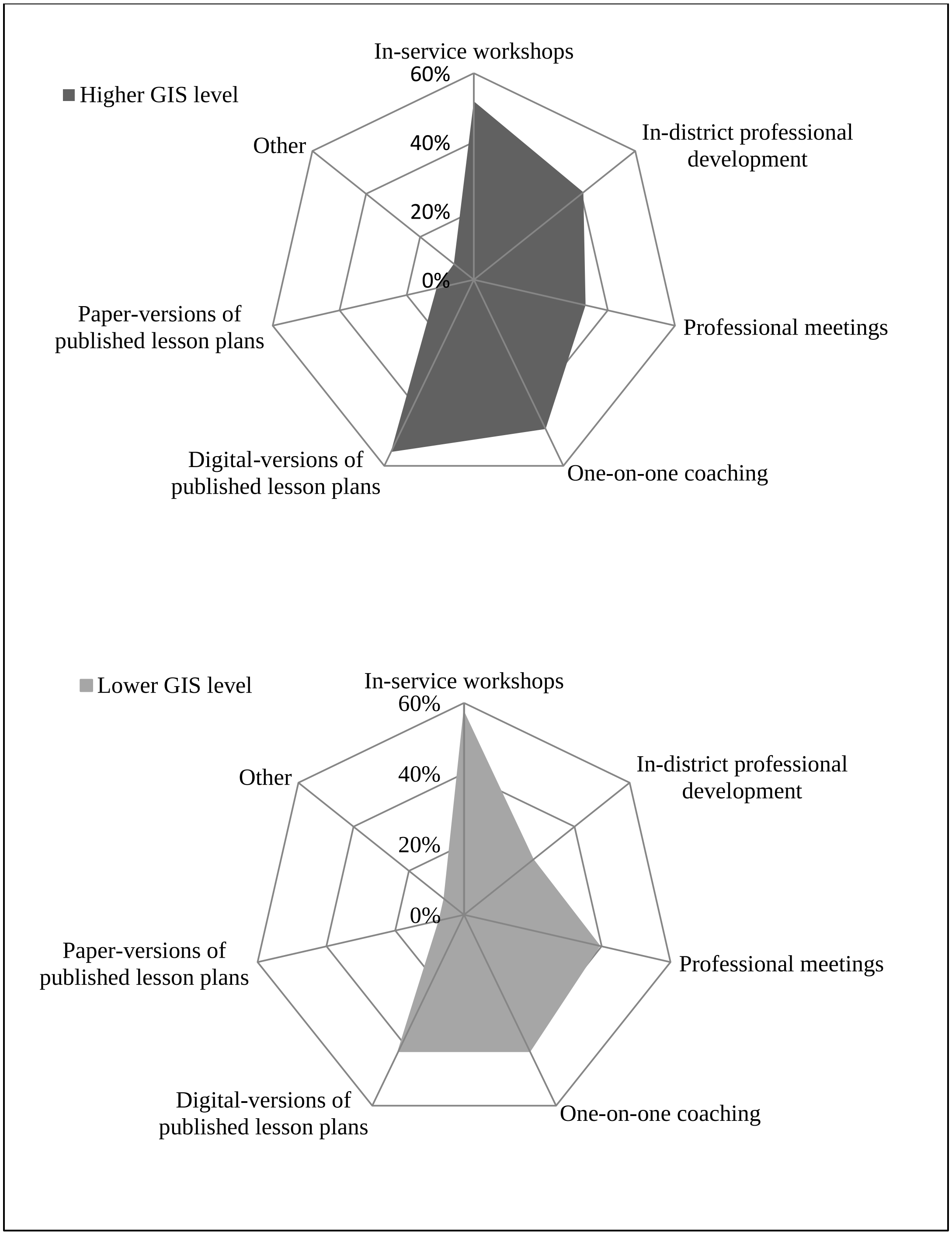


Figure 5.12. Comparison between participants with higher and lower GIS technology background levels' preferred training types

5.4 Survey Results of the Follow-up survey

Seventeen participants took the follow-up survey. Among them, 11 participants responded that they used web-based GIS technologies in their classrooms. After the user survey, 7 participants used tutorial topics from GIS for Social Studies, and 4 participants also used tutorial topics and created their own web-based GIS materials with their students (Figure 5.13). Six participants did not have a chance to implement web-based GIS in their classrooms. Therefore, the overall implementation rate was 20.0% (11 participants among 55 total participants). Out of 11 participants who implemented web-based GIS technologies in the classroom, 7 participants used them once or twice, and 1 participant used them three to four times. There were 3 participants who used them with their students more than five times. The results of the follow-up survey will be illustrated by four sub-sections, including assessment of training tutorials, description of participants' own materials, students' responses, and reasons not to implement web-based GIS.

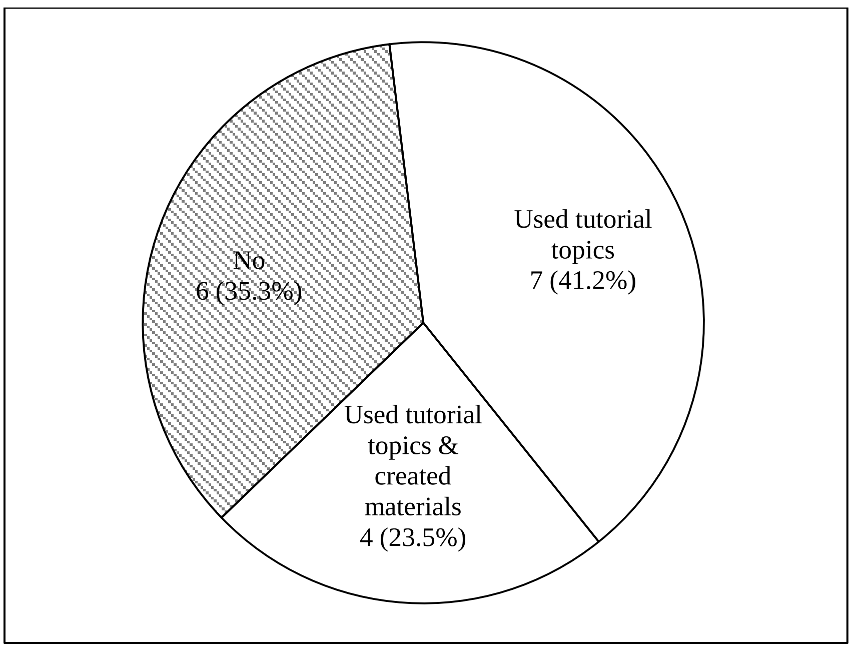


Figure 5.13. The results of classroom implementation

5.4.1 Assessment of the Training Tutorials for the Follow-up Survey

As described above, 11 participants used more than one tutorial topic from GIS for Social Studies in their classrooms. Table 5.13 shows tutorial topics that participants used with their students for the follow-up survey. Four participants implemented the 6th grade's *Deforestation in the Amazon Rainforest* topic. The 7th grade's *Ancient Greece and Rome* and *Human-Environmental Interaction* topics were implemented by 3 participants. Two of the 6th grade's topics, *Immigration to the U.S.* and *Natural Disasters in America* were not chosen by any participants.

Table 5.13. Tutorial Topic Selection for Follow-up survey (Total = 11 respondents)

Topic	Times Implemented
6th: Deforestation in the Amazon Rainforest	4
7th: Ancient Greece and Rome	3
7th: Natural Resources	2
7th: Human-Environmental Interaction	3
8th: Westward Expansion of the U.S.	1
8th: The Civil War	1
8th: Native Americans	1

Participants were asked to answer whether the tutorials were easy to use for participants and easy to follow for their students. Participants chose one of five categories (one: strongly disagree and five: strongly agree). The rating average of the first question, ease of use for participants, was 4.3, and the average score of the second question, ease of following for students, was 4.2. All 11 participants responded positively for the first question. In the case of the second question, only one participant chose a neutral response, "neither agree nor disagree."

Like the user survey, participants were also asked their best and least favorite features in the training tutorials (Table 5.14). Six respondents chose step-by-step instruction as the best features. One participant mentioned that "step-by-step instruction made it easy to understand and teach kids." The others also liked self-explanatory captured images of each step because "it was easier to see what the screens should look like to be sure the task was being done correctly." Two other participants liked interactivity of web-based GIS technologies because "students loved interaction," and "students were digital natives, so anything that used technologies appealed to them."

As the least favorite features, 5 respondents mentioned none. Two participants identified that instructions were too long, but they could customize the length for their classroom purposes. One participant commented with the following: "since the tutorials are so long when printed, I abbreviated them in a separate document with smaller sized pictures and brief explanations of tasks that students didn't already know. Also, I modified my purpose a bit, so I adjusted the instructions accordingly, but used the tutorial as a foundation (especially the pictures of what each step should look like!)."

Table 5.14. The Best and Least Favorite Features in the Results of Follow-up Survey

Best Features	Times Responded
Easy to follow	6
Students' engagement higher	2
Learning new tools	2
Engaging to real world	1

Least Favorite Features	Times Responded
Everything is fine	5
Too long direction	2
Need additional features	2
Advanced terms used	1
Difficult to replicate	1

Two other participants wanted to have additional features, such as how to save and create a trip in Google Earth and a student work sheet with more discussion questions. One participant mentioned that he or she had difficult time applying given activities for another location in the same topic. The participant mentioned that "I wanted to compare deforestation in Venezuela, but [I] couldn't figure out how to get similar maps over time [in Google Earth]."

5.4.2 Description of Participants' Own Materials

Four participants created their own materials with web-based GIS technologies and used them in their classrooms. For the question of whether the tutorials provided enough help to create and customize their own materials, 3 participants responded positively, and 1 participant chose the neutral response. Therefore, the rating average was 4.0 out of 5.0. As reasons, they mentioned that "detailed and easy to follow directions" were helpful. One mentioned that "the tutorials explained how to complete specific tasks for a variety of purposes."

These 4 participants created web-based GIS lessons for "deforestation in the world," "natural resources and its application of geographic studies," "using [web-based] maps to identify key concepts related to changes," and "to see the relationships among resource locations as well as examine the variations of climate around the globe." They used both Google Earth and ArcGIS Explorer Online to create the above lessons. The mapping tools that they used were labeling features or countries, dashboard, graduated colors, graduated symbols, adding a picture, and adding a map note.

5.4.3 Assessment of Web-based GIS Technologies

In order to find out students' achievement by implementing web-based GIS in the classroom, I asked participants four questions, including whether web-based GIS that they used encouraged students' engagement, increased students' understanding, helped reach the learning objectives, and were useful or effective instructional tools. All of the questions had very positive results. Except the question regarding increasing students' understanding (4.2), the other three questions' rating averages were 4.3 out of 5.0.

All of the 11 participants answered positively that web-based GIS technologies encouraged students' engagement in the classroom because students "were excited to do something new and relevant to our topics," and "they enjoyed interacting with a map instead of just looking at it." Also, except for 1 participant, all other participants agreed that web-based GIS technologies increased students' understanding of the topic the participants presented because "students were able to visually see where the events and cities were," and "they got to interact with some of the places that we discussed."

For the question regarding whether web-based GIS technologies reached the learning objectives of the topics participants presented, all participants answered either “agree” or “strongly agree.” Two participants mentioned that “use of technologies [could] reach standards, specifically, the national standard number 1, Map Skills. Other participants also mentioned that “students could visually see how geography affected the culture of Greece,” and “they became familiar with the places we discussed.” Lastly, I asked participants whether they thought web-based GIS technologies were useful and effective instructional tools. Except all but one participant, they agreed with the question. One participant mentioned that “students in the modern classroom are used to using technology; this enables them to interact with technology while visualizing the material in a unique way!” The participant who responded neutrally also commented that “[web-based GIS technologies] would be very useful if we could apply them to other situations.”

5.4.4 Reasons Not to Implement Web-based GIS Technologies

Out of 17 participants, 6 participants identified that they did not implement web-based GIS technologies in their classrooms yet for a variety of reasons (Table 5.15). The most common reasons were that the topics did not fit into their scheduled curriculum; they had not had an opportunity to implement web-based GIS technologies; and lack of time to learn and practice web-based GIS technologies.

Table 5.15. Factors Preventing Implementation of Web-based GIS Technologies in the Classroom

	Times Selected
Topics were not fit to my scheduled curriculum	3
No opportunity yet	2
Not enough time to learn and practice	2
Not comfortable to use due to lack of training and experience	1
Not available computing technologies in the classroom	1
Not a classroom teacher	1

5.4.5 Intentions to Implement Web-based GIS Technologies

All of the participants regardless of implementation experience in the classroom were asked to answer whether they would use web-based GIS technologies in their classrooms in the near future. Apart from one neutral response, all of the others responded positively. The rating average was 4.6. The rating average of participants who implemented (4.6) was slightly higher than participants who did not implement yet (4.5). However, both average scores were very much higher than any other of the previous questions. I think there is a chance that participants who already implemented will use web-based GIS technologies in their classrooms again; perhaps also, participants who have not yet done so will use web-based GIS technologies in the classroom in the near future.

5.5 Discussion

There are four major findings from the user survey and the follow-up survey.

5.5.1 Evaluation of GIS for Social Studies

Forty-seven participants (85.5% in Figure 5.5) identified that the training tutorials were easy to follow. Without direct support, most of the teachers were able to complete the tutorials. The detailed instructions seemed important; 40 participants (72.7% in Figure 5.7) responded positively that the tutorials provided enough help to create or customize web-based GIS by themselves.

However, there were different opinions about the level of detail provided in the tutorials. Participants who had fewer technological experiences commented that some instructions were too complex to complete; they wanted simpler and more detailed information. Some of them still wanted in-person help. For these participants, learning new technologies online without in-person help was difficult because of their lack of experiences and background. Some participants mentioned that some of the activities were too long to complete within their limited time and felt the tutorials were too time consuming. Other participants pointed out that some instructions were too repetitive, so they felt bored when they followed the instructions.

5.5.2 Evaluation of Web-based GIS as an Instructional Tool

Forty-nine participants (89.1% in Figure 5.8) agreed that web-based GIS technologies were useful and effective instructional tools because students could engage in and understand the contexts more effectively using interactive and visualizing functionality. Some of the participants mentioned that "not using technology is a mistake in this day and age," and web-based GIS technologies are "the wave of the future." Those participants knew that there would be barriers to using these technologies. But given the limitations, 51 participants (92.7% in Figure 5.9) answered that they would use web-based GIS technologies in their classrooms.

Among the various mapping tools in Google Earth and ArcGIS Explorer Online, participants identified some of the mapping tools, such as historical imagery and time navigator that helped to see any changes over time as useful to both participants and students. Being able to see the changes over time helped participants to explain reasons behind the changes and enabled students to better understand them. Also, participants liked mapping tools using color, like the multi-colored dot map and graduated colors tools. Participants mentioned that using colors was an easy way to make thematic maps to show differences or trends and to allow students to understand those themes and trends easily.

5.5.3 Comparison between Groups with Different Characteristics

Three group comparisons—online and off-line testing, participants' years of teaching experiences, and participants' levels of GIS technology background—were tested statistically to see whether there were significant differences in means of responses between different groups. As a result, only one question, tutorials' ease of following, in the second group comparison, participants' years of teaching experiences, showed that there were significant differences in the means of responses between participants based on teaching experiences. All of the other questions revealed that there were no significant differences between groups with different characteristics.

Participants' preferred training types were also compared in different groups. The biggest differences occurred between participants from online and off-line testing in terms of preference for digital-versions of published lesson plans. Twenty-five participants (62.5% of the online testing participants in Figure 5.10) from online testing chose digital-versions of published lesson plans as one of their favorite training types while only 2 participants (13.3% of the off-line testing participants in Figure 5.10) from off-line testing selected digital-versions of published lesson plans.

5.5.4 Positive Future of Classroom Implementation

From the results of the follow-up survey, I am able to see a positive future for the classroom implementation of web-based GIS technologies. Even though all of the 17 participants who agreed to participate in the follow-up survey did not implement web-based GIS technologies in their classrooms, all wanted to use web-based GIS technologies in the classroom. Participants who implemented had positive results in using GIS with students, such as encouraging students' engagement, increasing students' understanding, and reaching the learning objectives. Furthermore, they wanted to use web-based GIS technologies in the classroom again. Participants who did not implement yet also wanted to use web-based GIS technologies in their classrooms in the near future if they could have an opportunity to do so and enough time to learn and practice.

5.5.5 Possibilities of Self-selection Effects

As I described at Chapter 2, Methodology, I sent out several hundred emails to teachers directly across the U.S. to recruit participants for this study. Participants in this study, especially people who tested the tutorials online, were familiar with online training and had no objection to learning using online materials. Therefore, the survey results might be positively biased due to self-selection effects. I will discuss about this possible bias in detail in Chapter 6.

CHAPTER VI
DISCUSSION AND CONCLUSION

6.1 Research Questions

The goal of this study was to promote the teacher adoption of geographic information systems (GIS) technologies by providing teacher-centered and teacher-friendly training tutorials to middle school social studies educators. The study seemed to reach its goal, although it also suggested limitations and scope for improvement as discussed below. Overall, the user-centered design (UCD) approach helped design and develop the training tutorials to be easy-to-use and easy-to-follow for teachers. Therefore, most participants in this study reported positive attitudes towards the training tutorials. Among 55 participants for the user survey, 11 participants (20%) actually used the web-based GIS technologies in their classrooms with their students. Therefore, given this in-classroom usage, some of the identified barriers to limit the classroom implementation of technologies, such as lack of teachers' knowledge, seemed to be solved by this study. The study helped find types of training teachers liked or disliked and helped identify useful mapping tools for teachers and students in the classroom.

At the beginning of the study, four research questions were raised. The self-selection effects, described later in this chapter, may cause positively biased responses of those research questions. But, even though this study was likely to have attracted teachers interested in new technologies and be biased toward their experiences, their responses are still helpful in answering the research questions. In this section, I will identify answers of those four research questions based on the results of this study and introduce two additional important issues found in this research.

6.1.1 How would Teachers Like to Use Web-based GIS Technologies in the Classroom?

I found that majority of the participants (89.1% in Figure 5.8) "strongly agreed" or "agreed" with the statement that web-based GIS technologies are useful and effective instructional tools. They liked the functionalities of web-based GIS technologies, including their powerful visualization capabilities, interactivity, ability to engage students, multimedia features, availability for use at home (without the need to install software beyond a browser), currency of data, ease of use, and so on. The teachers' willingness to implement web-based GIS technologies was also very positive. As detailed in Figure 5.9, 92.7% of the participants indicated either "strongly agree" or "agree" when asked whether they plan to implement web-based GIS technologies in the classroom.

Even though some teachers reported difficulties in following the tutorials, they still appreciated the usefulness and effectiveness of web-based GIS technologies for them and for their students. This is an important point because without a positive attitude, it is difficult to persuade teachers to use new technologies in the classroom no matter how hard GIS researchers and professionals try to develop better GIS technologies for education. So, if well designed and matched to their interests, GIS technologies for K-12 have considerable potential as instructional tools in K-12 classrooms.

6.1.2 What Barriers do Teachers Report that Limit their Use of these Technologies?

Identifying factors to prevent using information and communications technologies (ICT) including GIS technologies were asked to participants for both the user needs analysis and the evaluation steps. Their responses were almost similar each other. Also, some of the responses paralleled previous findings regarding limitations of using desktop GIS technologies in the K-12 classroom by other researchers. In Chapter 1, I introduced four different barriers to the implementation of desktop GIS by K-12 teachers. Those limitations were lack of teachers' time to learn and practice, the difficulty and complexity of desktop GIS software, lack of computing and network systems within their schools, and inadequate curriculum time.

Participants in this study also identified barriers to prevent using ICT, including GIS technologies, such as unavailable technologies for every student at each school, lack of teachers' time and knowledge, and unstable networks. Limitations, like difficult and complex GIS software, seem to be solved through this study because many participants mentioned that the tutorials' step-by-step instructions helped them follow the tutorials without having direct support from another person. However, other issues remained, such as organizational and administrative issues in the education—lack of teachers' time to learn and practice up-to-date technologies and the unavailability of necessary technologies at some schools—which could not be overcome through this study.

6.1.3 What Sorts of Training and Help do Teachers Find Most Useful in Getting Started?

6.1.3.1 Teacher Training Types

One of the questions in the user survey asked participants' preferred teacher training types (Table 5.8). Among six different training types, the top three training types that participants preferred were in-service workshops (54.5%), digital-versions of published lesson plans (49.1%), and one-on-one coaching (45.5%). The main reason that they liked in-service workshops was that they could get credits such as service hours when they took workshops. In case of the digital-versions of published lesson plans, they liked the possibility to do training freely on their own time without having any restrictions. Also, many participants liked to have one-on-one coaching, but they knew that it was not possible in most situations.

Within the overall patterns, I found that individual participants often had clear preferences for certain types of training. The results seem related to Kolb's experiential learning theory, briefly introduced in Chapter 3, which suggests that individuals have preferred learning styles. There was also clear division between participants who preferred online training and participants who did not. Those of the participants who liked online teacher training wanted to learn at their own pace. However, other participants who preferred off-line training wanted to be coached by instructors to get feedback from them directly.

These differences in preferred training types suggest that no single type of training can satisfy every K-12 educator. This suggests that providing a variety of training types would be useful to helping teachers adopt GIS technologies. These might include offering both off-line and online teacher training. For the off-line training, workshops for teachers at the school district level should be effective. Although resources in school districts will vary, off-line training might be coupled with incentives, such as in-service credits or stipends, to make the training more attractive. To boost completion rates, other rewards might be offered at the end of the training, depending on the context of the training program. The training might also be customized to suit the teachers' technical backgrounds and goals with different workshops or training sessions aimed at each audience. For example, groups could be formed for beginning, intermediate, and advanced users separately.

Groups with small numbers of participants would be helpful. Also, the regularity of offering workshops may be important. Rather than offering a workshop as a one-time event, having workshops regularly, such as bi-weekly or monthly might be helpful to teachers in order to learn GIS technologies. The workshop members would be learning partners and supporters at the same time; they would help each other, discuss together, and share materials together. The same materials for the off-line training would be available online, too. Therefore, teachers who prefer learning online could also participate in the training.

6.1.3.2 Effective Design of Teacher Training

From the results of the user survey, I found that it is very difficult to satisfy teachers with different technical levels using one version of training tutorials. Based on the results of the user needs analysis, I determined to design tutorials as detailed as possible to fit the level of novice computer users. The detail of the tutorials was not as well suited to teachers with more advanced skills; they found the tutorials less engaging and too time consuming. For them, overly detailed instructions were unnecessary. Therefore, for more advanced teachers, the ability to skip instructions would be very useful.

However, the tutorials were not detailed enough to teachers at the beginner level. The beginners wanted to have even more specific instructions than the current version provided. For teachers who have almost no computing experience, providing basic training of computer technologies will be a priority: for example, how to copy and paste and how to create a new file and folder. One of the participants mentioned that “the difficulties I had are based on the fact that I'm not very familiar with new technology, so I had some basic issues that involved computer literacy more than understanding how to use the tutorials.” Once teachers are comfortable with working on computers, then training with GIS technologies will be much effective.

The different degrees of detail based on levels of technology suggest the value of implementing context-sensitive help. Context-sensitive help can be defined as a type of online help that a user can receive when he or she needs help documentation for a certain part of an application/system instead of having the entire help documentation all the time when the user uses the application/system (Lammers 2000). There are two types of context-sensitive help—a dialogue-level and a field-level (James-Tanny and Nelson 1999) (Figure 6.1). The dialogue-level offers help documentation for the all of the objects on the entire screen. A traditional and commonly seen example of the dialogue-level context-sensitive help is the Window’s F1 key to call help documentation for a certain page. The second type is a field-level, a short paragraph of help documentation for one object on a screen. The field-level context-sensitivity help appears as a pop-up window when a user wants to know a tool or function among many others on the screen. The "What's This?" tool in Esri’s ArcMap is a good example of field-level help.

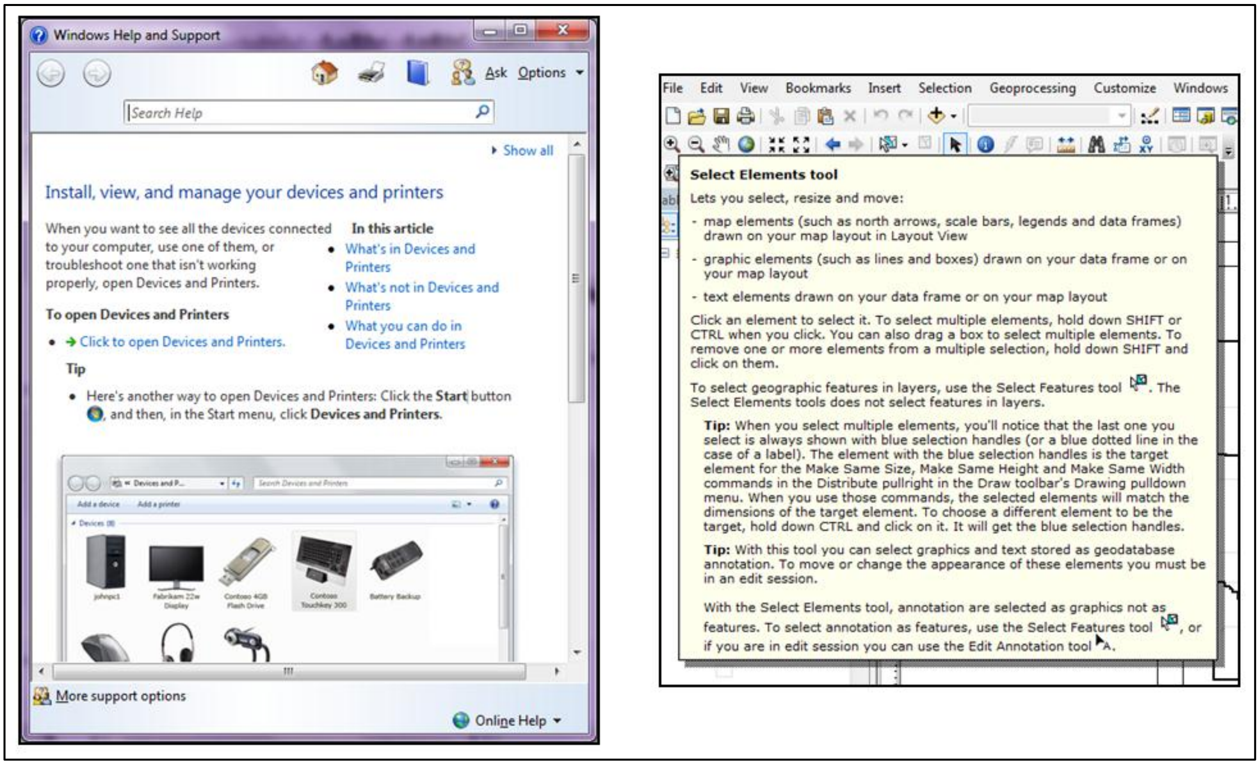


Figure 6.1. Examples of a dialogue-level help (left) and a field-level help (right)

For tutorials for K-12 teachers, implementing a field-level context-sensitive help format might be valuable. For example, the basic structure of tutorials can be presented on a webpage (as was done in the current version), but additional information would be provided in a pop-up window for teachers who asked for more help. If a teacher does not need additional information, he or she can move to the next step without using the additional help. In this case, one version of the tutorials can be developed rather than several versions for different skill levels. In this way, teachers could choose the level of help they need rather than have developers try to anticipate these needs in advance.

6.1.4 What Kinds of Mapping Tools are Most Useful to Teachers Wishing to Implement in the Classroom?

Of the sixteen different mapping tools provided in the training tutorials, the most highly rated fell into two groups. The first group included historical imagery, the time navigator, and the map presentation tools. The second group included functions for using color, such as a multi-colored dot map and graduated colors for mapping data.

The historical imagery tool in Google Earth seemed to be the most useful mapping tool (Figure 6.2). This tool allows users to see landscapes of the past using the time slider. Participants thought the historical imagery tool was useful because they could see landscape changes over time. For similar reasons, participants rated highly the usefulness of the time navigator and map presentation tools in ArcGIS Explorer Online. The time navigator tool is similar in function to the historical imagery in Google Earth, and the map presentation tool can be used as a slide show like in Microsoft PowerPoint. These results seem to imply that teachers find these features useful in explaining concepts relating to change through time. Such implication recalls the popular phrase, “a picture is worth a thousand words.” Showing changes in an image can be much more effective than explaining them in difficult words. Also, this type of mapping tool can be useful in classrooms with students to make students understand the concept easily and engage in the activity. With this tool, teachers can help students become interested in the course topic.

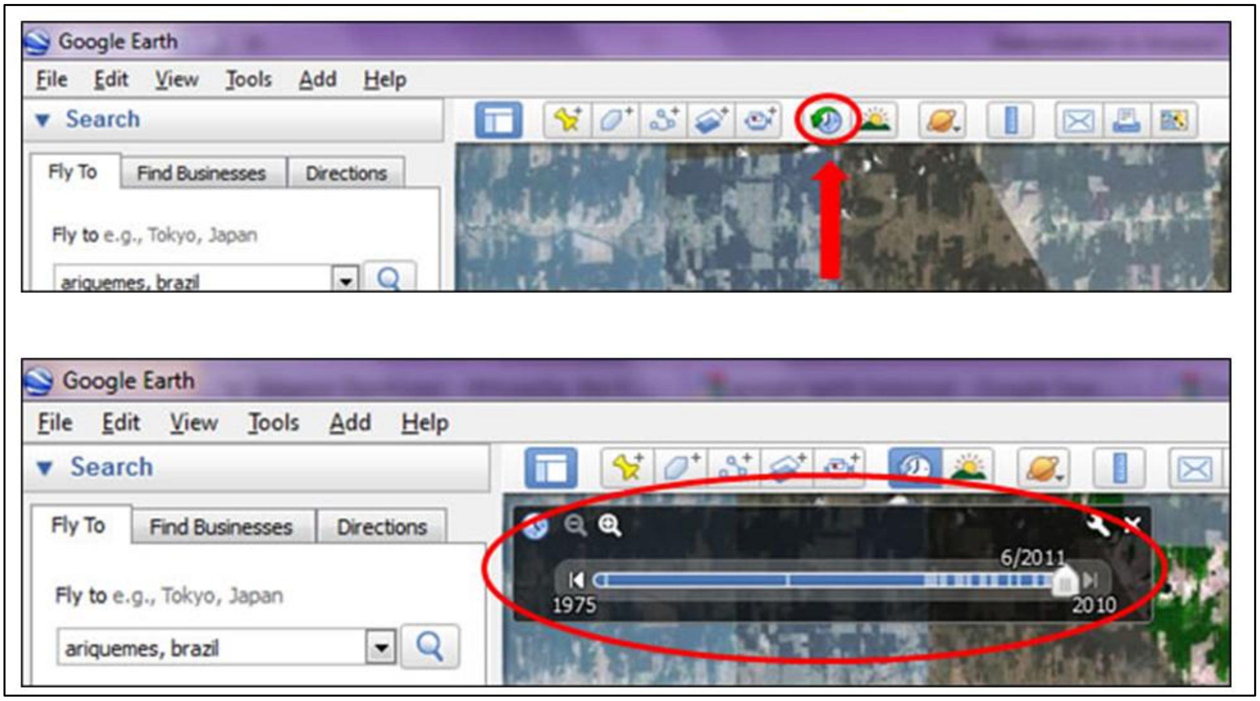


Figure 6.2. Historical imagery in Google Earth (above) and its time slider (below)

Participants also valued the thematic mapping tools of the online systems. These tools allowed the teachers to use colors and symbols to map qualitative and quantitative data. For example, the multi-colored dot map tool was used to create a map to show major products of the U.S. from the 1820s to 1860s (Figure 6.3). Each major product was represented by a color-coded circle symbol. The graduated colors tool was introduced in several different tutorials. A continuous range of colors can be used to represent quantitative information.

There is similarity between the two groups of mapping tools, those for historical information and those for color-coding; that is, mapping tools in both groups are only available or well applicable in GIS technologies. In other words, those tools cannot be used exactly the same way in other technologies, or even when they can be employed in other cases, it is difficult to use them as effectively as in GIS technologies. Mapping tools with colors can be implemented using colored pencils and paper maps. However, it would be inconvenient and rather cumbersome to do it.

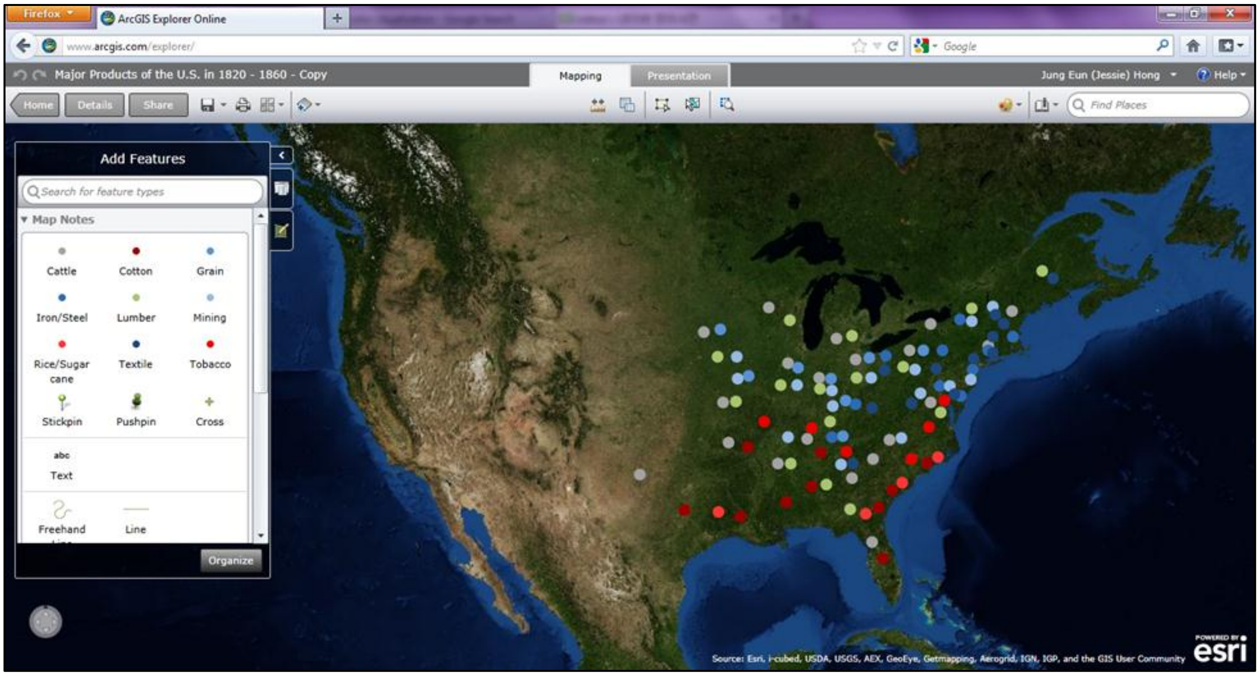


Figure 6.3. Showing major products of the U.S. in 1820s-1860s using multi-colored dot map

Lastly, not all of the tools used in the tutorials were highly rated. For example, the 3D trees and drawing tools were not rated highly. It seemed that, for teachers, they had other ways of showing such concepts and information.

As a result, most participants thought mapping tools, which were provided by only GIS technologies or used effectively in GIS technologies, were useful to them and students in the classroom. That is, some of tools in GIS technologies would be useful and effective in K-12 classrooms. If those tools were designed and developed to be easy-to-use for both teachers and students and to add educational features, then more teachers would find those tools useful and implement them frequently.

6.1.5 Other Issues

6.1.5.1 Mismatch between Tutorials' Design and Users' Needs

It is notable that, even though the tutorials were designed and developed based on suggestions made during the user needs analysis, one topic of the tutorials was not used at all and some received relatively little use. This suggests that even if a user needs analysis is performed, such analysis is not infallible. This observation cautions against putting too much weight on the findings of this study.

Nine topics were chosen by participants' responses at the user needs analysis step (Table 3.19). The participants suggested that these nine course topics would be well developed with GIS technologies. However, at the evaluation stage, no one tested the *Immigration to the U.S.* topic, which was suggested by three participants at the user needs analysis step. Participants were not specifically asked for their reasons of selecting a topic to test. My assumption is that the *Immigration to the U.S.* topic was less attractive to the participants than other topics because it might not fit into the participants' curriculum schedule, or the participants might not teach this topic at all.

This implies that even if the tutorials were designed solely based on what a group of teachers suggested, there was still gap between the tutorials' design and actual users' needs. That is, opinions and preferences of 23 teachers who participated in the user needs analysis cannot represent those of a large group of teachers. Therefore, the findings from the user needs analysis are not easy to generalize. This mismatch issue might be inevitable no matter how many teachers' opinions are analyzed and considered in the design of tutorials in advance because everyone has different opinions, and a sample cannot represent the population in reality, especially where different school districts hold differing curriculum requirements. However, the amount of mismatch can be lessened by interviewing a greater number of teachers for the user needs analysis.

6.1.5.2 The Time and Effort Required to Create and Update Online Learning Materials

It is worth reflecting on two other aspects of the research: the time involved in creating the tutorials and the challenges of continually updating the materials to respond to application updates and improvements. Two online mapping applications, ArcGIS Explorer Online and Google Earth, used in this study are constantly updated. The constant updating means that the companies keep developing new and technically improved features for users. However, it also means that the user interface designs of both applications might be slightly changing every update, and there might be some tools unavailable in newer versions.

The version update occurred during the development process of this study, too. The locations of some features were changed, so I had to re-capture the screen shot for the tutorials to reflect the changes. However, during the evaluation step, I did not revise the tutorials based on the updates of both mapping applications. Therefore, some participants identified slight interface differences between the tutorials and the applications and questioned these differences on the survey.

If the interface of the tutorials is different from the actual applications, participants might react differently depending on their different levels of computing proficiency. For participants with the intermediate and advanced computing technology levels, the slight changes of interface might not be a big problem because they have an ability to adjust to the newer interface once they spend a little time with a given application. However, the slight changes can have huge impact on the novice computer users. Because the novice users are not familiar with the computing environment, they might have difficulties if the interface of an application is different from the captured image in the tutorials. Some of them might give up following the tutorials because they cannot figure out what to do. Therefore, to prevent this issue, the tutorial developer/designer should update the tutorials immediately if the applications are updated.

However, updating tutorials based on an application's updates is not easy in reality. It takes substantial time and effort to revise tutorials every time the application is updated. The tutorial developer/designer needs to pay attention to the application updates continuously. He or she needs to find out newly added and removed features and any constraints of a newer version. Re-capturing images of the application for the tutorials might be required at every update. If a tool is removed in the newer version of an application, the tutorial developer/designer needs to find other tools to substitute the previous tool. It takes a great deal of time and effort. This issue will be another significant barrier against teaching tutorials for any applications.

6.2 Limitations of the Study

There are two limitations of this study that limit my generalizations.

6.2.1 Sample Size

In this research, 23 teachers participated in the user needs analysis step, and 23 teachers helped in the tutorial development step. Also, there were 55 participants for the evaluation step. Opinions and suggestions of the first 23 participants for the user needs analysis provided the foundation for planning and designing the tutorials. Twenty-three participants also provided feedback on the tutorial development as they were being developed. Fifty-five participants, including some of the original 23 participants, evaluated the final tutorials.

Although these numbers are sufficient for the current project, they mean that the results reported here cannot be generalized too widely beyond the sample itself. The results suggest the value of improved training materials, but a larger sample of teachers would need to be involved. As I mentioned above, despite the input provided by the user needs analysis, one of the tutorials was not used at all. If more participants were recruited for the user needs analysis, this sort of mismatch of needs and resources might be avoided. Also, if a greater number of participants gave opinions at the tutorial development step, the final versions of tutorials might be more teacher-centered and teacher-friendly to help be attractive to a larger extent of teachers. Collecting diverse opinions and getting in-depth feedback from a greater number of participants in first two methods steps would lead to more positive results in the evaluation step. Therefore, not having enough participants in each method step would be a limitation in this study.

6.2.2 Self-Selection Effects

Participation in this study was voluntary. There was no reward for participation and no pressure by others, such as school districts or state departments of education, even though some of my invitation letters to teachers were forwarded by administrators. Out of the approximately one thousand teachers who received the invitation letter for this study, 30 teachers responded that they were interested in participating in this study for the user needs analysis and the tutorial development steps, and 55 elected to participate in the evaluation step. It is likely that those who responded already had an interest in mapping and web technologies and, perhaps, more familiarity with instructional technologies than teachers who did not respond.

This self-selection effect may be related to the overall positive results of the user survey. For example, the average rating score of the question regarding ease of following of the tutorials was 4.1 out of 5.0. The average rating scores of both the usefulness of web-based GIS technologies as an instructional tool and the willingness to implement web-based GIS technologies in their classrooms were 4.4. The results of the follow-up survey were even more positive than the user survey results. The average rating scores of all of the questions were above 4.0., as examples, the tutorials' ease of use to teachers (4.3), ease of following to their students (4.2), students' engagement (4.3) and understanding (4.2) with web-based GIS technologies, and willingness to implement again (4.6).

I do believe that the methodological approach I adopted was effective in reaching its goals since the overall feedback was positive, but the very high ratings may be due to the self-selection effects. As I mentioned the above, among so many teachers who received the invitation letter for the study, people who actually participated in the study might already have positive attitudes towards learning and implementing new instructional technologies in their classrooms. Some participants might have previous exposure to GIS technologies, or others might not have had any experience, so they wanted to learn about GIS technologies. Either way, because they originally had interest or curiosity regarding GIS technologies, they agreed to participate in this study without receiving direct rewards.

Also, the positive results of the follow-up survey were very obvious. I asked participants for the user survey to leave their contact information, so that I could ask them follow-up questions later. Out of 55 total participants for the user survey, only 19 participants provided their contact information, and 17 of them completed the follow-up survey. I assume that these 17 participants originally had strong interest and willingness to implement web-based GIS technologies in their classrooms compared to participants who did not provide contact information. Therefore, the results of the study might be positively biased due to self-selection effects, but the amount of influence cannot be estimated.

In order to collect not-biased results of the study, recruiting teachers with diverse characteristics and opinions is recommended, for example, teachers who do not have any intention to use technologies at all and teachers who have never used technologies in the classroom. However, pragmatically, encouraging these teachers to participate in this type of study is not easy. They might not want to spend their personal time to participate in a study that they are not interested in. We have to admit that not all teachers want to learn and practice new technologies for their students. The actual number of these teachers might be large. Encouraging them to participate in the study in order to know their opinions is fundamentally important to increasing the implementation rate of GIS technologies. To do that, attractive rewards or mandatory requirements by school districts will be necessary. However, there might be still an issue because teachers with greater interest would test the tutorials better and engage in participation more than other teachers. This type of educational study, introducing new instructional technologies, seems to be impossible to avoid the self-selection effects.

6.3 Broader Implications of the Study

This study was somewhat successful to promote teacher adoption of GIS technologies by providing teacher-centered and teacher-friendly training tutorials of web-based GIS technologies. The training tutorials were designed and developed based on what teachers actually needed and wanted. As collaborators, a group of teachers participated in the planning, designing, and developing processes of the training tutorials. Therefore, their collaboration helped other teachers follow the tutorials easily.

Classroom implementation was not required and not asked of participants in this study. However, from the results of the follow-up survey, 11 participants responded that they used web-based GIS technologies in their classrooms with students. That is, this study encouraged and persuaded 20% of the total participants for the user survey to implement web-based GIS technologies in their classrooms. The teacher adoption rate might be higher if all 55 participants for the user survey were asked, instead of only 17 participants who took part in the follow-up survey. Out of 17 participants, 11 participants implemented web-based GIS technologies in their classrooms and remarked that these technologies helped students engage into the classroom, students understand the contents, and reach planned learning objectives of the course. All 11 participants agreed that web-based GIS technologies were useful and effective instructional tools in the classroom, and they would like to use them again.

Therefore, some barriers, including costs of software, lack of teachers' knowledge of technologies, and lack of resources, seemed to be solved by using free online mapping applications and providing effective training tutorials of the applications. However, still there were other substantial barriers to prevent the classroom implementation of GIS technologies, such as the lack of computers and information technology at some schools, lack of teachers' time, unstable Internet connections, and so on. These barriers could not be solved by this study, and these require long-term solutions on the institutional and societal level.

This study suggested one useful and effective way of promoting teacher adoption of GIS technologies, but it could not be the best and fundamental solution. Participants wanted to have a broad range of detailed training materials available for entire course units and aimed at teachers with varying levels of computer skill. Such resources would be difficult to provide in a project like this, but are an issue that suggests further research on designing and developing useful and effective GIS training materials for K-12 teachers to increase the implementation rate in the classroom.

6.4 Next Steps for Future Research

6.4.1 Pre-service Teacher Training: A Long-term Solution for Effective Teacher Training

This study focused on in-service training for teachers who are already in the classroom. In-service GIS teacher training can be a good way of increasing the adoption rate of GIS technologies in the K-12 classroom, but it is not necessarily the best method. Many in-service teachers in this study mentioned that they did not have enough time to learn and practice new technologies because they were busy preparing and developing lessons during planning time and needed to spend time for themselves and/or their families after working hours. Also, some teachers believed that implementing new technologies was not necessary because they were already used to teaching without them and teaching with traditional methods was still effective.

Therefore, it may be more effective and efficient to train pre-service teachers GIS technologies during their teacher certification programs. Generally, pre-service teachers are younger than in-service teachers, so they tend to understand and learn new technologies rapidly because they are used to using computing technologies. If GIS training is provided as a form of a coursework, the results of training will be optimistic because there is an obligation as a class that pre-service teachers need to complete it. The focus of such a course will be how to use GIS in the classroom as an instructional tool (teaching with GIS) rather than what GIS is (teaching about GIS). Instead of teaching the overall GIS technologies like an introductory GIS course at a geography department, the course should be designed uniquely for K-12 education.

Also, offering this course for the senior-level students might help them gain familiarity with these technologies before they become in-service teachers. This type of course should be taught by GIS professionals with expertise in K-12 education, who know the general curricula in K-12 education and have the ability to apply their GIS technical skills for educational circumstances. This will be a recommended way of improving teacher adoption of GIS technologies in the K-12 classroom.

6.4.2 Development of Web-based GIS Applications for Educational Purposes

Some participants remarked that online mapping applications were not teacher-friendly even though the training tutorials appeared easy-to-follow. Their comments made me question the necessity of web-based GIS applications for solely educational purposes. No matter how current online mapping applications have been designed to be easy-to-use for the general public, still novice computer users have difficulties using these applications without training or support. In K-12 education, for some teachers and students who do not have a certain level of computing experience, using these existing online mapping applications is too difficult and complex. Besides, in these applications, there are many functions that may be valuable for general use but not useful and important in K-12 classrooms. These difficulties directly link to the low teacher adoption of GIS technologies. Some people might say that developing new online mapping applications for educational use is not necessary and not a financially valuable investment because it is not profitable for development companies.

However, this might not be true; such applications can be a moneymaking item for developers. In order to develop marketable online mapping applications for K-12 education, the developers should consider two key factors—design and content. The design of the application should be user-friendly; that means an easy-to-use design for both educators and students. The user interface design should be simple and straightforward but visually appealing. The contents imply map contents, including layers and attribute information. I found that many participants wanted to have map contents for their entire course units if possible. They wanted to use map layers for a certain region or country to represent various themes of the location based on the learning objectives of the course unit.

Training teachers how to create map layers and combine attribute information on the layers can be an option to increase GIS adoption. Training K-12 teachers how to customize and edit map contents is pragmatic. However, training substantial technical background material and applications of GIS technologies to K-12 teachers in a situation like a semester-long college level introductory GIS course is not feasible due to a lack of teachers' sufficient time. Therefore, developing and providing related map contents for all levels of K-12 education by the developers is required, and continuous updating of these map contents is necessary, too. The map contents should follow basic national standards, but also consider commonly applicable state standards. Besides, based on the map contents, the developers need to decide useful and effective mapping tools, and provide only these tools rather than offering all available tools.

Also, the mapping applications should provide context-sensitive help to be effectively applicable for all levels of teachers. As mentioned earlier, one version of help cannot satisfy all teachers when they possess various technical levels of computer skill. The advanced level teachers might not need detailed instruction while the novice level teachers might want step-by-step instruction. Therefore, the mapping applications for K-12 teachers should offer context-sensitive help, so that teachers with different technical levels are able to get the right amount of help if they need.

Well-developed online mapping applications for K-12 education will be attractive to school districts. Once the school districts understand the usefulness and effectiveness of GIS technologies for their students, they will be likely to purchase the applications. Of course, the developers need to provide ongoing support and training opportunities to educators in the school districts if necessary. This scenario will eventually increase the implementation rate of GIS technologies in K-12 education.

6.5 Conclusion

The fundamental reason for developing these training materials was to see if new web-based techniques would make it easier for teachers to learn and use GIS technologies. Even though students' geographical reasoning and spatial thinking skills can be improved without using GIS technologies, teachers and students can gain many benefits by teaching with GIS technologies, such as access to rich and up-to-date resources, increased student engagement, easily customized materials, high visual impact, and so on.

The planned goal of this research was to promote teacher adoption of GIS technologies in the classroom. To reach the goal, this study adopted the UCD approach, which originally requires an ongoing iterative designing process—revising design and contents continuously followed by users' feedback and suggestions (Figure 2.1) to develop products with the high level of usability. According to the UCD approach, I might have continued my research by revising the training materials again after the evaluation step. However, I decided to stop after the evaluation for several reasons.

First, the purpose of this study was not developing the complete GIS training materials for middle school social studies educators. Rather, it was to see how much some principles of the UCD approach could help increase the adoption rate of GIS technologies in the classroom. Second, the study was not intended to test the UCD approach in a strict experimental testing environment, but rather to see if some of the principles of UCD would improve teacher adoption. A strict experimental or quasi-experimental design would have been very difficult to undertake. Finding teachers, who are willing to participate with similar levels of computer experience, of similar demographic background and who will access to comparable computer technology would be very difficult, if not impossible. Therefore, this was more of a general exploratory study into whether the UCD approach can help teachers develop GIS skills and materials.

In this study, two free online mapping applications, ArcGIS Explorer Online and Google Earth, were implemented. Google Earth widely used application that can be downloaded for free. ArcGIS Explorer Online is also a free application and does not require installation since it operates on an Internet browser. Among nine tutorial topics, only one topic was developed with Google Earth, and other eight were developed with ArcGIS Explorer Online. The reason that ArcGIS Explorer Online was used for most of the topics was its ability to share shapefiles. In ArcGIS Explorer Online, a user can upload his/her local shapefiles to display on the map. The map with shapefiles can be shared with other users easily once they know the URL of the map. However, In Google Earth, sharing shapefiles is not straightforward. It requires converting to a KMZ file and then sending the KMZ file to other users. Above the reason, ArcGIS Explorer Online was more frequently implemented than Google Earth in this study.

One of the interesting results from the interviews and surveys is that some of the participating teachers were interested in learning GIS and GIScience not only as instructional tools, but also as a field of study. They were mostly motivated teachers with advanced experience with technology. They wanted to learn capabilities such as creating new shapefiles, using various analysis tools, creating database, understanding cartographic principles, and using remotely sensed imageries. These teachers wanted more than these tutorials could provide. They would have liked college-level GIS courses or GIS certificate programs.

This study suggests important directions to GIS education for the K-12 level. Many teachers are interested in using instructional technologies because they agree that these technologies are helpful for them to teach and also useful for students to understand a course topic. The current low adoption rate of these technologies indicates that they do not know where and how to start. Once we provide effective mapping applications designed for the educational purposes with examples of various classroom activities and offer substantial training materials and opportunities to K-12 teachers continuously, more and more educators will use GIS technologies in their classrooms.

The key point is active collaboration among GIS software companies, K-12 teachers, and GIS professionals. In GIS software companies' situation, collaborating with K-12 educators and other GIS professionals will help them develop more profitable products in the education market by making them directly implementable in the K-12 classroom and having more number of consumers. It will directly provide an opportunity to K-12 teachers that they can use GIS software suited to their needs. On the basis of the high rate of classroom implementation of GIS technologies, GIS professionals will be able to do various in-depth research on GIS education. These three groups should not be inseparable to increase teacher adoption of GIS technologies.

Rather than just talking about the merits of using GIS technologies in K-12 classroom, we need to provide sufficient support to K-12 teachers to make them useful. By working with K-12 teachers, GIS software companies and GIS professionals will gain insights what teachers really want and need and what kinds of support are indeed helping them. The focus and principle of support should not be solely determined by GIS software companies and/or professionals. K-12 educators' opinions should be actively reflected in the formats, contents, and levels of support. Once we implement these strategies, the classroom adoption of GIS technologies may increase, and at the same time, it may increase the opportunities for students to use GIS technologies in productive and educative ways.

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APPENDIX A

INTERVIEW QUESTIONS FOR THE USER NEEDS ANALYSIS

1. General teaching questions: experience as teachers and teachers with technology
   1) What do you see as one or two of your greatest strengths as a teacher?
   2) Daily teaching
      a) What areas you are trying to improve or change?
      b) What makes you feel challenged in explaining a new concept?
   3) Using information technology
      a) What are the barriers not to use a new technology in the class?
      b) What are advantages and disadvantage to use computer software in the class?

2. Learning tool/material questions
   1) Lesson plans
      a) How do you develop lesson plans?
      b) Do you use paper maps often in your lesson plans?
      c) How about digital maps or Internet resources like satellite images, Google Earth, etc.?
      d) What is the purpose to use the above tools in class? (to show location, to explain social phenomena, to introduce topology, etc.)
      e) What resources would help you develop lesson plans using online and paper maps?
   2) Roles of computers and Internet in lesson plans
      a) What role do computers and the Internet play in your lesson planning?
      b) If you use computer software, what kinds of software do you use?
      c) Do you enjoy learning and trying new technology for your class?
      d) What kinds of computing skills do you want to improve for your class?
      e) Do you share your lesson plans with other teachers?

3. Experience and "comfort" computer technology questions
   1) Self-rating for computer experience and computer usage
      a) How do you see your proficiency with computers? (expert, intermediate, or novice)
      b) On average how many days a week do you use a computer?
      c) On average how many hours do you spend on your computer per day?
   2) Activities
      a) Apart from your teaching, what kinds of activities on the computer do you usually do? (email, web surfing, social networking, watching video, office work, etc.)
   3) Website development experience
      a) Have you ever created websites?
      b) Do you have any programming experience?
   4) Attitudes of using and learning computers and information technology
      a) Do you enjoy working with computers and information technology?

b) Why is it enjoyable, or not?
c) What's the best way to learn computing technology?
d) What motivates you to learn computing technology?

4. GIS is the abbreviation of geographic information system which allows collect, manage, visualize and analyze geographically referenced data.
   1) Have you ever learned about GIS before?
      a) If yes, where, what, how long, to what level?
   2) GIS vs. paper maps
      a) Have you used GIS application as an educational tool?
         (i) If not, what are the barriers to limit use GIS applications in the classroom?
      b) Which do you prefer? GIS application or paper maps
      c) Do you think GIS applications are more helpful than paper maps for your class?
   3) Web-based GIS applications (virtual globes)
      Can I show you some of web-based GIS features? (show them some mapping tools of ArcGIS Explorer Online and map mashups created in Google Earth with APIs.)
      a) Have you used web-based GIS applications such as Google Earth in the classroom?
         (i) If yes, how often have you used?
         (ii) Which course topics have you used for?
         (iii)What kinds of mapping tools have you used?
      b) Do you think which mapping tools are most useful in the classroom? (adding a new feature, animation, querying, etc.)
      c) What kinds of mapping tools do you want to learn? (basic tools or more advanced functions such as creating map mashups with APIs?)
      d) Which course topics (curriculums) do you want to develop with web-based maps?

5. Teacher training questions: the method to get most useful help and assistance
   There are lots of ways for helping teachers like you get started with new technologies and concepts—in-service workshops, other types of in-district professional development, activities at professional meetings, one-on-one coaching, published lesson plans (either paper or digital).
   1) What is your favorite way of learning new techniques?
   2) What wouldn't work for you?

APPENDIX B

SURVEY QUESTIONS FOR THE USER SURVEY

<Background>

Please answer the following questions to the best of your knowledge and feel free to add addition al comments.

1. What grade are you currently teaching? (Choose all that apply)
   - 6 grade
   - 7 grade
   - 8 grade
   - Other (please specify)

2. How many years have you been teaching?

3. Please rate your knowledge level of the following technologies.

None: Have neither heard of nor used.
Beginner/Just a little: Have heard of and tried to use recently.
Some: Have used occasionally (4 to 5 times per year), or just know the basic functionality such as finding location and zoom-in/out.
Moderate: Use frequently (more than once a month), or can follow the tutorials without direct assistance.
Advanced: Use very often (2 to 3 times per week), have done professional training/course work, and know the advanced functionality such as analysis.

GIS:
Web-based maps:
Virtual Globes:
ArcGIS Explorer Online:
Google Earth:

<Topics>

If you have tested more than one topic, answer the questions based on one topic now. You can re peat the survey for another topic once you complete the survey for the first topic.

4. Which topic did you test?
   - 6th: Deforestation in the Amazon Rainforest
   - 6th: Immigration to the U.S.
   - 6th: Natural Disasters in America
   - 7th: Ancient Greece and Rome
   - 7th: Natural Resources

- 7th: Human-Environmental Interaction
- 8th: Westward Expansion of the U.S.
- 8th: The Civil War
- 8th: Native Americans

< Tutorials>

5. Was the tutorial easy to follow?
   - strongly disagree
   - disagree
   - neither agree or disagree
   - agree
   - strongly agree

6. If you had problems following the tutorial, identify them.

7. What is the best feature in the tutorial? Why?

8. What is your least favorite feature of the tutorial? Why?

9. What elements or features of the tutorial need the most improvement? How?

< Valuableness and usefulness of mapping tools>

I am now going to ask questions about: 1) what features of the tutorial are most valuable to you in learning about these technologies and perhaps creating additional learning materials; and 2) what features you think would be most useful to you and your students in the classroom as they learn about these and other topics.

10. Please rate (from 1 to 5) the mapping tools you used in terms of their value to you personally.

11. Please rate (from 1 to 5) the mapping tools you used in terms of their useful to you as a teacher and to your students in the classroom.

12. In the previous question, I asked you to rate all of the mapping tools. Now I would like you to pick just one mapping tool that you found most valuable to you and one that is most useful in the classroom. Why?
Most valuable to you:
Most useful in the classroom:

13. Like the previous question (# 12), pick one mapping tool that you found least valuable to you and least useful in the classroom. Why?
Least valuable to you:
Least useful in the classroom:

14. Besides provided mapping tools in the tutorials, what else tools and techniques do you want to learn?

<Teacher Training>

I am going to ask questions about your preferred type of teacher training.

15. Do you like this type of teacher training (online training)? Why?
    - strongly disagree
    - disagree
    - neither agree or disagree
    - agree
    - strongly agree

16. What are your favorite types of teacher training? (Choose all that apply)
    - In-service workshops
    - In-district professional development
    - Professional meetings
    - One-on-one coaching
    - Paper-versions of published lesson plans
    - Digital-versions of published lesson plans
    - Other (please specify)

< Implementation in the classroom>

17. Did the tutorials provide enough help for you to create and/or customize web-based GIS by yourself? Why?
    - strongly disagree
    - disagree
    - neither agree or disagree
    - agree
    - strongly agree

18. Do you think web-based GIS are useful and effective as an instructional tool? Why?
    - strongly disagree
    - disagree
    - neither agree or disagree
    - agree
    - strongly agree

19. Would you use web-based GIS in your class?
    - strongly disagree
    - disagree

- neither agree or disagree
- agree
- strongly agree

20. What are possible barriers to limit use of these technologies in the classroom?

<Follow-up survey>

21. In order to know whether you use web-based GIS in the classroom, the researcher will contact you by e-mail in April 2012. Do you want to participate in the follow-up questions?
- Yes
- No

22. Please provide your contact information.
Your name:
School name:
Email address:

APPENDIX C

SURVEY QUESTIONS FOR THE FOLLOW-UP SURVEY

< Rate of GIS adoption>

1. Did you use one of tutorial topics from GIS for Social Studies website and/or create your own materials in your classroom?
    - Did not use
    - Used one of tutorial topics from GIS for Social Studies website
    - Created my own materials
    - Both

<Frequencies>

2. How many times did you use web-based GIS applications in your classroom?
    - 1 to 2 times
    - 3 to 4 times
    - More than 5 times
    - Other (please specify)

<Tutorial topics>

3. Which topic did you use? (Check all that apply)
    - 6th: Deforestation in the Amazon Rainforest
    - 6th: Immigration to the U.S.
    - 6th: Natural Disasters in America
    - 7th: Ancient Greece and Rome
    - 7th: Natural Resources
    - 7th: Human-Environmental Interaction
    - 8th: Westward Expansion of the U.S.
    - 8th: The Civil War
    - 8th: Native Americans

4. To you, was the tutorial easy to use in the classroom?
    - strongly disagree
    - disagree
    - neither agree or disagree
    - agree
    - strongly agree

5. To your students, was the tutorial easy to follow?
    - strongly disagree

- disagree
- neither agree or disagree
- agree
- strongly agree

6. If you had problems using the tutorial, identify them.

7. What is the best feature in the tutorial? Why?

8. What is your least favorite feature of the tutorial? Why?

< Description of your materials>

9. Did the tutorials provide enough help, so that you could create and/or customize web-based GIS by yourself? Why?
   - strongly disagree
   - disagree
   - neither agree or disagree
   - agree
   - strongly agree

10. What were the topics or learning objectives of the materials?

11. Which web-based GIS application(s) did you use?
    - ArcGIS Explorer Online
    - Google Earth
    - Both
    - Other (please specify)

12. What kinds of mapping tools or tasks did you use in your materials?

< Students responses and your opinions>

13. Did the web-based GIS applications you used encourage student engagement in the classroom? Why?
    - strongly disagree
    - disagree
    - neither agree or disagree
    - agree
    - strongly agree

14. Did the web-based GIS applications you used increase the degree of your students' understanding of the topic you presented? Why?
    - strongly disagree

- disagree
- neither agree or disagree
- agree
- strongly agree

15. Did the web-based GIS applications you used help reach the learning objectives of the topic you presented? Why?
    - strongly disagree
    - disagree
    - neither agree or disagree
    - agree
    - strongly agree

16. Do you think the web-based GIS applications you used are useful and effective as an instructional tool? Why?
    - strongly disagree
    - disagree
    - neither agree or disagree
    - agree
    - strongly agree

17. Would you use web-based GIS applications in your class again?
    - strongly disagree
    - disagree
    - neither agree or disagree
    - agree
    - strongly agree

<No GIS adoption>

18. What factors prevented you from using of web-based GIS applications in your classroom? (Check all that apply)
    - Not enough time to learn and practice
    - Not comfortable to use due to lack of training and experience
    - Not available computing technologies in the classroom
    - Topics were not fit to my curriculum
    - Other (please specify)

19. In the near future, would you try to use web-based GIS applications in your class?
    - strongly disagree
    - disagree
    - neither agree or disagree

- agree
- strongly agree

APPENDIX D

SAMPLES OF TRAINING TUTORIALS

APPENDIX D-1: DEFORESTATION IN THE AMAZON RAINFOREST
(One of the sample tutorials for 6th grade)

Deforestation in the Amazon Rainforest

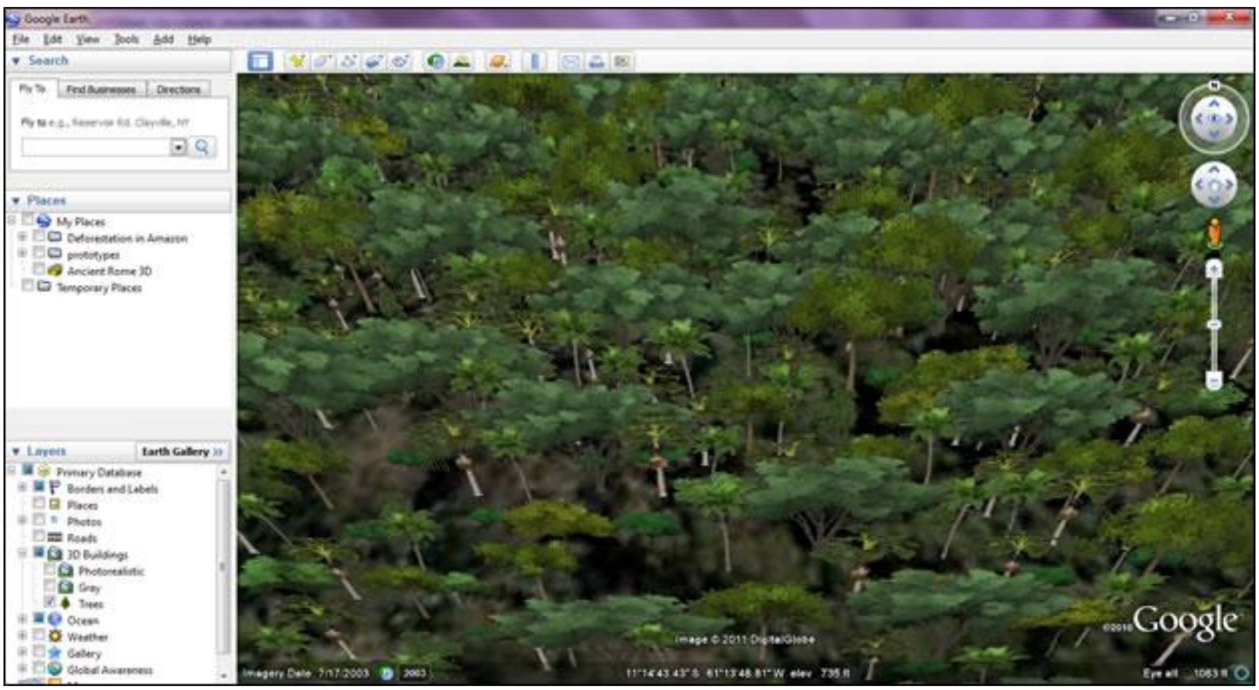
Learning objectives

- To understand the structure of the Amazon rainforest canopy
- To observe and predict changes in the landscape due to deforestation
- To find evidence of several factors that contribute to deforestation

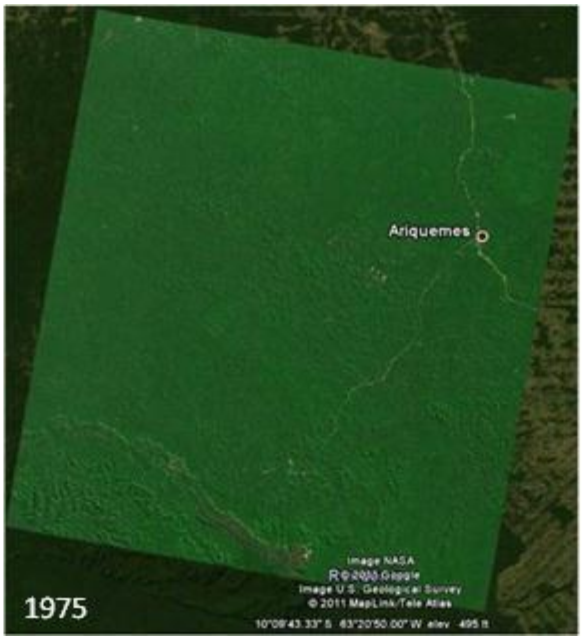
Summary

Preparation: In this activity, we use Google Earth.

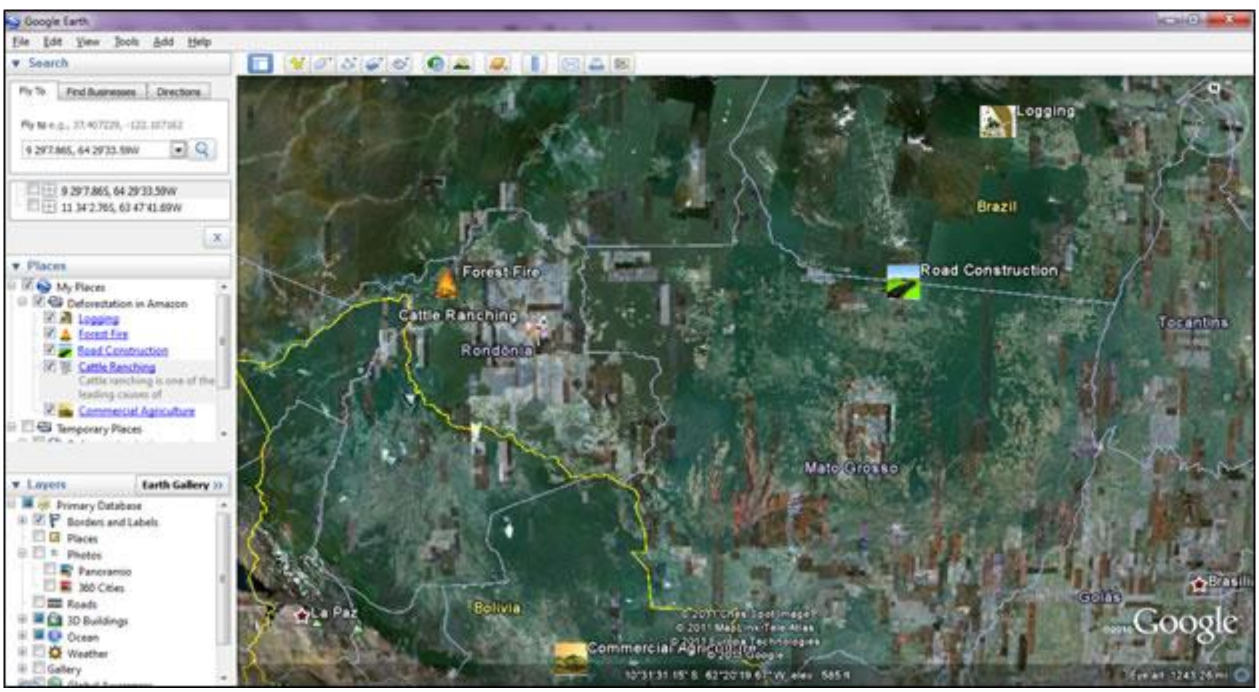
Activity 1: We will observe various plant species with the "3D Trees" function.



[Activity 2](#): We will observe landscape changes due to deforestation with the "Historical Imagery" tool.



[Activity 3](#): We will find evidence of several activities that lead to deforestation, and add images of these activities to the corresponding spots.



National and Colorado Standards

<table>
<tr><th>National/CO</th><th>Content Area</th><th>Standards</th></tr>
<tr><td rowspan="7">National</td><td rowspan="5">Geography</td><td>The World in Spatial Terms
1. How to use maps and other geographic representations, tools and technologies to acquire, process and report information from a spatial perspective.</td></tr>
<tr><td>Places and Regions
4. The physical and human characteristics of places.</td></tr>
<tr><td>Physical Systems
8. The characteristics and spatial distribution of ecosystems on Earth's surface.</td></tr>
<tr><td>Environment and Society
14. How human actions modify the physical environment.</td></tr>
<tr><td>Uses of Geography
18. How to apply geography to interpret the present and plan for the future.</td></tr>
<tr><td>History</td><td>Historical thinking - 1. Chronological Thinking
C. Establish temporal order in constructing their [students'] own historical narratives.</td></tr>
<tr><td>Life Science</td><td>4. Populations and ecosystems</td></tr>
<tr><td rowspan="3">Colorado</td><td rowspan="2">Geography</td><td>1. Use geographic tools to solve problems.</td></tr>
<tr><td>2. Human and physical systems vary and interact.</td></tr>
<tr><td>Life Science</td><td>1. Changes in environmental conditions can affect the survival of individual organisms, populations, and entire species.</td></tr>
</table>

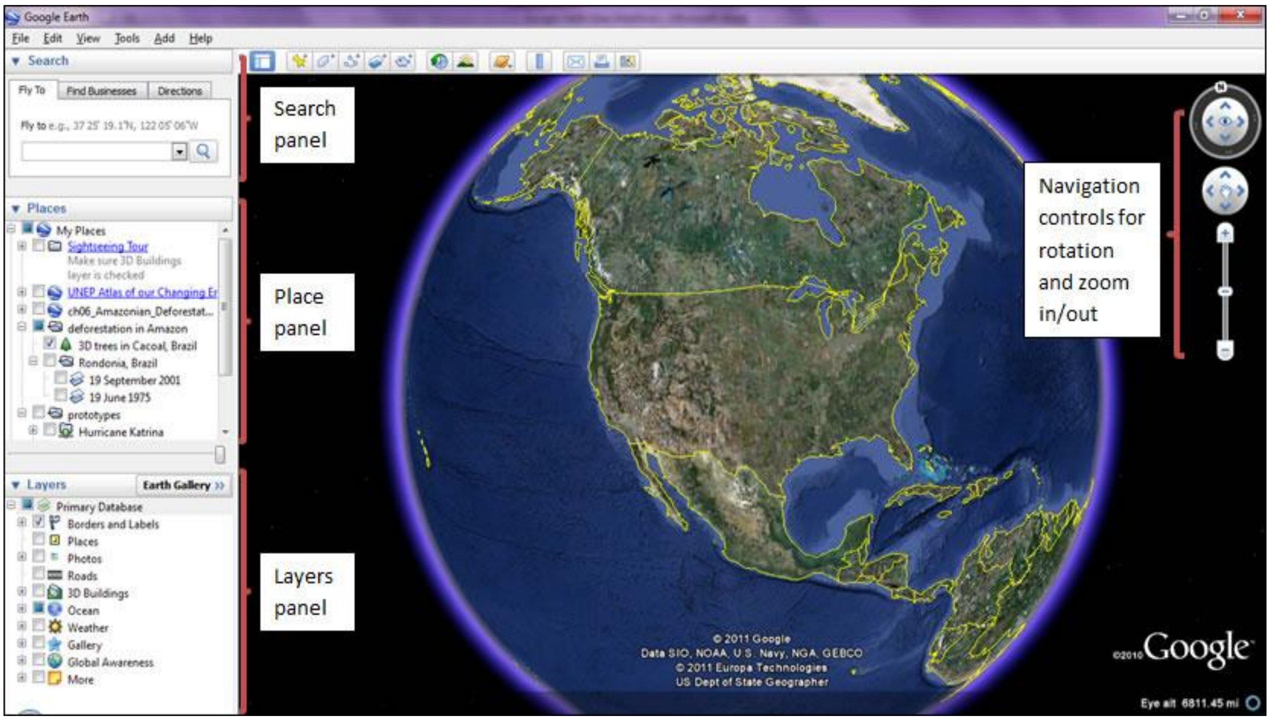
Deforestation in the Amazon Rainforest - Preparation

*** If you have not read the instruction about how to use the tutorials, please click here. ***

1. Open Google Earth on your computer.

2. If necessary, update Google Earth to the latest version, Google Earth 6.

3. If you are not familiar with the interface of Google Earth, look at the image below. If you need more information, please click here.

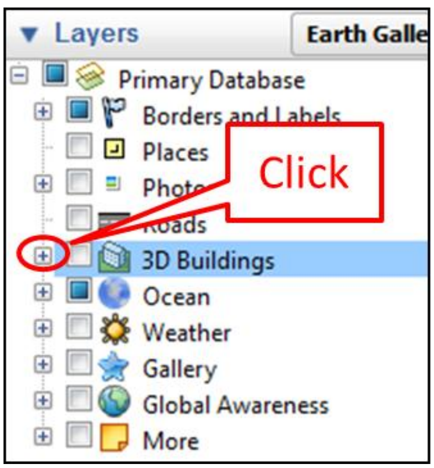


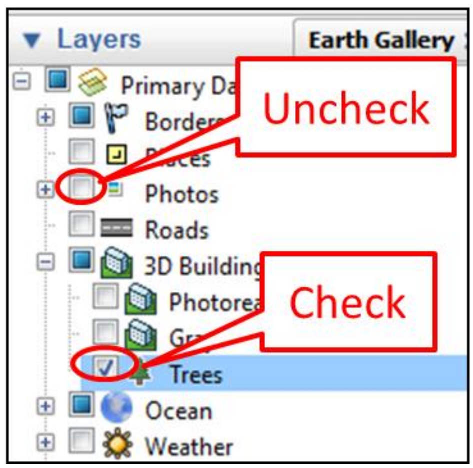
4. Move the Earth to show South America and the Amazon rainforest. Orient the students to the location. Show the map of the Amazon rainforest, and note its size with respect to the United States.

Deforestation in the Amazon Rainforest - Activity 1. The Canopy

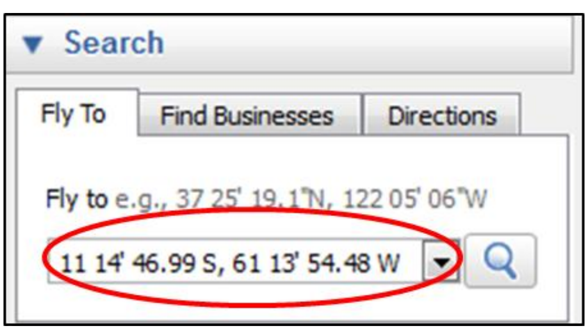
*** If you have not gone through the preparation of this topic yet, please click here. ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. Go to the “Layers” panel. Open the “3D Buildings” layer (click on “+” as shown), then check the box next to “Trees.” If the “Photos” checkbox is checked, please uncheck it.

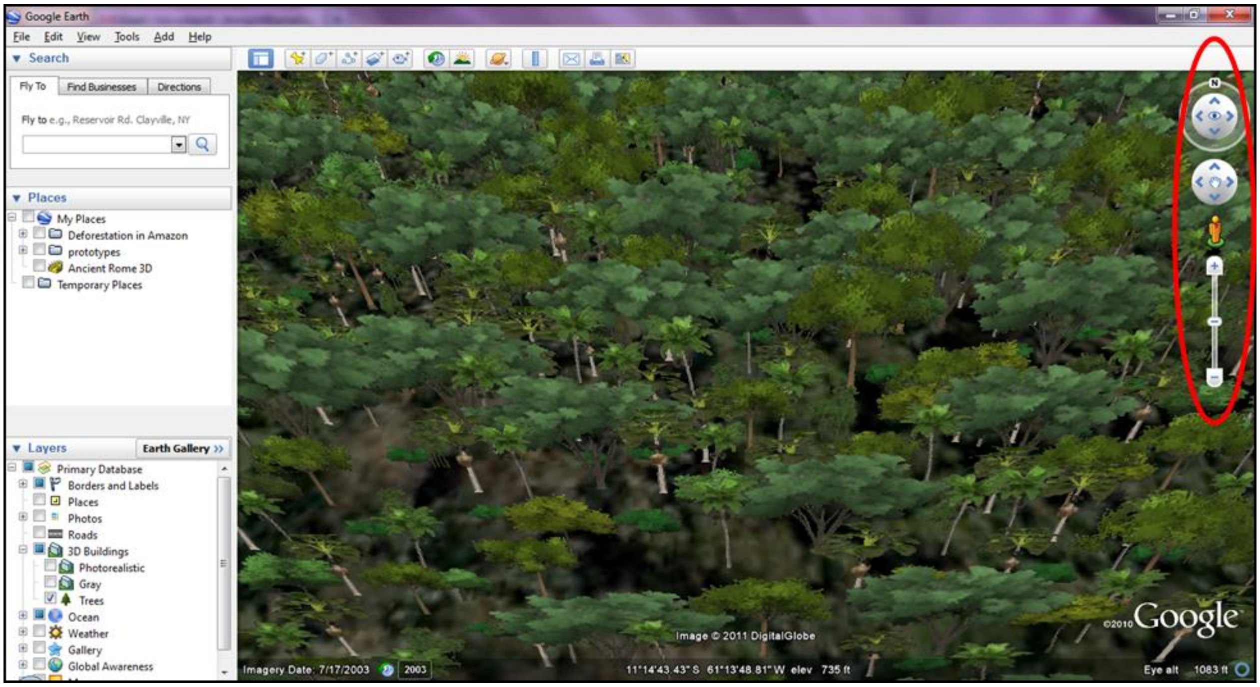




2. Type, or copy and paste, the following latitude and longitude into the “Search” panel. Then hit the enter key.
11 14'46.99S, 61 13'54.48W (There is space between the first and the second number => 11_14)

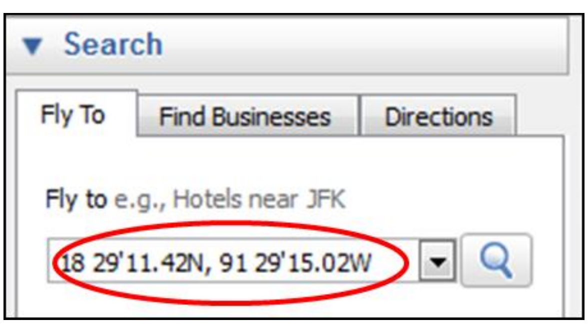


3. Zoom in until you can see 3D trees. Explain to students that there are nearly 40,000 known plant species in the Amazon, and one hectare (2.47 acres, roughly two football fields) may contain over 750 types of trees and 1500 species of tall plants. Navigate the area to see different kinds of trees. Navigation controls are on the right side of the map. Once you do the mouse-over, you will see the navigation control clearly. If your mouse has a wheel, you can use the wheel to zoom in (scrolling up) and out (scrolling down).

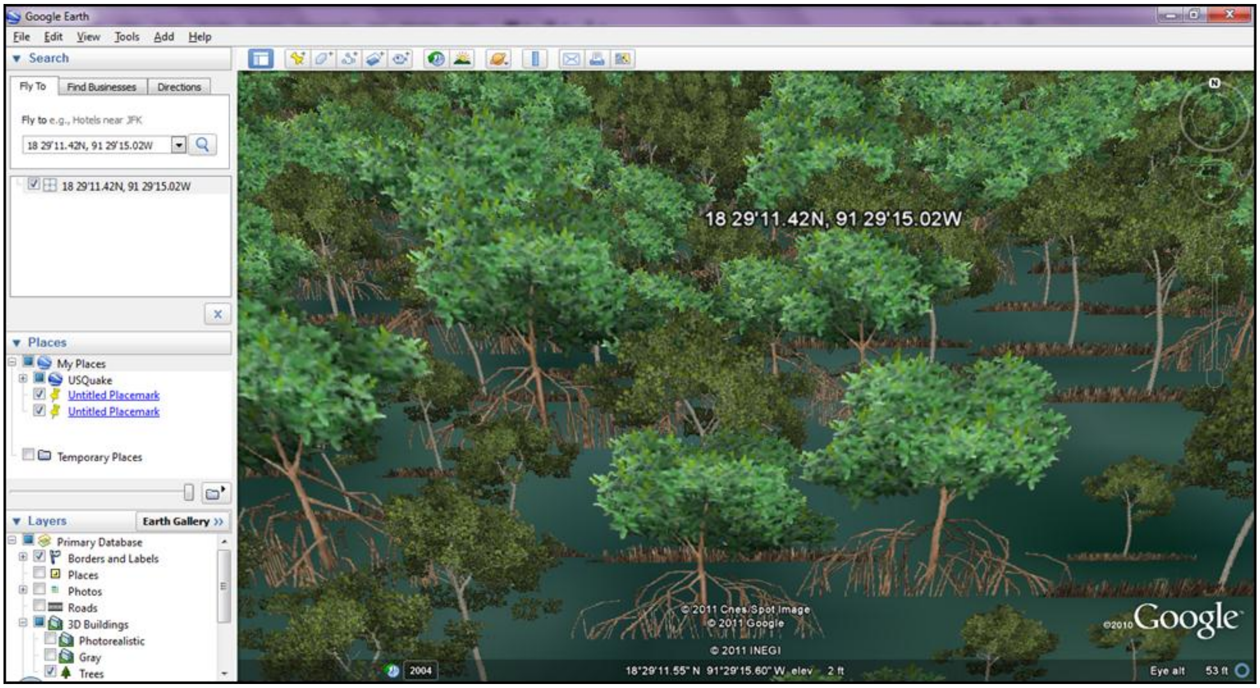


4. In order to compare types of species between the Amazon rainforest and the Mangrove forest in Mexico, we will explore trees in the Mangrove forest with the “3D Trees” tool.

5. Type, or copy and paste, the following latitude and longitude into the “Search” panel.
18 29'11.42N, 91 29'15.02W (There is space between the first and the second number => 18_29)



6. Once you zoom in, you will see 3D trees in the Mangrove forest as in the following image.



- Discussion questions
    - Describe the appearance of the Amazon rainforest.
    - What are some differences you see between trees in the Mangrove forest, Mexico and those in the Amazon rainforest?
    - The Amazon rainforest is sometimes called the lungs of the earth. What does this mean?
    - Can you suggest other places around the world that might be as densely forested as the Amazon?

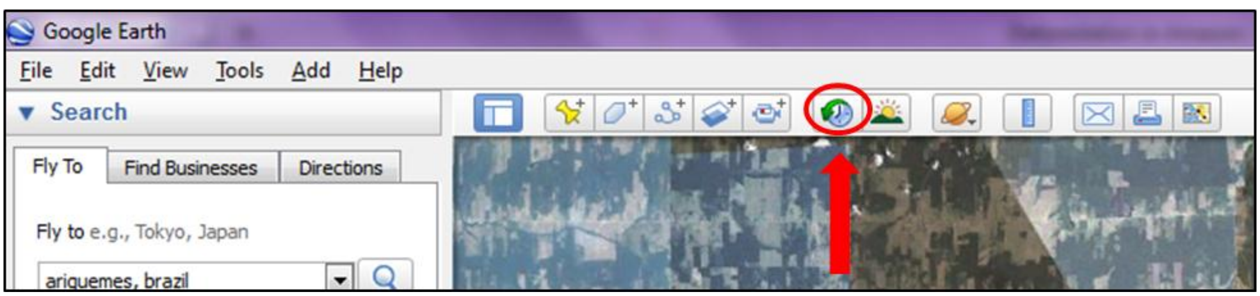
- Additional sources
    - 3D Trees forest collection (Google Earth)

Deforestation in the Amazon Rainforest - Activity 2. Landscape Changes

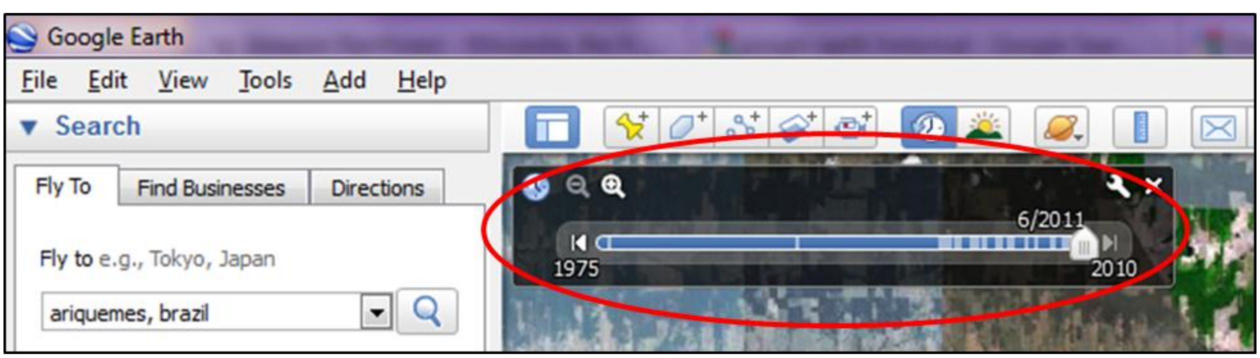
*** If you have not gone through the preparation of this topic yet, please click here. ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. Move to **Ariquemes, Brazil** by typing, or copying and pasting, this placename into the "Search" panel (not case sensitive).

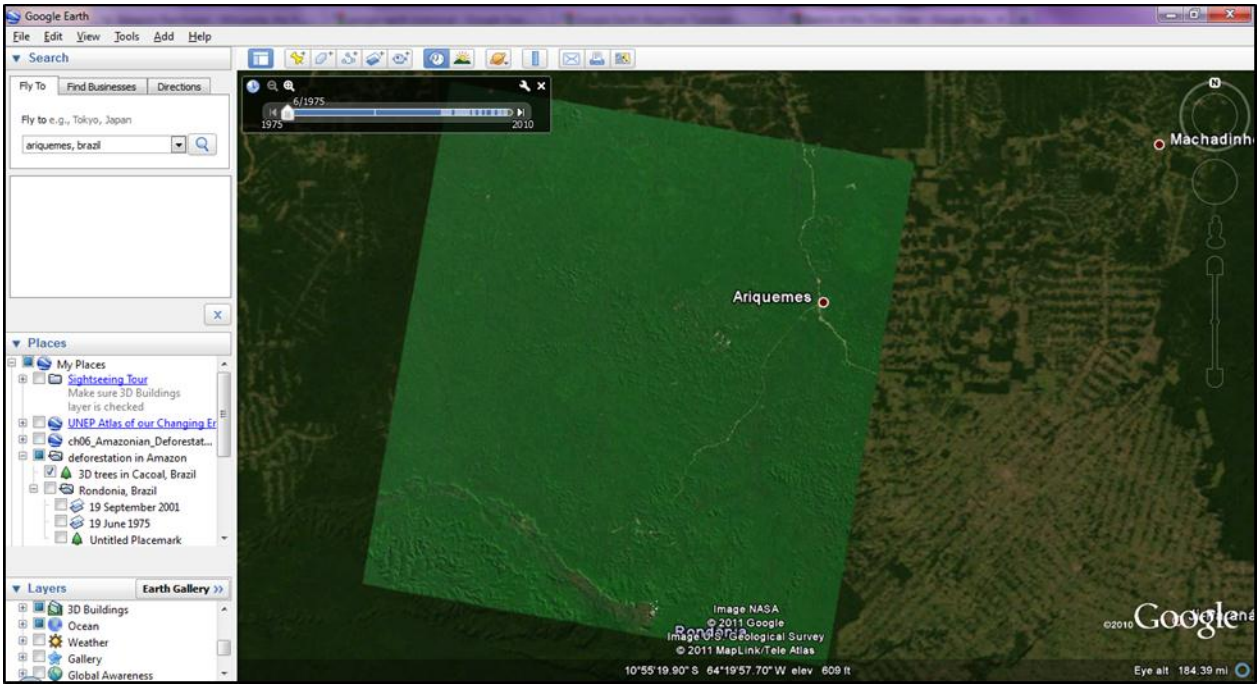
2. Click the "Historical Imagery" tool on the main toolbar.



3. The "Time Slider" will appear on the screen.

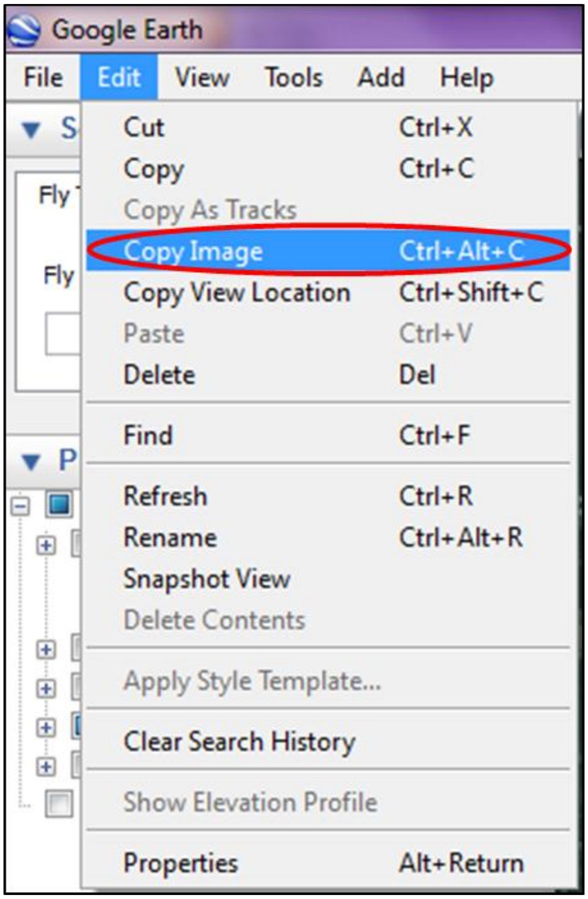


4. Move the slider to 1975, and position your map to look like the following image.



5. Move the slider to 7/1989 => 9/2001 => 8/2008. Look at the box around Ariquemes. There are many small cells of aerial photos in this area which might make it difficult to see the changes. For more information about the aerial photo, click here

6. You can copy the images of different time frames, and save them in your computer. On the main toolbar, click "Edit," and then click "Copy Image."



7. Paste the copied images into MS Word, MS PowerPoint, or any painting program, and save the images.

8. If you want, you can make an animated gif file. There are many free websites to make gif files. You can search for "gif maker" on the web.
If you need additional help, here are the detailed steps to make a gif file. Click here.

9. This is my animated image. Once you have completed this activity, close the “Historical Imagery” tool before going to the next activity.

- Discussion questions
    - How much time separates each of the images you looked at?
    - What changes are taking place? Why is there less green and more white as the years advance?
    - How do these changes impact the forest, animals, and people?
    - Predict what this area will look like in 20 years
    - Will the speed of deforestation be faster, slower, or remain the same? Why?

Deforestation in the Amazon Rainforest - Activity 3. Finding the Evidence

*** If you have not gone through the preparation of this topic yet, please click here. ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. Now you need to explain several factors that cause deforestation in the Amazon rainforest. Examples of these factors are cattle ranching, logging, commercial agriculture, road construction, and forest fires.

2. There are two choices of classroom activities that you can do with students.
Choice 1: You can show the actual locations of one or two main causes of deforestation on Google Earth. Then you can find related pictures on the web, and add those pictures on the corresponding locations. You can then ask students to do the same thing for each deforestation factor. You might ask students to think about factors that may cause deforestation, such as dam construction or urban growth. They might need to spend time researching these other factors on the web. To save class time, you can give the major location of each factor to students as listed below.

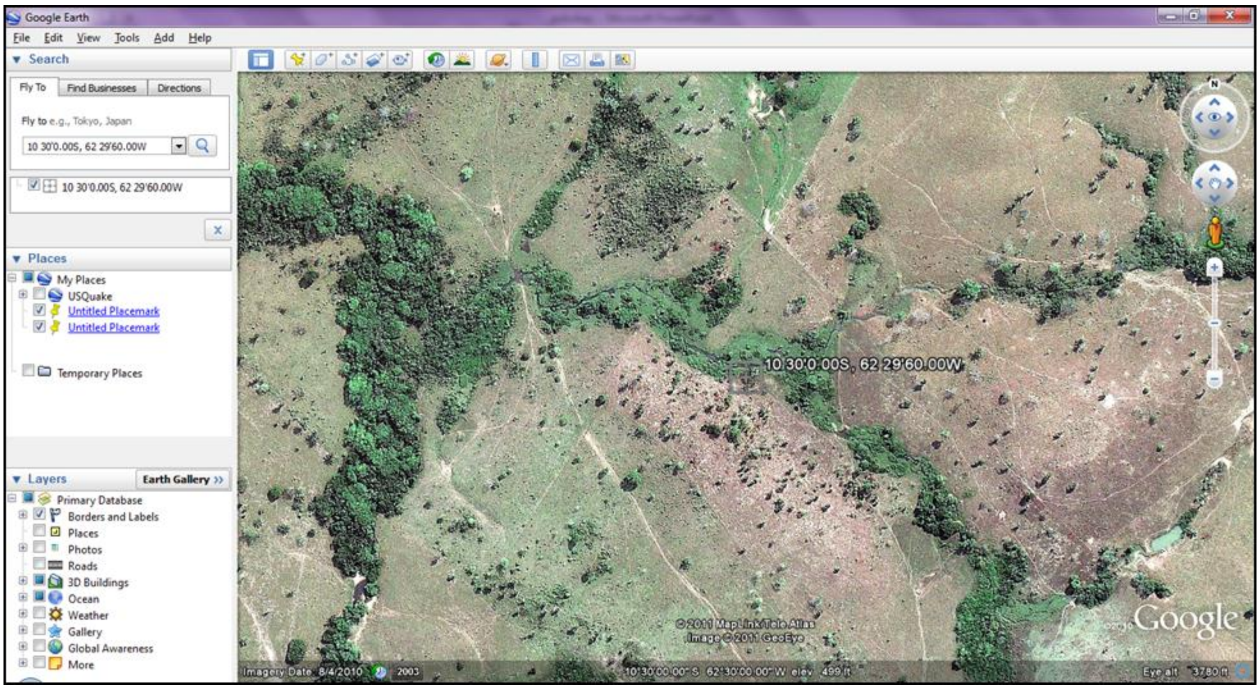
Choice 2: You can show the landscape of a certain location on Google Earth with the evidence of deforestation and ask students to determine what caused the damage to the landscape.

3. Here are major sites for each factor. When you click the links, you will get more information about the factor and its location.

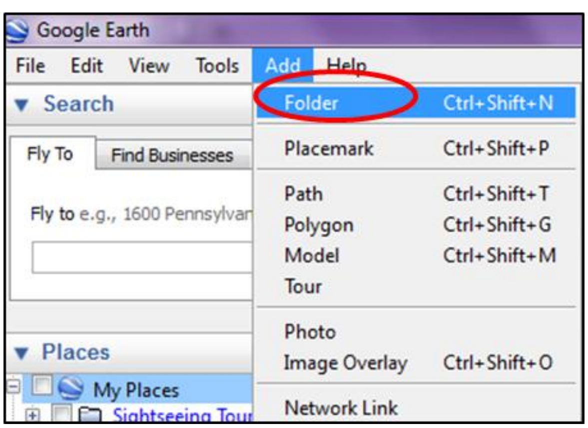
Deforestation Factors	Major sites
Cattle Ranching	Rondonia, Brazil
Logging	Para, Brazil
Commercial Agriculture (Soybean)	Eastern Santa Cruz, Bolivia and Santarem, Brazil
Road construction	BR-163, Brazil and Trans-Oceanic Highway, Brazil and Peru
Forest Fire	Rondonia, Brazil

4. You need to find appropriate pictures for each activity. You can simply search on the web, or you can use the images that I provide here: Images of Deforestation. When you search images on the web, make sure to keep a record of each image's URL. If you do not know how to do this, click here.

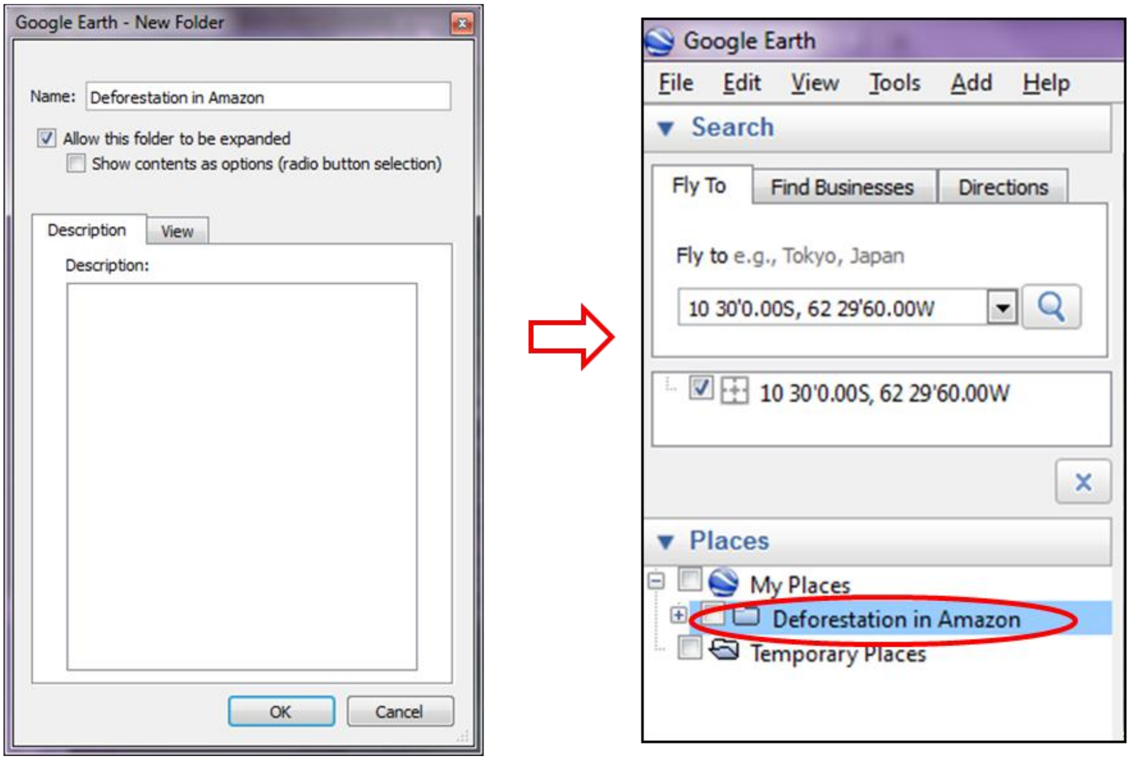
5. Now we need to find the location of the above places on Google Earth. You can find the evidence of deforestation due to cattle ranching in Rondonia, Brazil. You can simply find the location by typing its latitude and longitude **(10 30'0.00S, 62 29'60.00W**) into the "Search" panel (refer to step #2 in Activity 1).



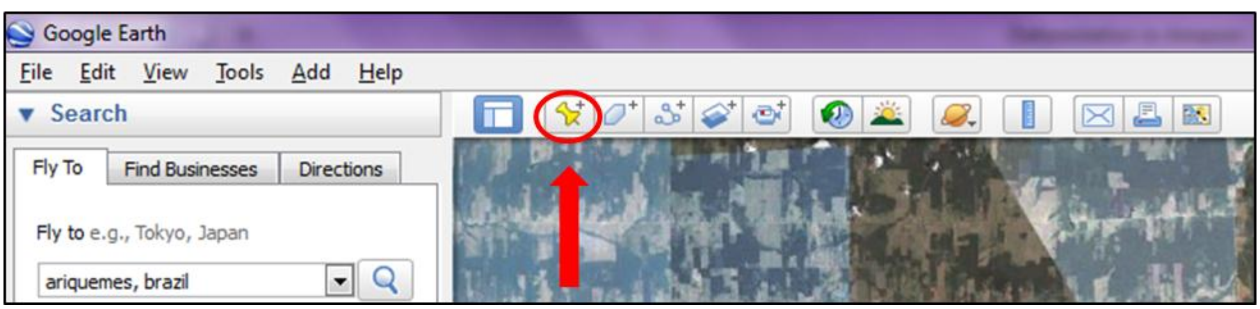
6. Let's make a folder inside of the "Places" panel to organize the placemarks we are about to make. On the main toolbar, click "Add" and then click "Folder."



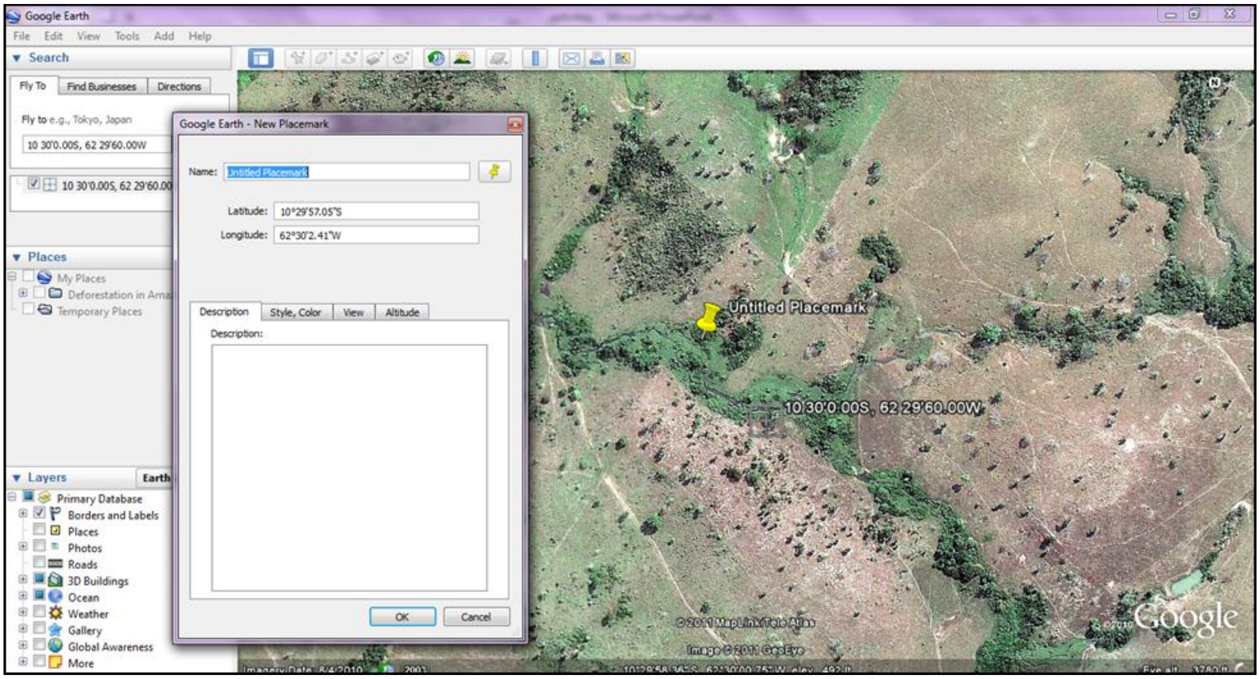
7. Name the folder "Deforestation in Amazon" and write a brief description of this folder. Then click "OK." Your folder has been added to the "Places" panel.



8. Click the "Add Placemark" tool on the main toolbar.

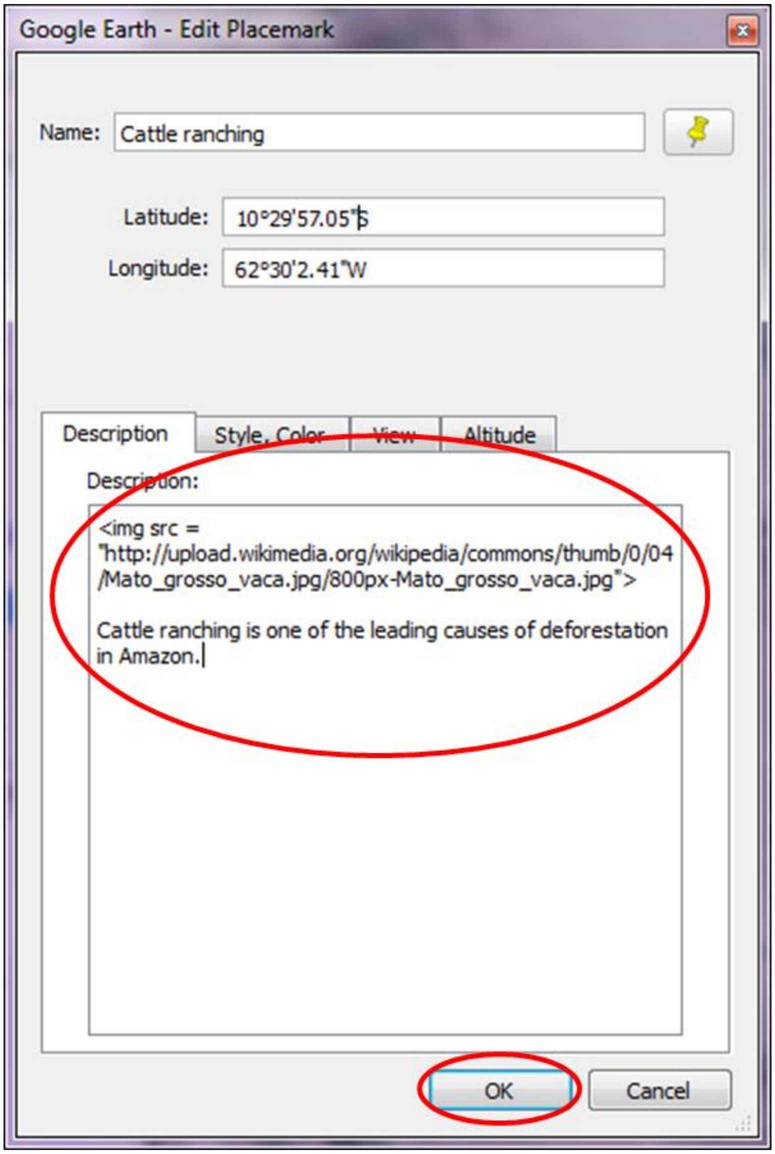


9. You can move the placemark around anywhere you want. If the popped up window blocks the placemark, make it small, or move it to the side, so that you can see the placemark on the map.

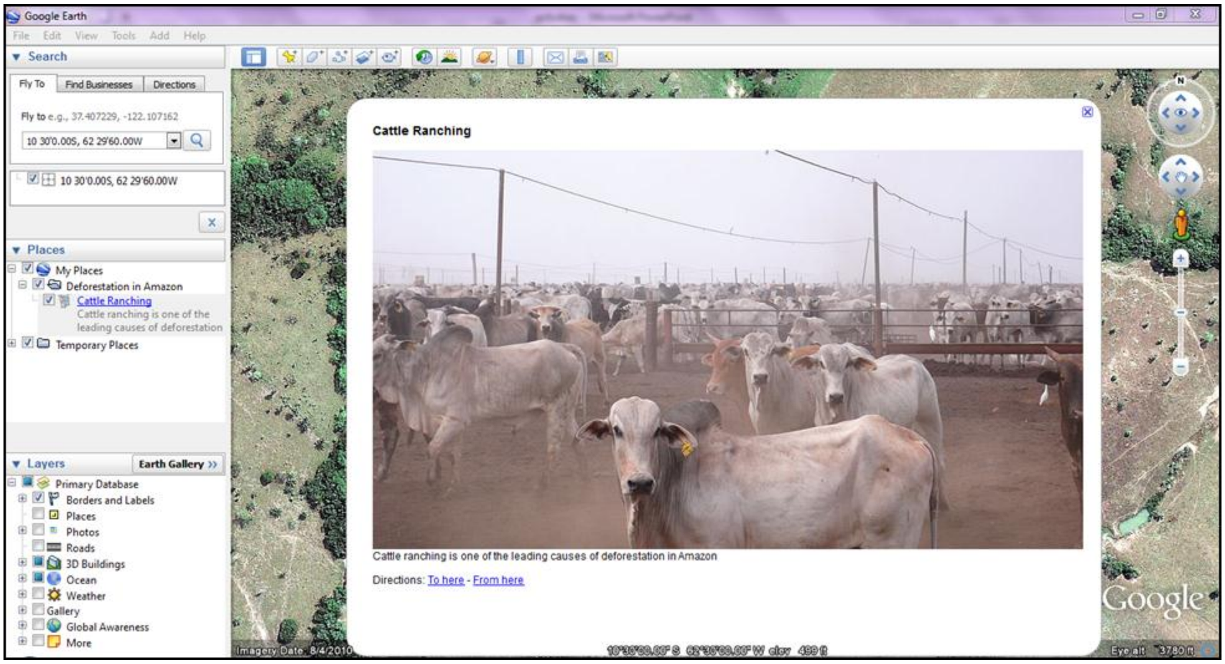


10. Name it "Cattle ranching."
If you want to change the icon of the placemark to a different style, or use customized icons, click here.

11. Now we need to add the image that we found earlier (Images of Deforestation). On the description, type **<img src = “URL of the image”>** (including the brackets) to add the image. **img src** is an HTML tag which allows us to make a link to the actual location of the image on the web. Then write the explanation of the image. Then click “OK.”



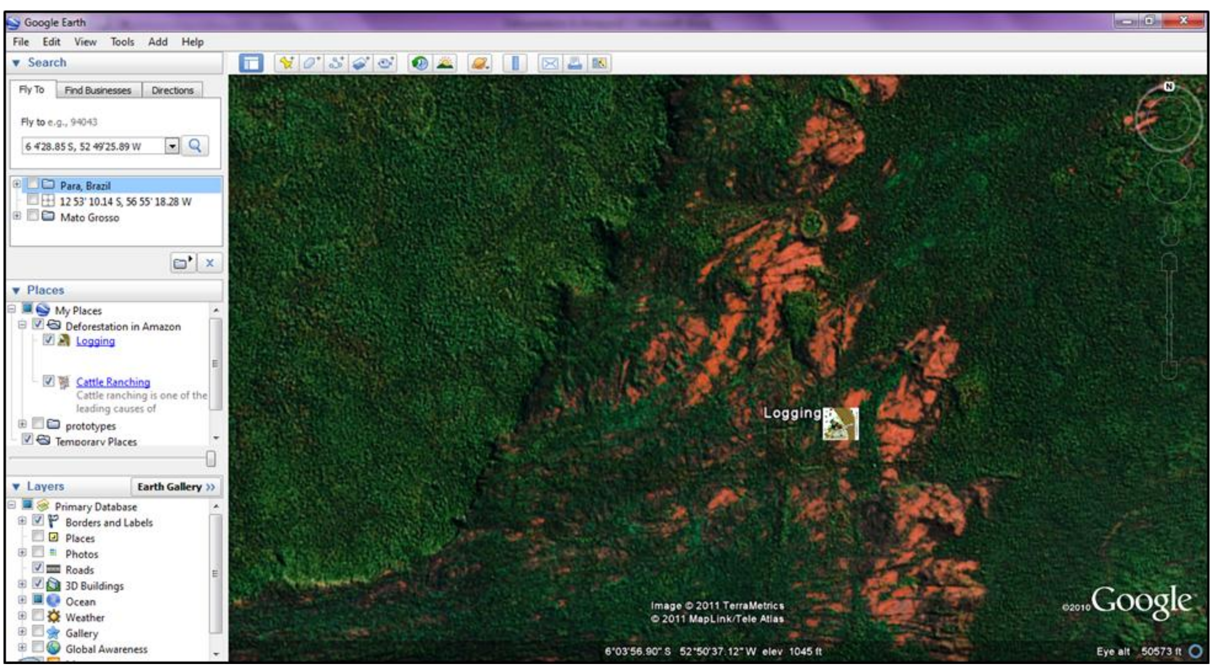
12. Click the placemark we just created to see the result.



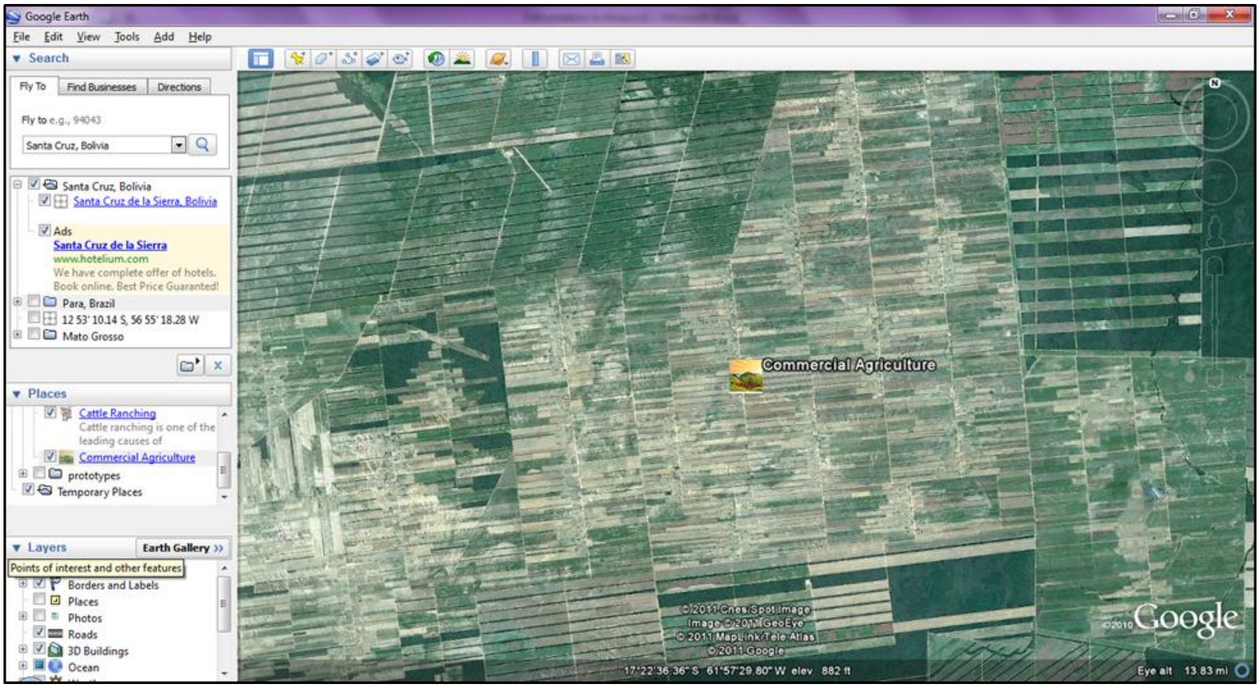
(Image source: By [Ottocarotto](#) [[CC-BY-SA-3.0](#) or [GFDL](#)], via Wikimedia Commons)

13. Follow the previous steps from #**5** to #**17** for other factors of deforestation in the Amazon rainforest. If you have trouble finding the actual locations of those factors, here are my suggestions.

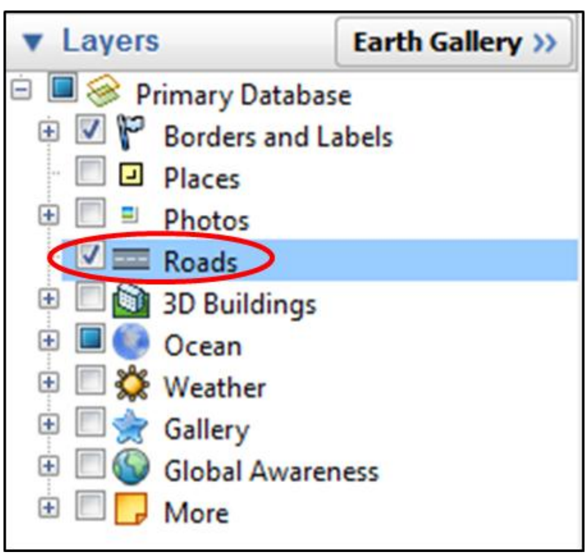
- Logging: **6 4'28.85 S, 52 49'25.89 W**

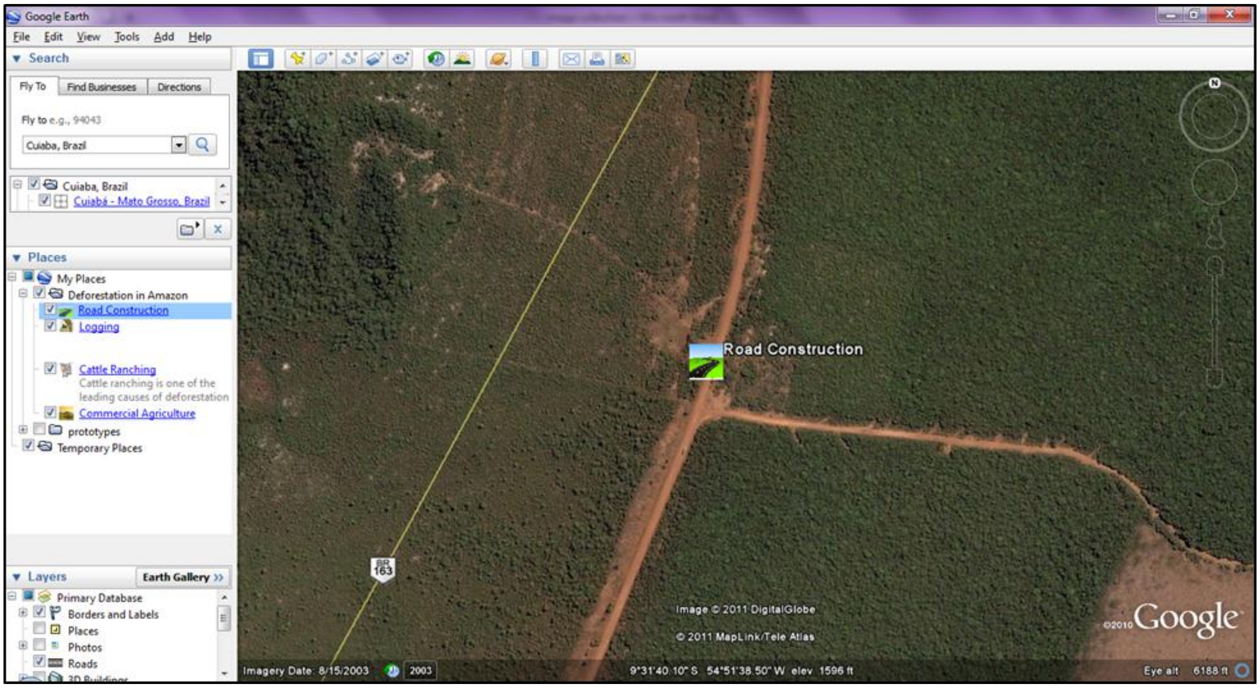


- Commercial Agriculture: **17 22'36.36S, 61 57'29.80W**

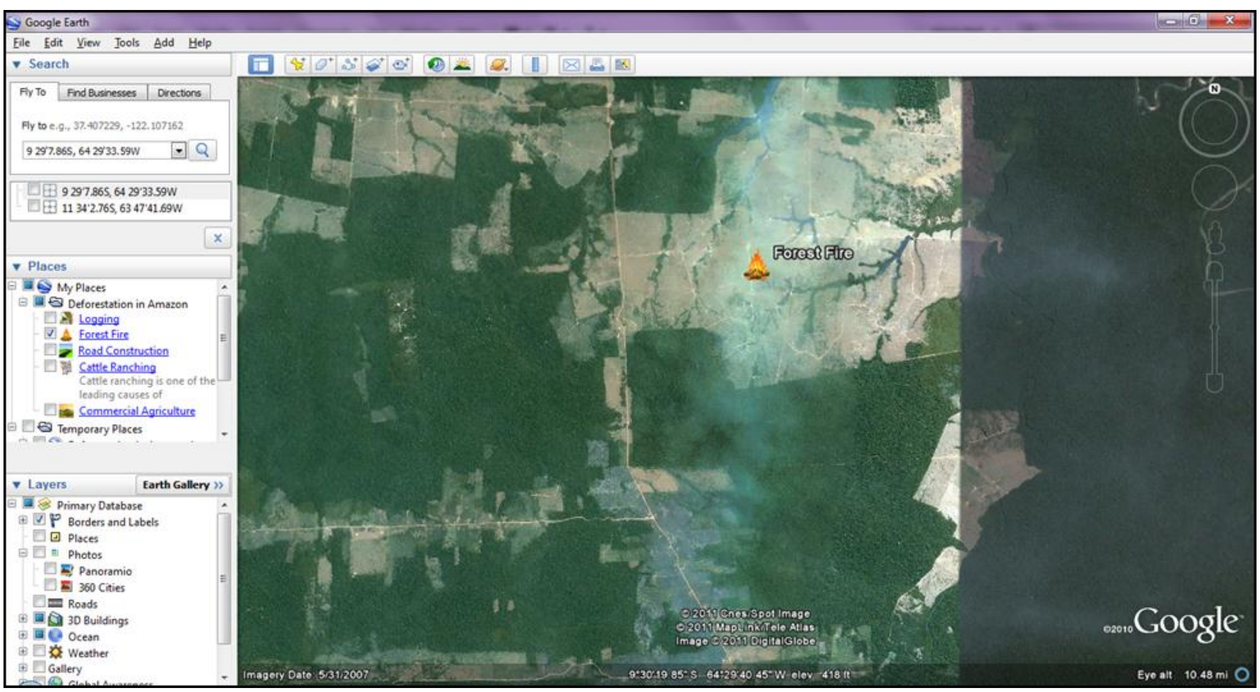


- Road Construction: **9 31'39.35S, 54 51'40.58W** (to see the highway, check the “Roads” layer on the Layers panel)

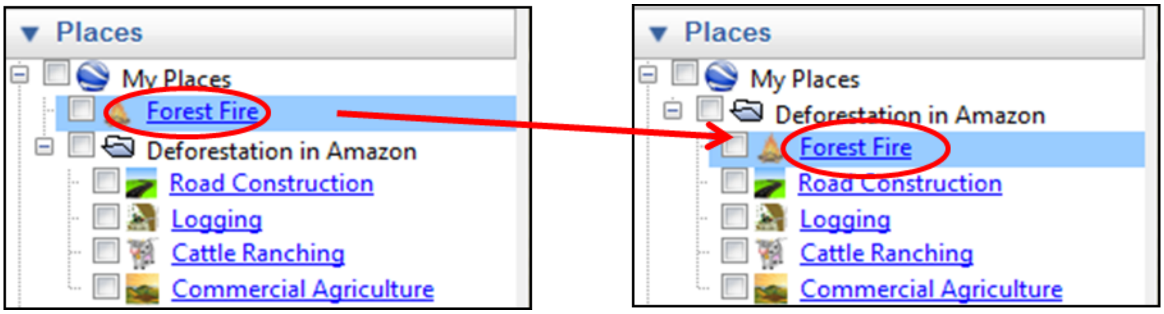




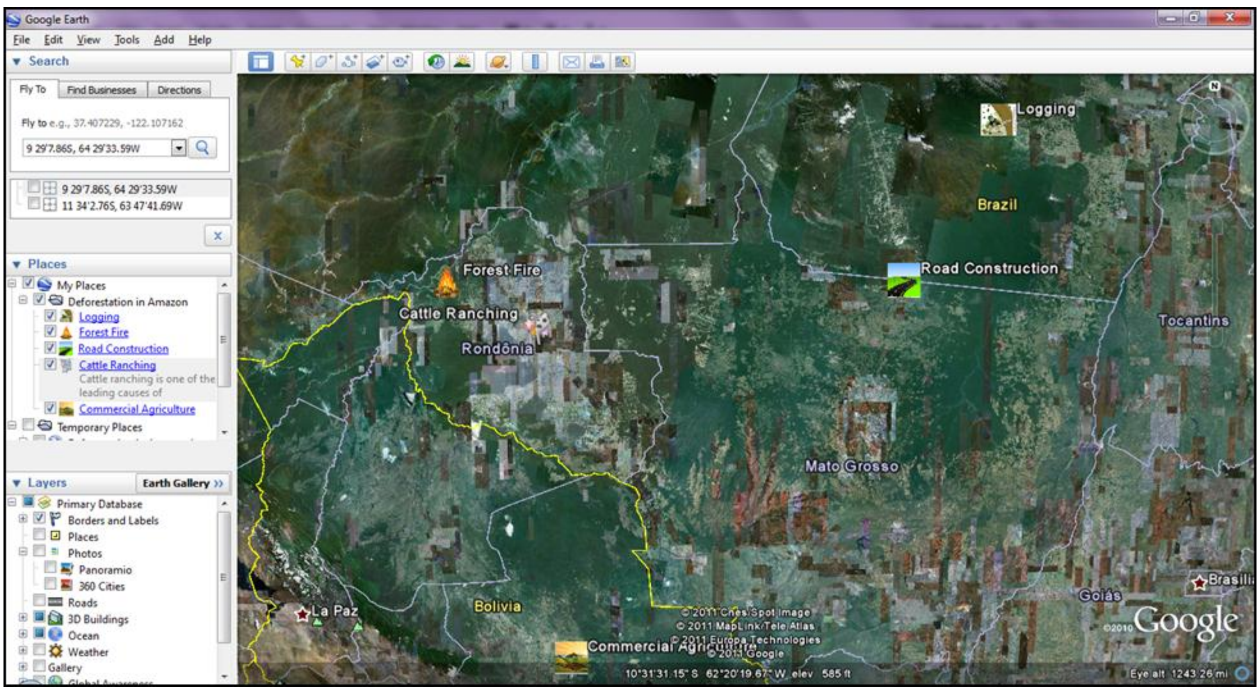
- Forest Fire: **9 29'7.86S, 64 29'33.59W**



14. If the placemarks are not inside the “Deforestation in Amazon” folder, you can drag and drop them into it on the “Places” panel.



15. Here is my final map.



- Discussion questions
  - What are additional factors that contribute to deforestation in the Amazon rainforest?
  - How is the deforestation of the Amazon rainforest related to products that we use in the U.S.?
  - Can you understand why people are causing deforestation? Why they are finding this necessary?
  - What would we do to stop deforestation?

    - In addition to the Amazon rainforest, what other regions of the world might suffer from deforestation?

- Additional sources
    - Fire in Brazil (Google Maps)

APPENDIX D-2: NATURAL RESOURCES
(One of the sample tutorials for 7th grade)

Natural Resources

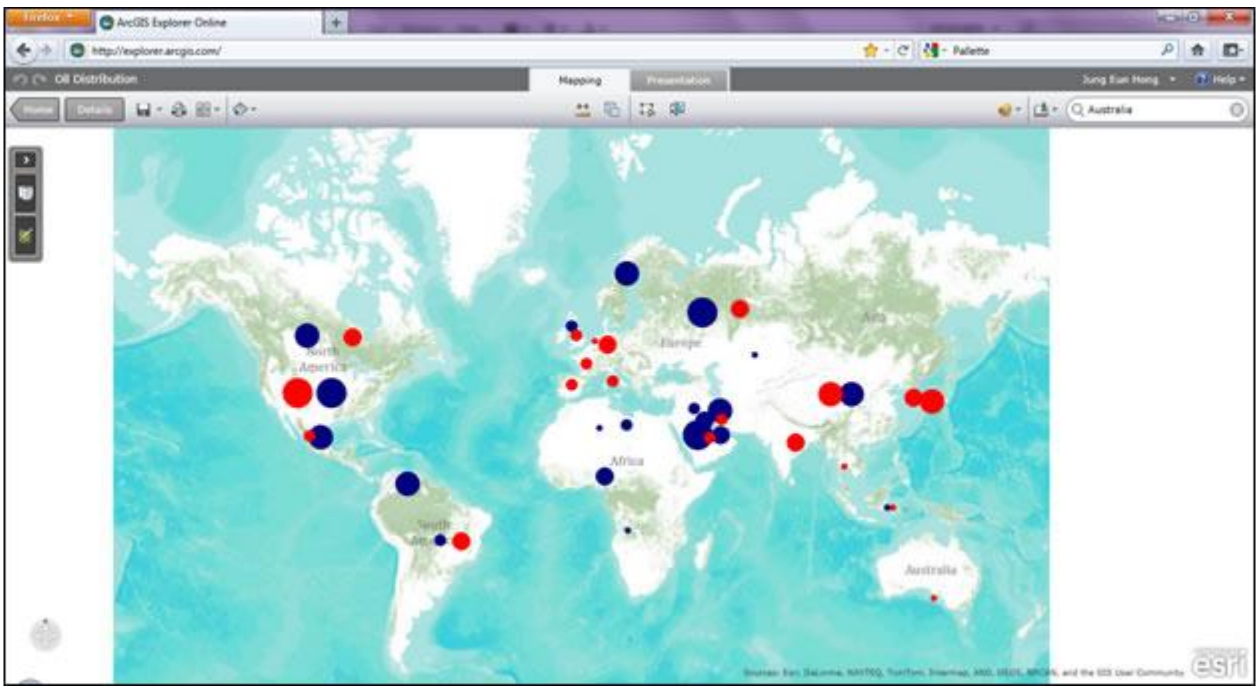
Learning objectives

- To compare major oil-producing and oil-consuming countries
- To study OPEC and its relationship with non-OPEC countries
- To gain knowledge of renewable energy sources

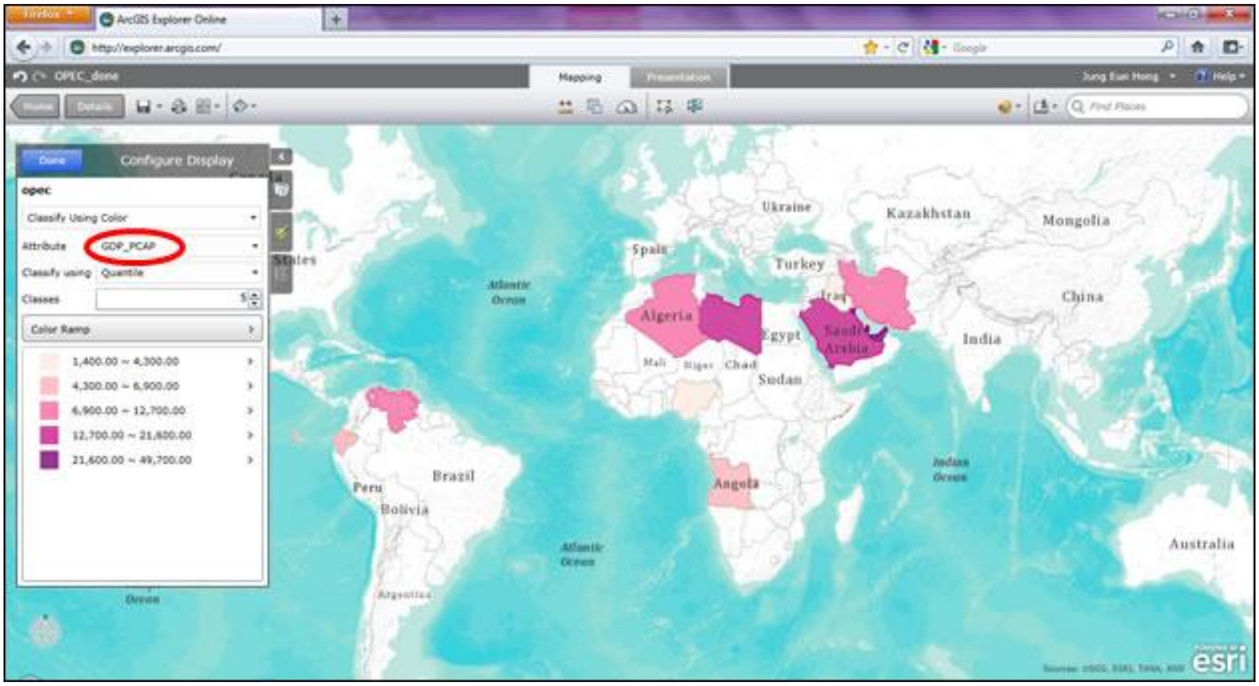
Summary

Preparation: In this activity, ArcGIS Explorer Online is used.

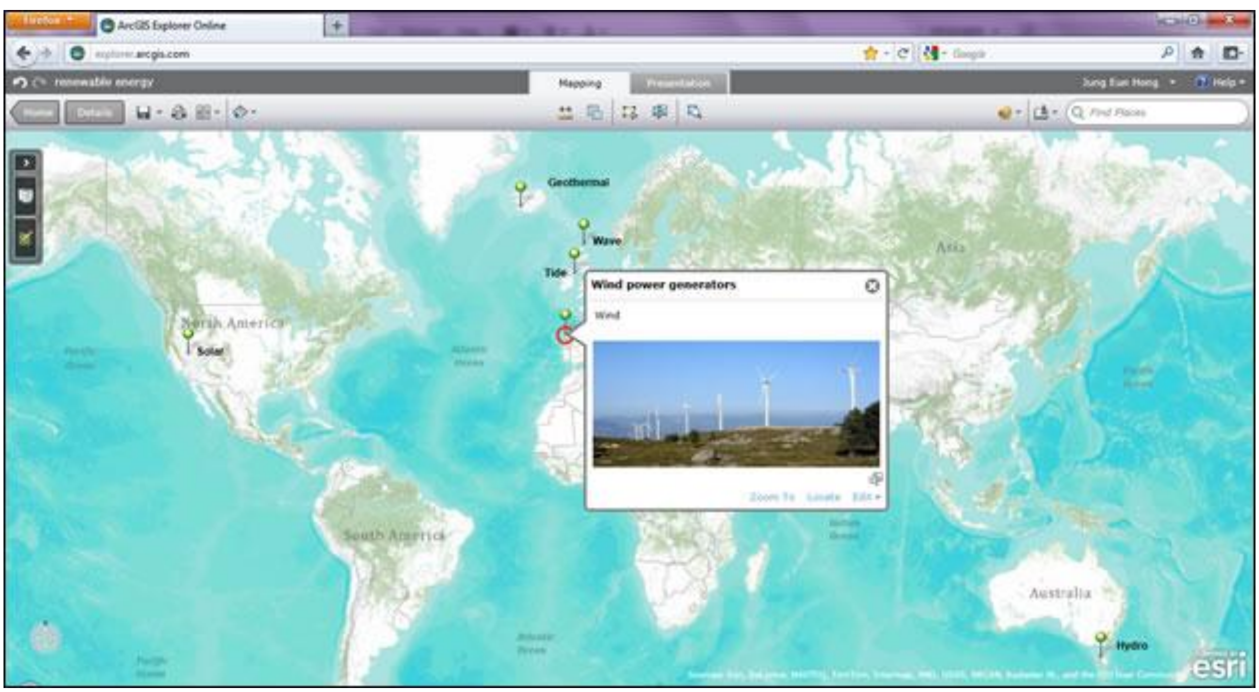
Activity 1: We will make a graduated symbol map to represent major oil-producing and oil-consuming countries.



Activity 2: We will study OPEC members using the dashboard tool and graduated colors.



Activity 3: We will learn about renewable energy sources by marking their locations and attaching related pictures.



National and Colorado Standards

National/CO	Content Area	Standards
National	Economics	1. Scarcity Productive resources are limited. Therefore, people can not have all the goods and services they want; as a result, they must choose some things and give up others.
		5. Trade Voluntary exchange occurs only when all participating parties expect to gain. This is true for trade among individuals or organizations within a nation, and among individuals or organizations in different nations.
		7. Markets and Prices A market exists when buyers and sellers interact. This interaction determines market prices and thereby allocates scarce goods and services.
		8. Role of Prices Prices send signals and provide incentives to buyers and sellers. When supply or demand changes, market prices adjust, affecting incentives.
	Geography	The World in Spatial Terms 1. How to use maps and other geographic representations, tools and technologies to acquire, process and report information from a spatial perspective.
		The World in Spatial Terms 3. How to analyze the spatial organization of people, places, and environments on Earth's surface.
		Human Systems 11. The patterns and networks of economic interdependence on Earth's surface.
		Human Systems 13. How the forces of cooperation and conflict among people influence human control of Earth's surface.
		Environment and Society 16. The changes that occur in meaning, use, distribution and importance or resources.
	Science	Science in Personal and Social Perspectives 2. Populations, resources, and environments
Colorado	Civics	1. Different forms of government and international organizations and their influence in the world community.
	Economics	1. Supply and demand influence price and profit in a market

		economy.
		2. The distribution of resources influences economic production and individual choices.
	Geography	1. Use geographic tools to gather data and make geographic inferences and predictions.
		2. Regions have different issues and perspectives.

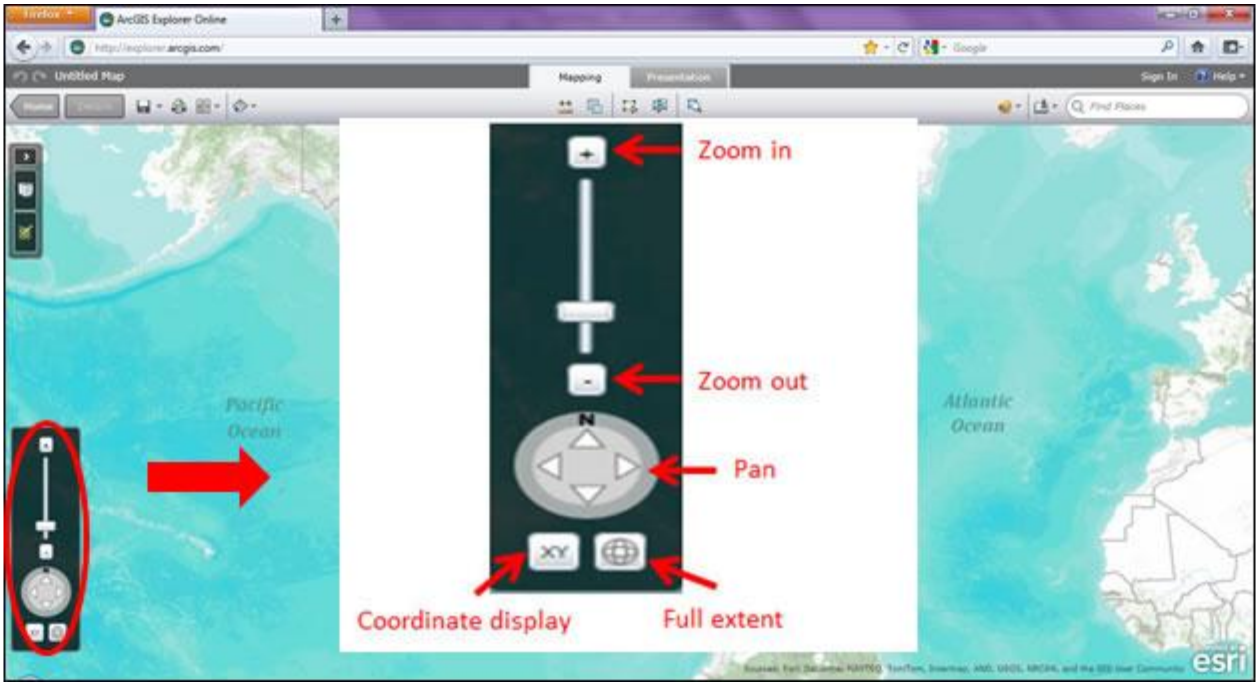
Natural Resources - Preparation

*** If you have not read the instruction about how to use the tutorials, please click here. ***

1. Go to “explorer.arcgis.com.” If you do not have the lastest version of Microsoft Silverlight, it will ask you to download and install it. Click the link, and follow the instructions. It is mostly clicking yes, yes, and yes.

2. Sign in with your Esri account if you already have it. If you do not, sign up as a new user. The detailed steps how to create a new user account are here.

3. The navigator is at the bottom left of the map. Once you move your mouse cursor over the navigator, you can see it. With the navigator, you can zoom in and out, pan, get coordinates, and see the whole map with "Full extent." If your mouse has a wheel, you can use the wheel to zoom in (scrolling up) and out (scrolling down).

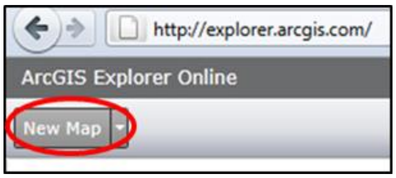


4. If you mouse-over on each icon/button/tool, you can see its name with a brief explanation. Spend some time familiarizing yourself with these controls.

Natural Resources - Activity 1. Oil Produced vs. Consumed

*** If you have not gone through the preparation of this topic yet, please click here. ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. We will start a new map. If ArcGIS Explorer Online is not opened now, go to "explorer.arcgis.com." Then click "New Map."



2. Let's save the map first. Click the "Save" button on the toolbar.

3. Give the map a title. You can add tags to be searchable by others. Once you fill out the form, click "Save."

4. In this activity, we will make a graduated symbol map of the top 20 oil-**producing** and top 20 oil-**consuming** countries, as measured in barrels of oil per day. The data source of this activity is from the CIA Factbook 2007.

5. I have already grouped the 20 top oil-producing countries into five groups. These 20 countries produce 83.82% of oil in the world. We will assign the biggest circle to the first group (32.87% of oil produced in the world), and the smallest circle to the last group (6.62% of oil produced in the world).

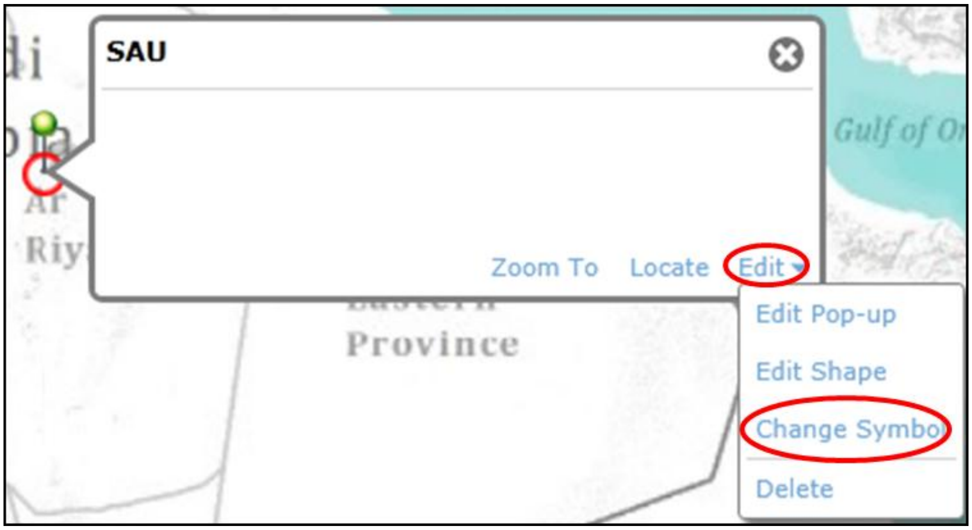
Group	Country	% of Oil Produced
1	Saudi Arabia	11.76
	Russia	11.67
	United States	9.45
2	Iran	4.94
	China	4.51
	Mexico	4.24
	Norway	4
	Canada	3.9
	Venezuela	3.82
3	Nigeria	3.04
	Kuwait	3
	United Arab Emirates	2.97
4	Iraq	2.6
	Brazil	2.59
	United Kingdom	2.58
	Libya	2.13
5	Angola	1.99
	Algeria	1.7
	Kazakhstan	1.61
	Indonesia	1.32

6. We will start with the first group. Let's find Saudi Arabia on the map. Type its name in the "Find Places" box. Then hit the enter key.

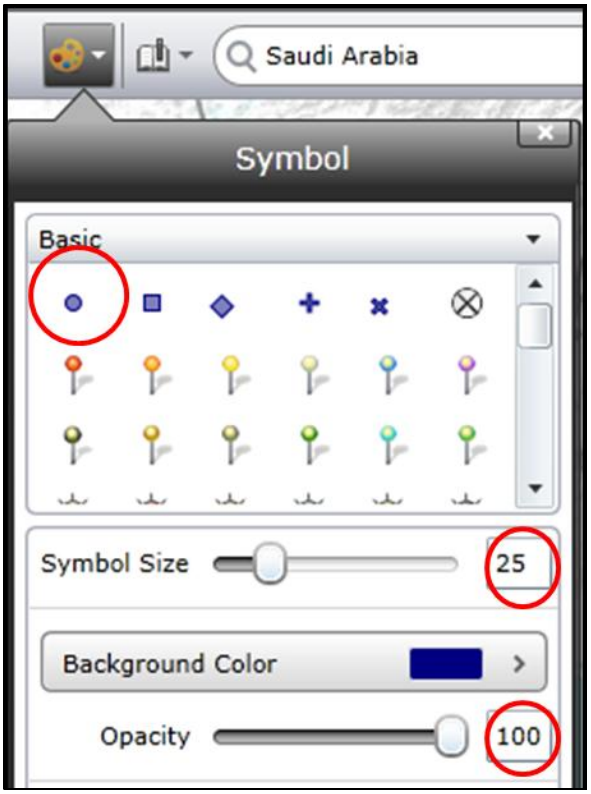
7. Click the "+" sign, and then choose "Map Notes."

8. Now you can see a green point symbol.

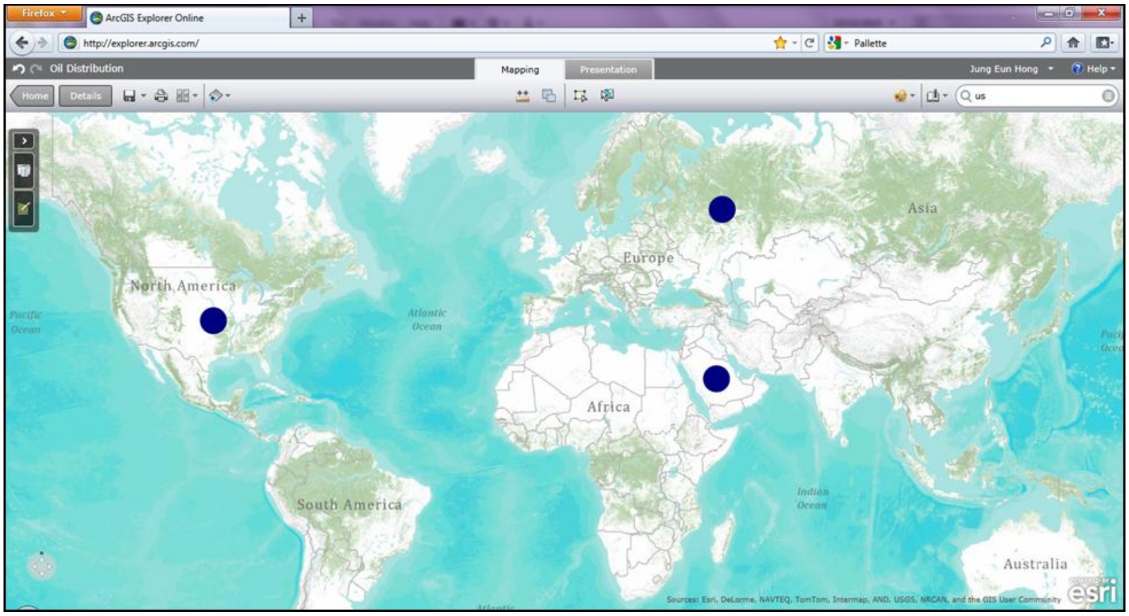
9. Click the point symbol, and then choose "Edit." Then click "Change Symbol."



10. The Symbol Palette will pop up. Choose a circle. Then change the symbol size to **25** and opacity to **100**. You can type the number directly. Once you are done, zoom out from the map to see how it is shown on the map.

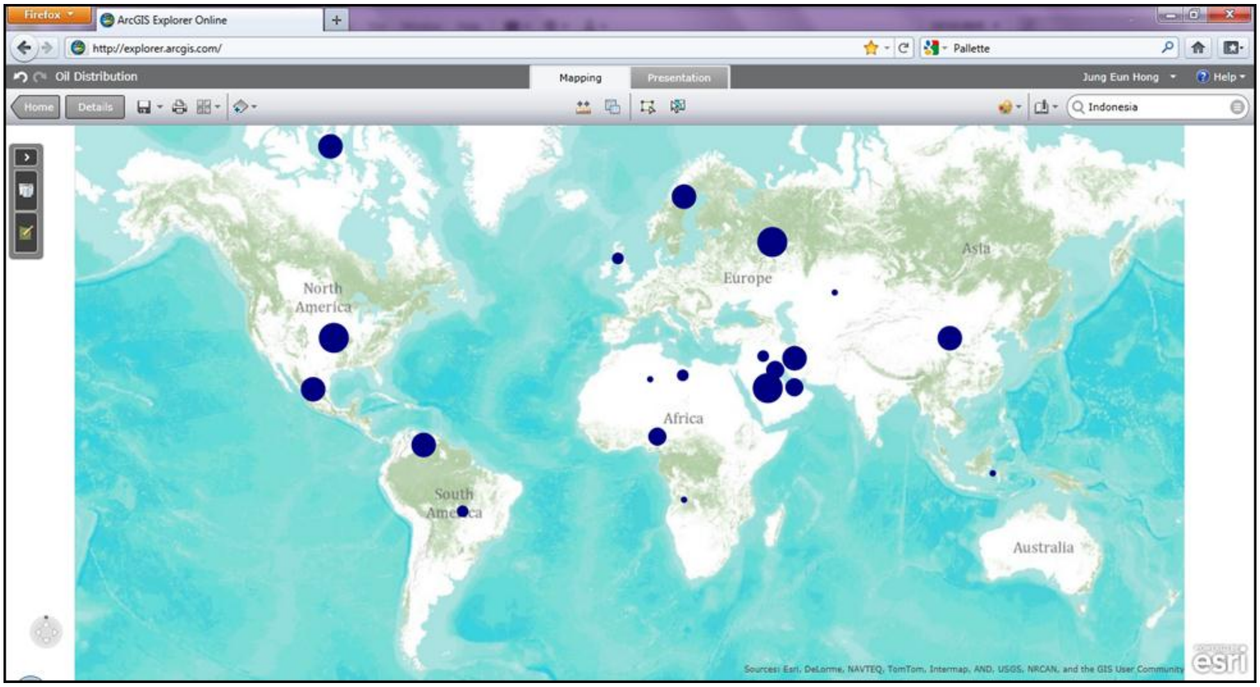


11. Follow the previous steps from #**6** to #**10** for Russia and the United States. Your map will look like the following:



12. Let's follow the previous steps from #**6** to #**10** for the rest of the groups (go to [the oil-producing countries table above](#)). The procedures are the same except for the circle size. Assign **20** for the second, **15** for the third, **10** for the fourth, and **5** for the fifth group. You can determine any size of circle for the first group. Make sure that you set the sizes for the rest of groups with the same increments (i.e. 7, 14, 21, 28, and 35). Do not forget to use the same color for all groups. Just in case, keep saving your map by clicking the "Save" button.

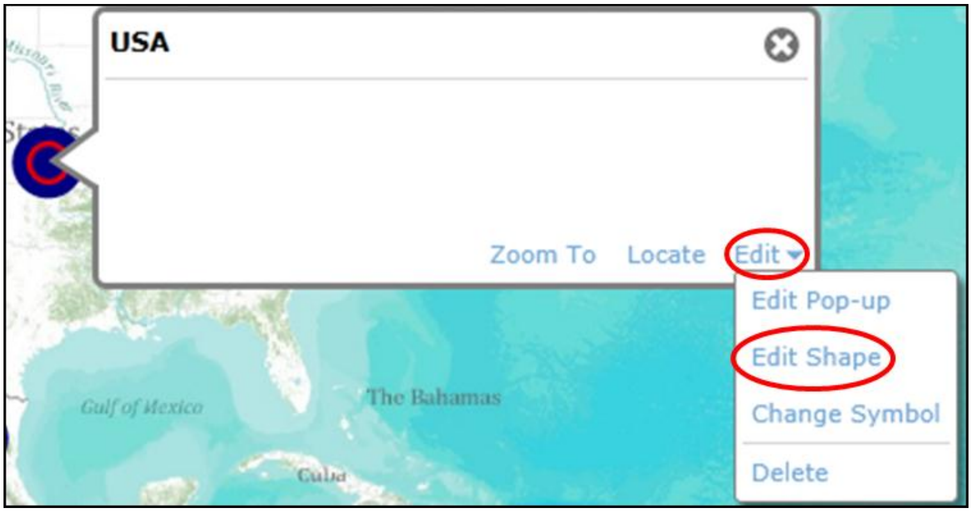
13. Here is my map.



14. The following table lists the information for the top 20 oil-consuming countries (56.12% in the world). Again, follow the previous steps from #**6** to #**10** to make a map of these countries. Keep in mind that you need to use a contrasting color to the one for the oil-producing countries (i.e. Blue and Red).

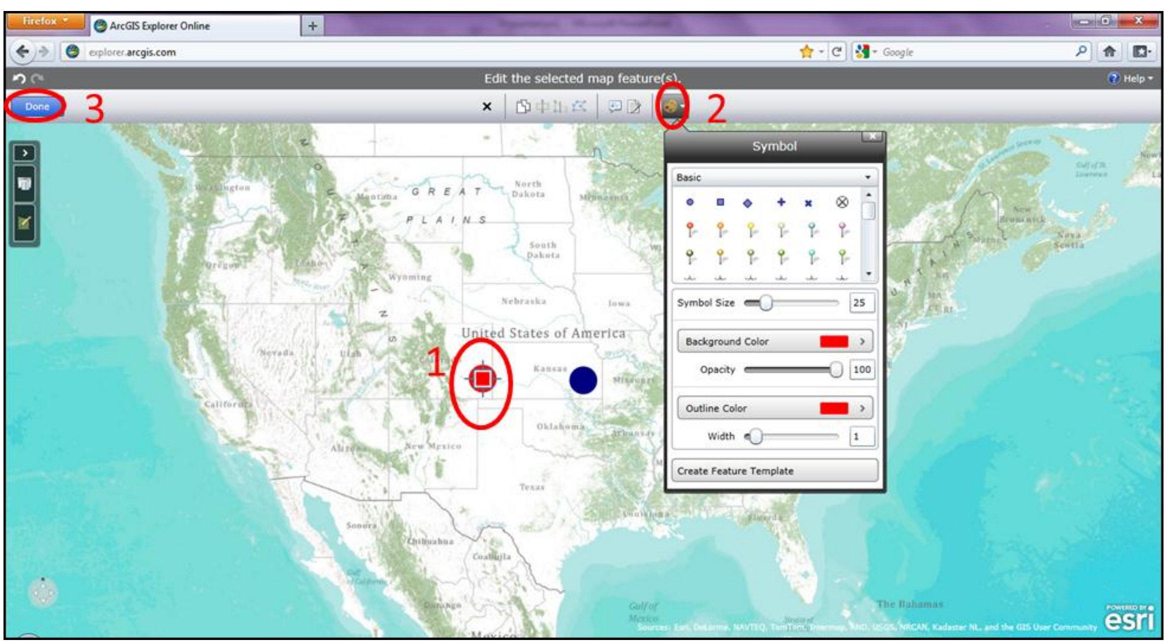
Group	Country	% of Oil Consumed
1	United States	25.62
2	China	8.08
	Japan	6.62
3	Germany	3.28
	Russia	3.09
	India	3.03
	Canada	2.84
	Brazil	2.71
	South Korea	2.66
4	France	2.44
	Mexico	2.43
	Italy	2.32
	Saudi Arabia	2.28
	United Kingdom	2.26
	Spain	1.94
	Iran	1.87
5	Indonesia	1.34
	Netherlands	1.17
	Thailand	1.11
	Australia	1.08

15. For countries listed in both tables, you need to move one point symbol right next to the other one. To do this, click the point symbol, and then click "Edit." Then click "Edit Shape."

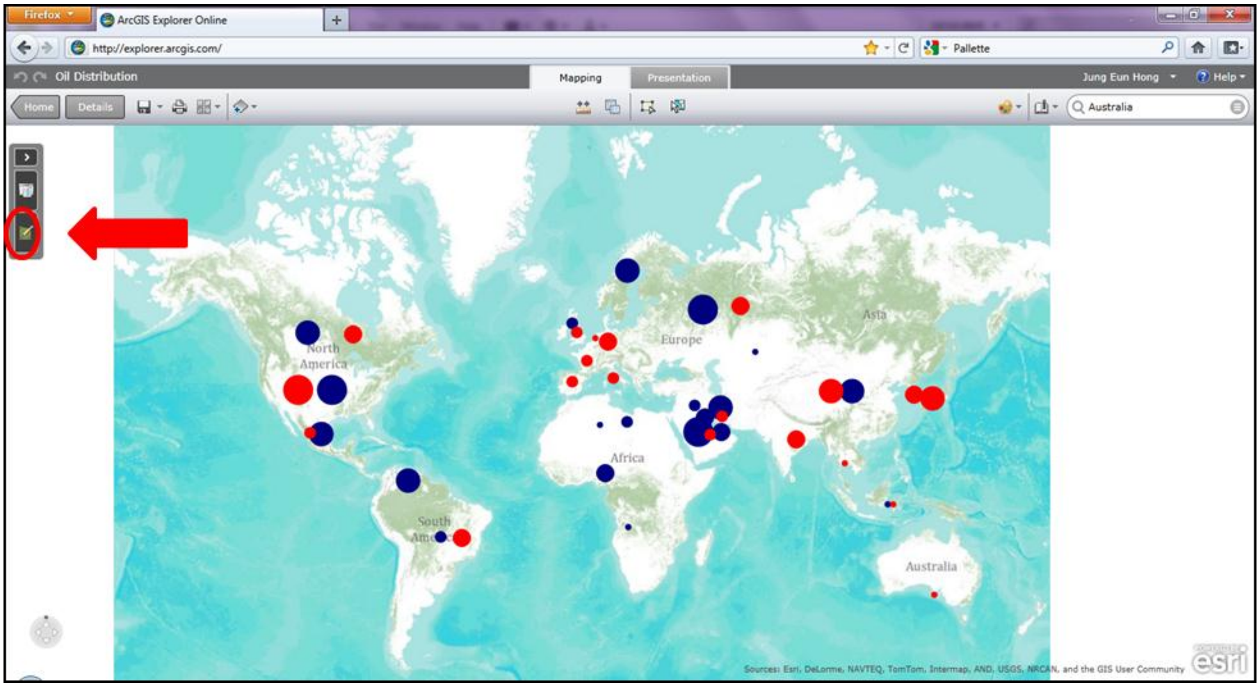


16. The location of the point symbol now is editable.

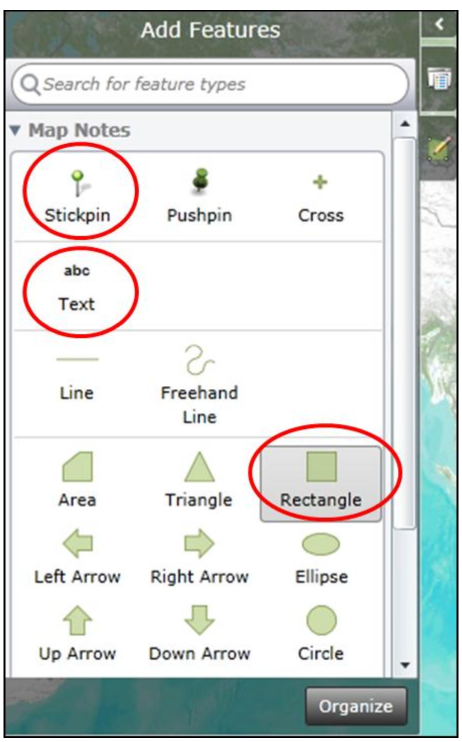
17. Move the point symbol. Then click the "Change Symbol" tool on the main toolbar to change its color, size, and opacity. Once you change the symbol, click "Done."



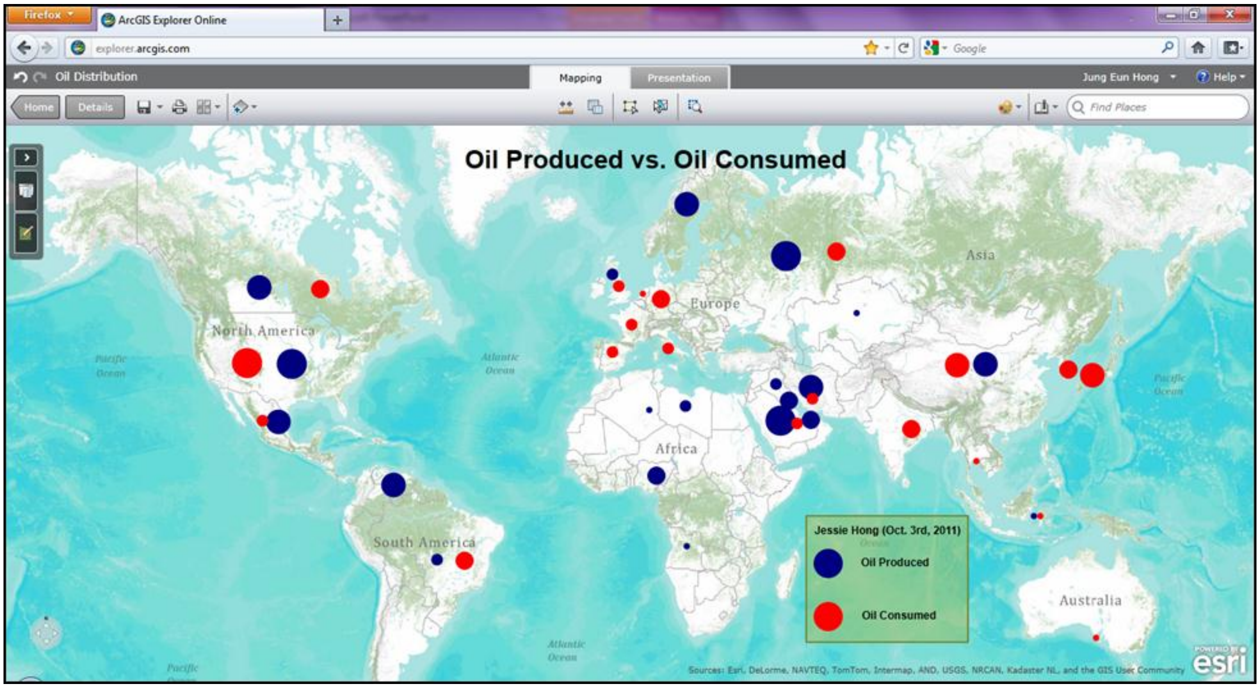
18. Your map may look like the following. Blue circles indicate oil-producing countries, and red circles indicate oil-consuming countries. If you want to add a legend on the map, click “Add Features.”



19. Use the “Rectangle,” “Text,” and “Stickpin” symbols to create a legend and a title. Click [this link] to see the detailed steps.



20. Here is my final map.



- Discussion questions
  - Look at the distribution of major oil-***producing*** countries? Where are they mostly located?
  - Look at the distribution of major oil-***consuming*** countries? Are they mostly developed countries?
  - Based on the above map, the U.S. consumes huge amounts of oil (25.62%), but we also produce significant amounts of oil (9.45%). Do we have enough oil?
  - From what countries would you predict that we import oil? Why?

Natural Resources - Activity 2. OPEC

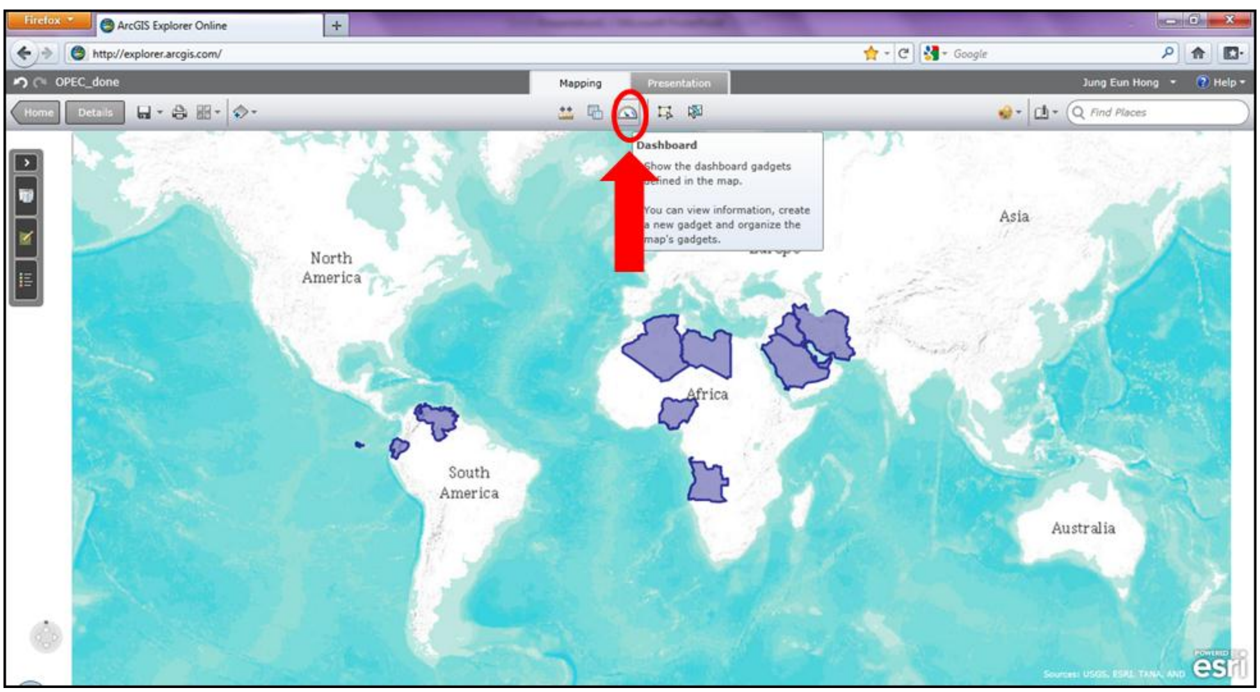
*** If you have not gone through the preparation of this topic yet, please click here. ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. Click this link.

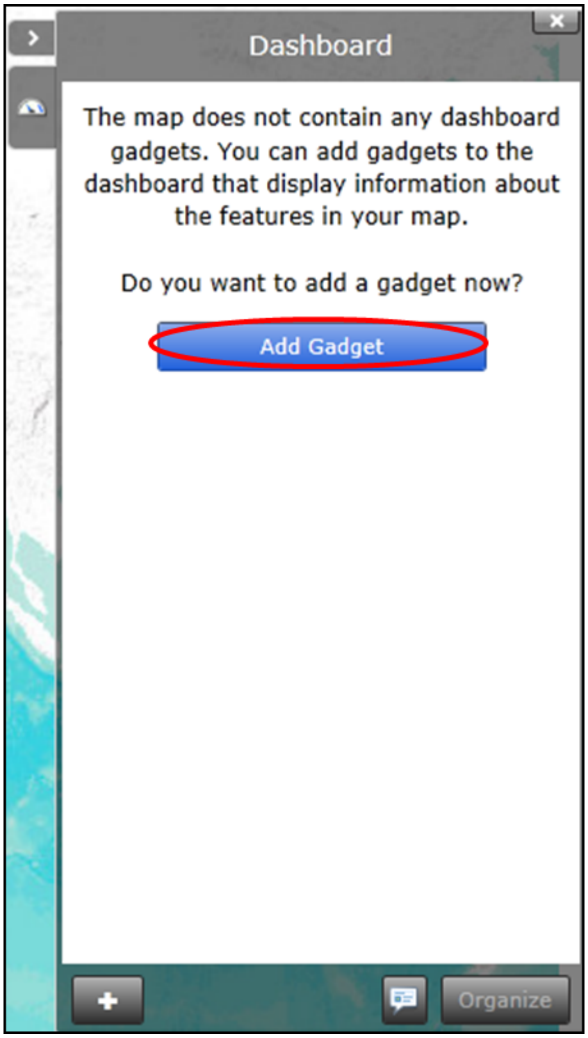
2. This is the prepared map for this activity. Once the map is loaded, save this map in your Esri account using "Save."

3. This map shows twelve OPEC countries and their oil related information such as percentage of total oil produced and exported in barrels per day. OPEC countries are Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela. The data source is from the CIA Factbook 2007 and Esri. If you want to look at the actual dataset, click this link to download its excel file. The meaning of each field is explained in step **#13**.

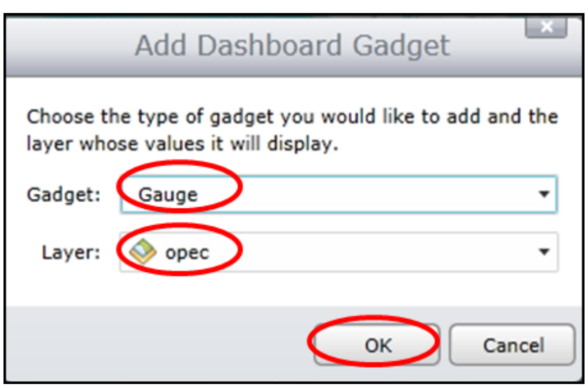
4. First, we will add a dashboard gadget to represent total oil exported of OPEC countries. Click the "Dashboard" tool on the main toolbar.



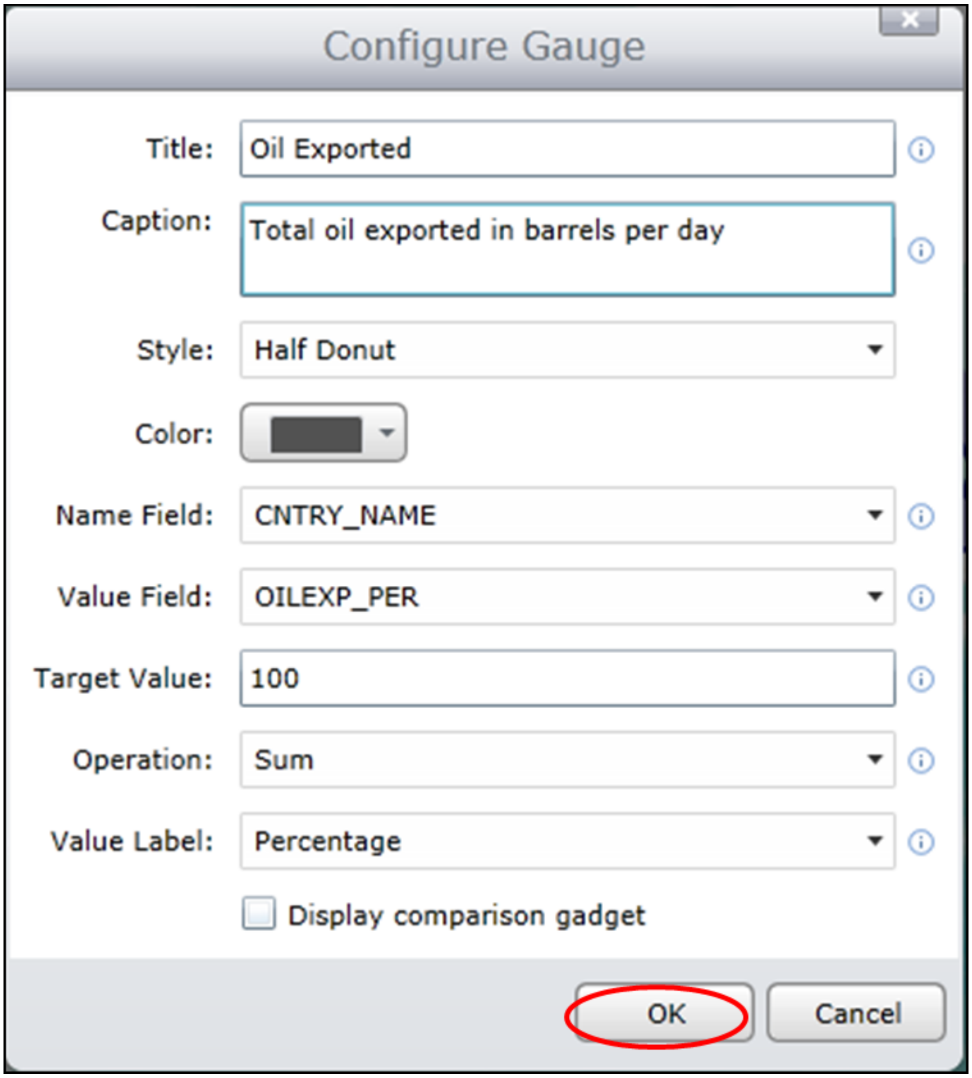
5. The “Dashboard” window will pop up. Click the “Add Gadget” button.



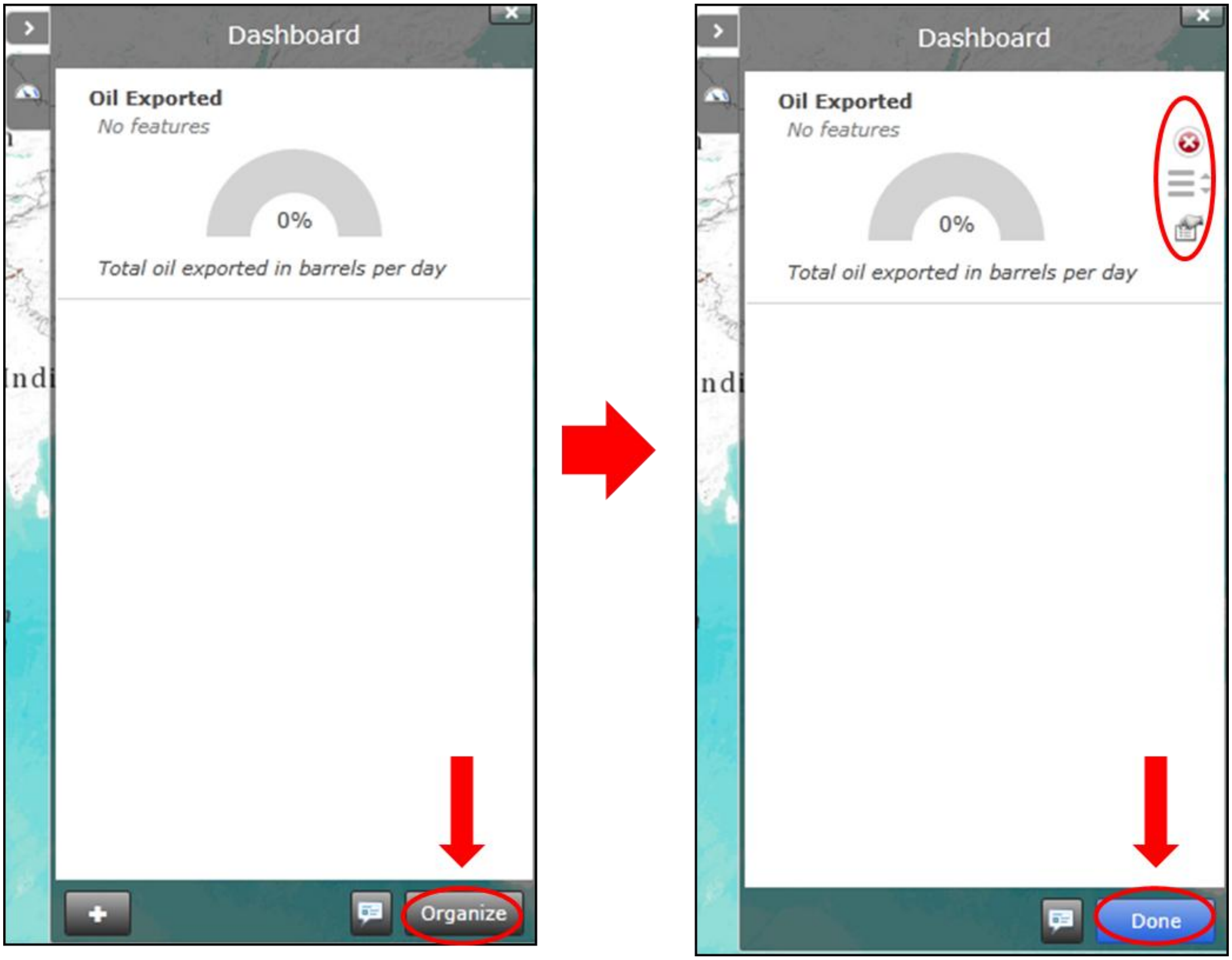
6. We will use the “Gauge” gadget for the ***opec*** layer. Then click “OK.”



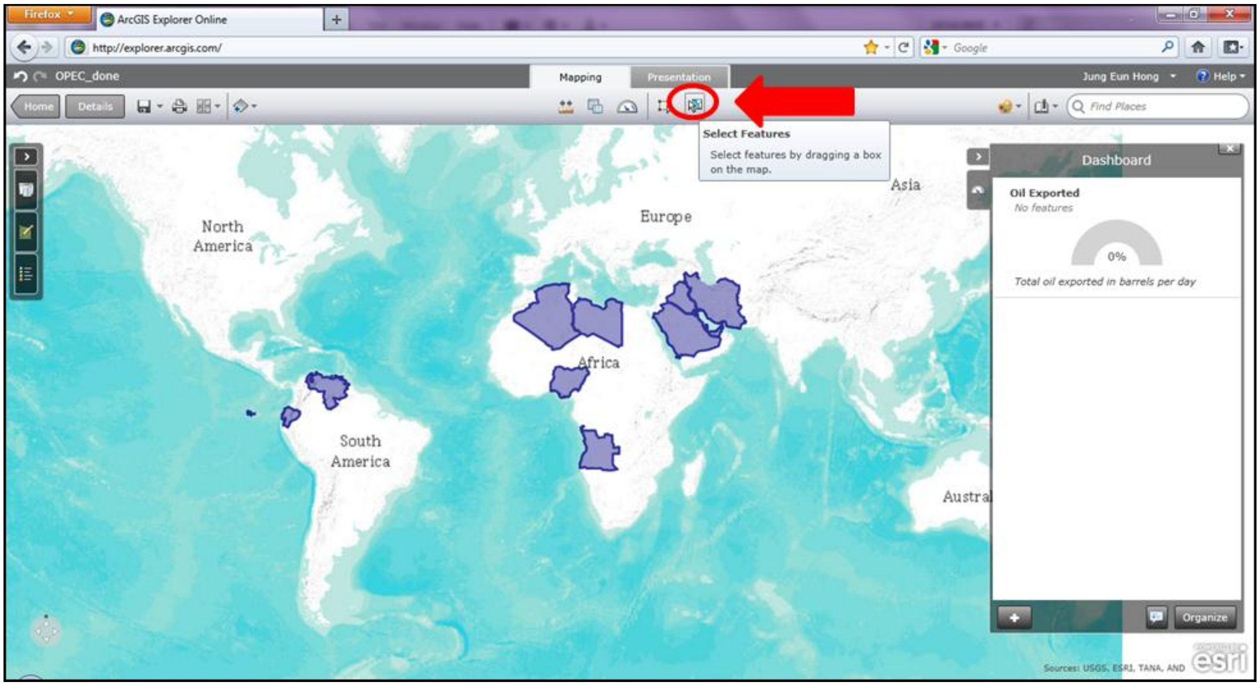
7. Fill out “Configure Gauge” as the following. You might need to click the drop-down menus to select. Once you are done, click “OK.”



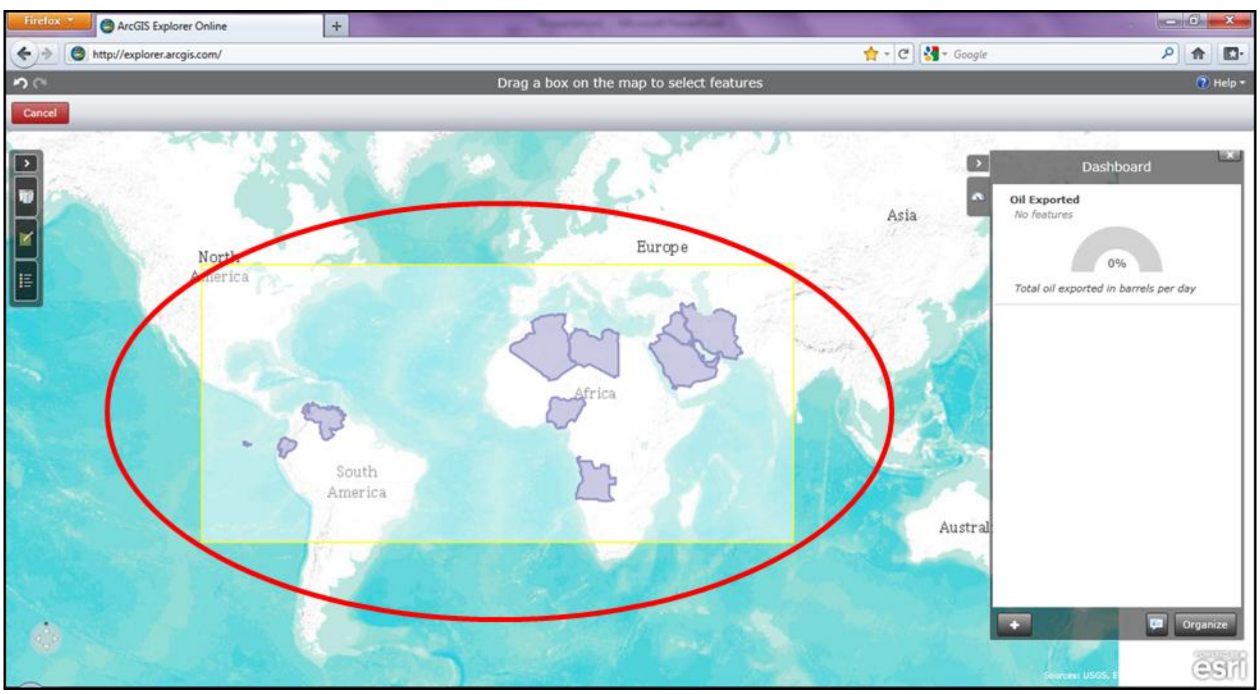
8. If you want to edit the gadget, click the “Organize” button. There are three options—“Remove,” “Drag to re-order,” and “Properties.” If you click “Properties,” you can see “Configure Gauge” again (refer to step #**7**). Once you have finished editing your gadget, you need to click “Done.”



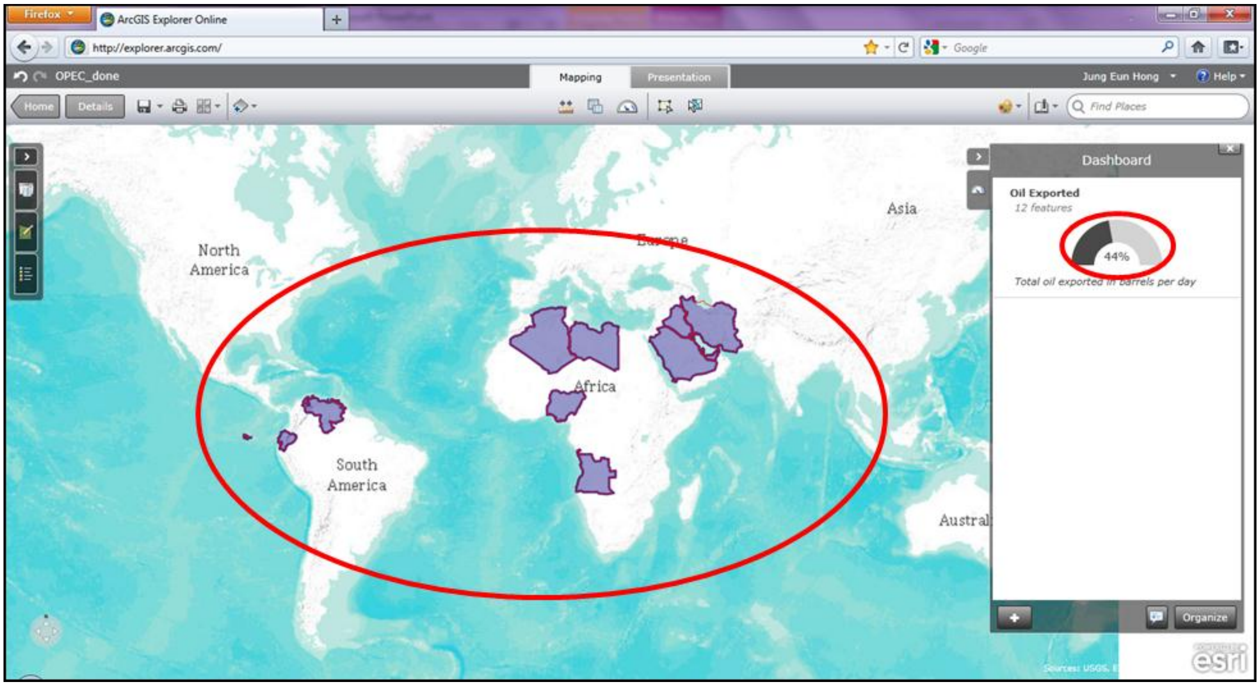
9. Let's figure out the total percentage of oil exported from OPEC countries. Click the "Select Features" tool.



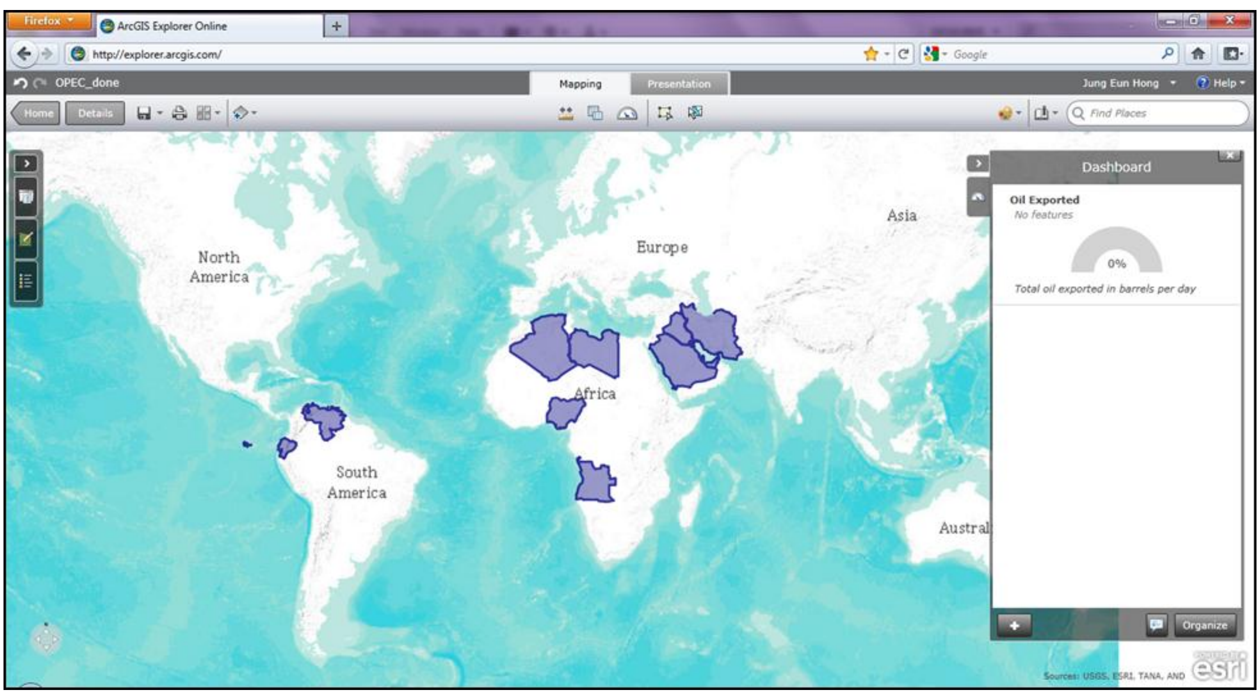
10. Draw a box on the map. This may take some practice. Click a corner of the map with your left mouse button and hold the button down. With your finger still holding down the left mouse button, move to mouse diagonally to where you would like to place the opposite corner of the box. In this case, your box needs to include all OPEC countries, like this:



11. Twelve countries are now selected. You can see that their outlines turned to red. On the Gauge, you can see that the amount of oil exports of OPEC countries is only 44%.

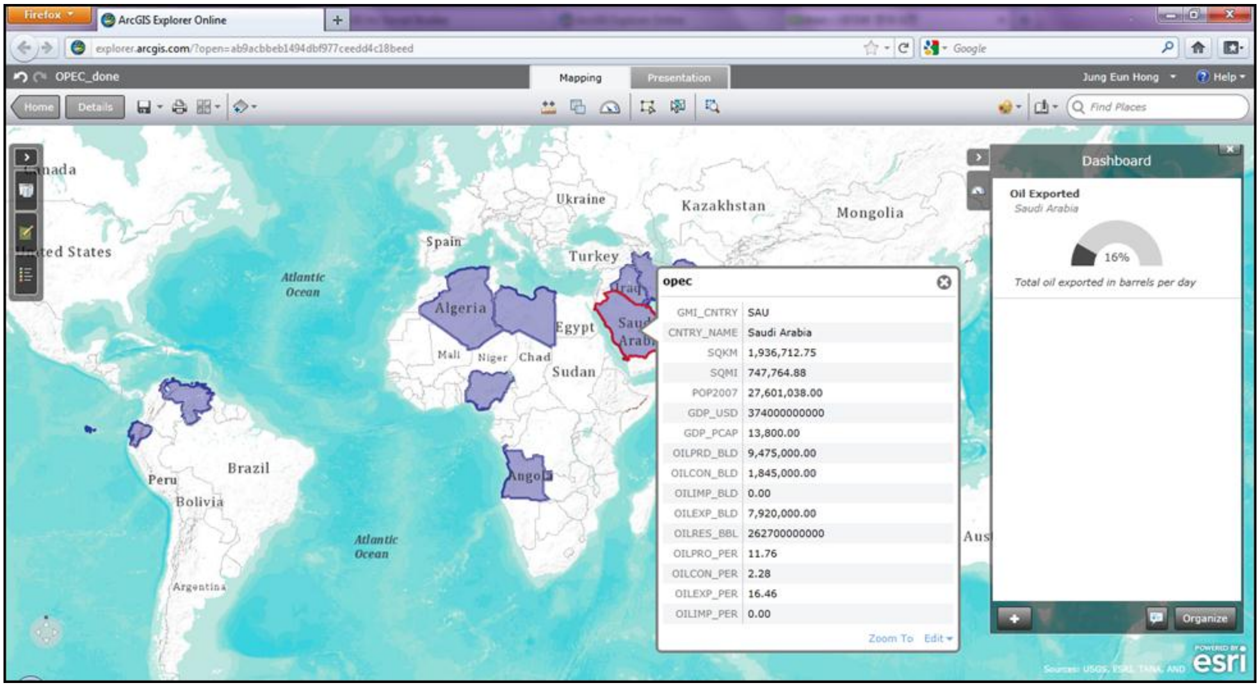


12. Click anywhere on the map to unselect OPEC countries. Now the Gauge says no feature is selected, and the boundaries of countries turn to blue now.

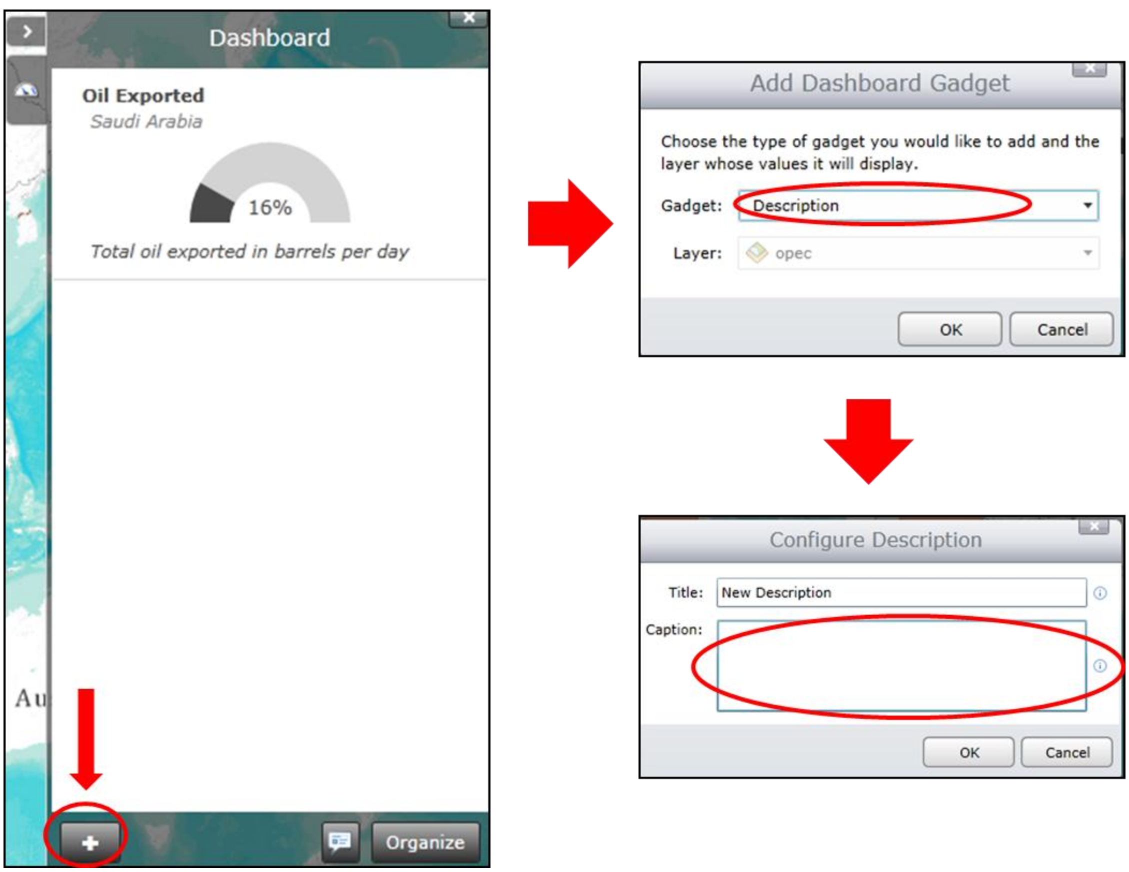


13. When you click one of OPEC countries, you will see its pop-up window. There are sixteen fields on the pop-up. The following is explanation of each field.

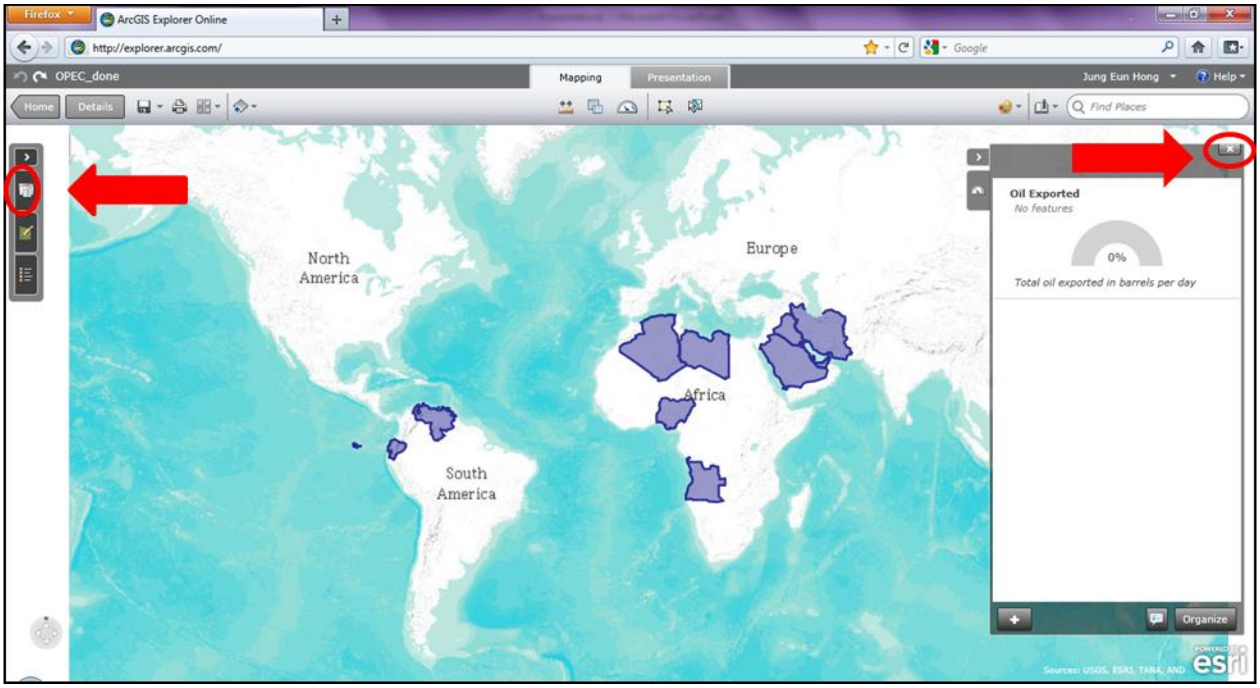
Field	Meaning
GMI_CNTRY	Three letter code for the country or geographic entity from Global Mapping International
CNTRY_NAME	Country name in common use
SQKM	Area in square kilometers using an equal area projection
SQMI	Area in square miles using an equal area projection
POP2007	2007 midyear population estimate (Source: US Census Bureau, International Division)
GDP_USD	Gross Domestic Product (GDP) in US dollars
GDP_PCAP	GDP per capita in US dollars
OILPRD_BLD	Total oil produced in barrels per day
OILCON_BLD	Total oil consumed in barrels per day
OILIMP_BLD	Total oil imported in barrels per day
OILEXP_BLD	Total oil exported in barrels per day
OILRES_BBL	Stock of proved reserves of crude oil in barrels
OILPRD_PER	Percentage of total oil produced in barrels per day
OILCON_PER	Percentage of total oil consumed in barrels per day
OILEXP_PER	Percentage of total oil exported in barrels per day
OILIMP_PER	Percentage of total oil imported in barrels per day



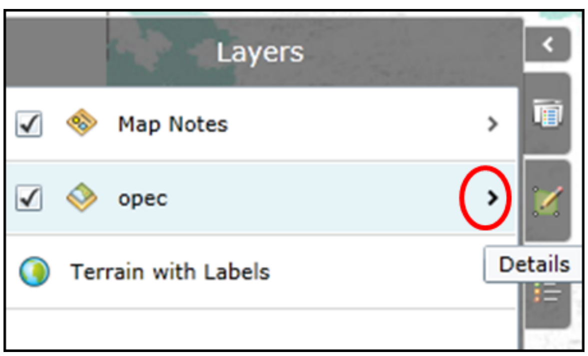
14. If you want, you can add the above field information in the "Description" gadget. To do so, click the "+" sign to add a new gadget, and then choose "Description." In "Configure Description," add that information in "Caption."



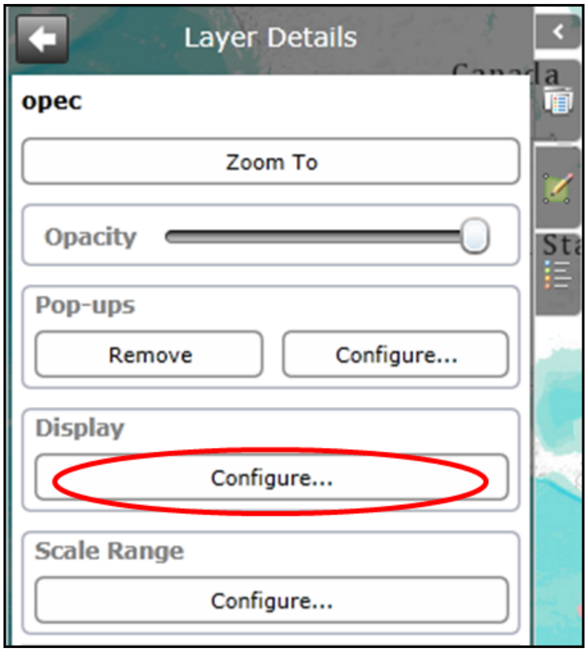
15. Close “Dashboard” by clicking the “x” button, and then click “Layers.” You can make the dashboard appear again if you click the “Dashboard” tool on the main toolbar.



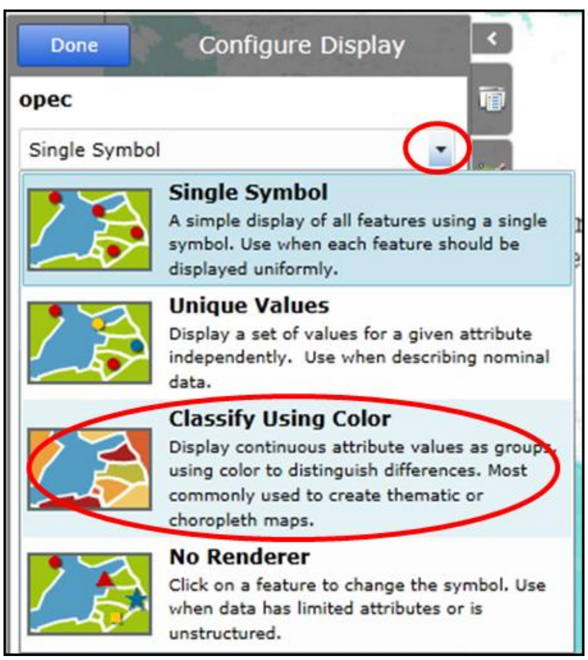
16. Now we will make a graduated color map of OPEC countries’ percentage of total oil exported in barrels per day. Click the details of the ***opec*** layer.



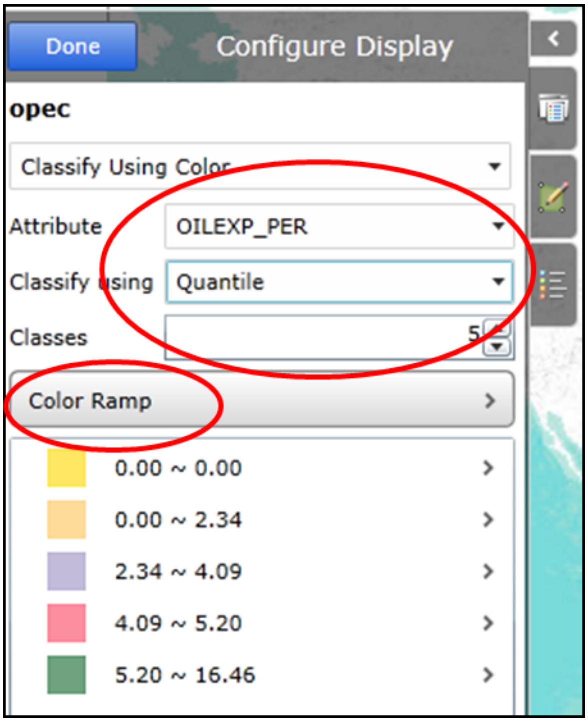
17. In the "Layer Details" window, click "Configure" in the row labeled "Display."



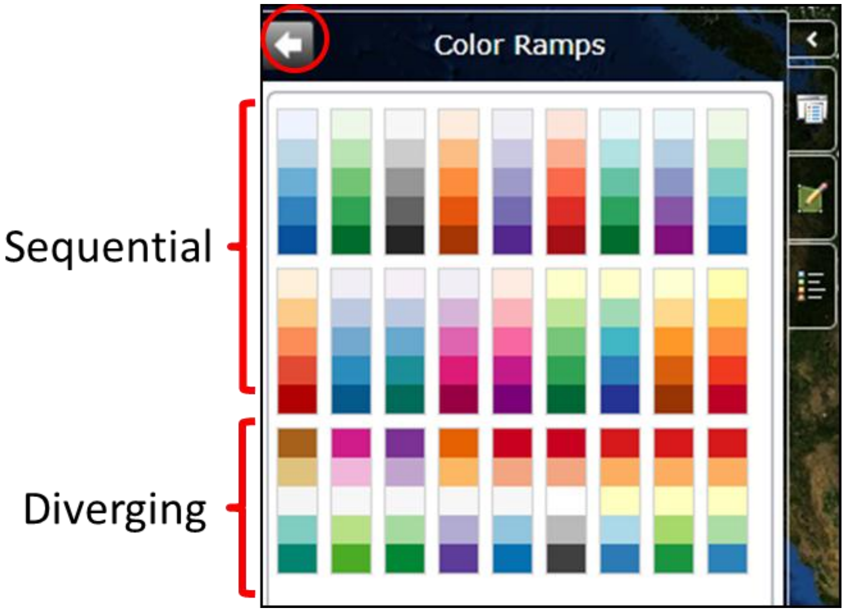
18. Click the drop-down menu "Single Symbol," and then choose "Classify Using Color."



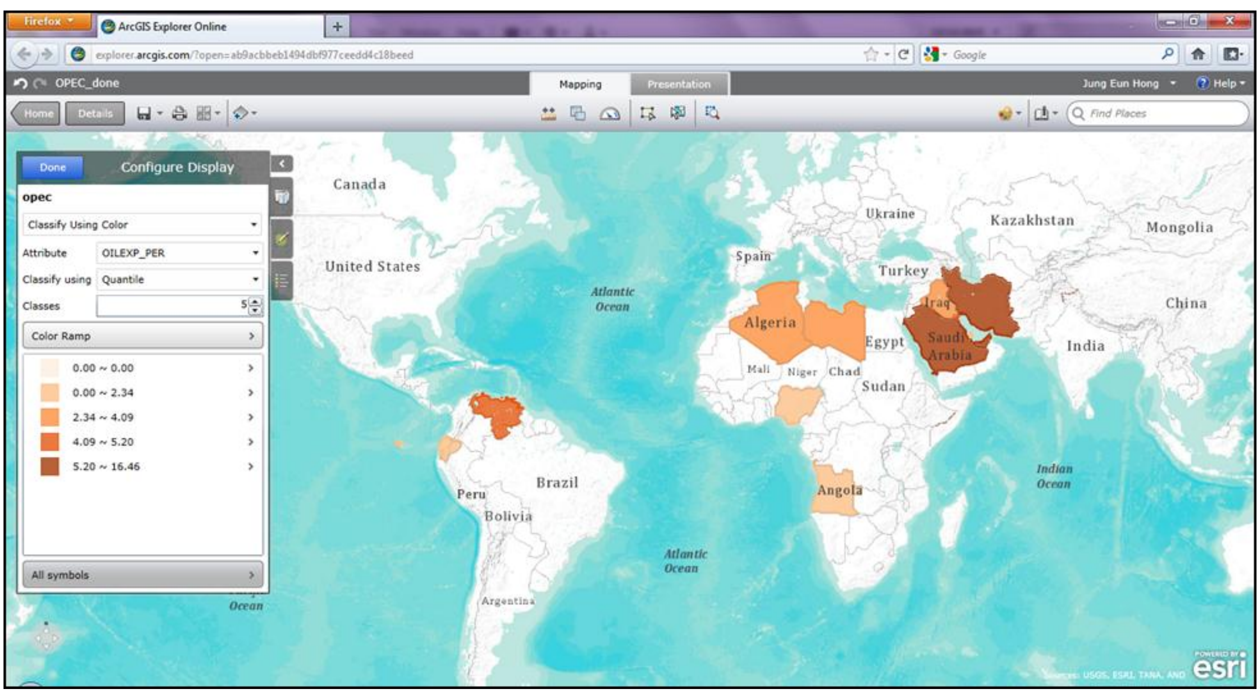
19. Set the “Configure Display” in the following ways. You need to click the drop-down menus for the “Attribute” and “Classify using” fields to choose:
Attribute: “OILEXP_PER” (% of total oil exported in barrels per day)
Classify using: “Quantile” (For more information about the classification methods, click here.)
Classes: “5” (Setting the number of classes determines the number of groups in which you will divide your data.)
Then click “Color Ramp.”



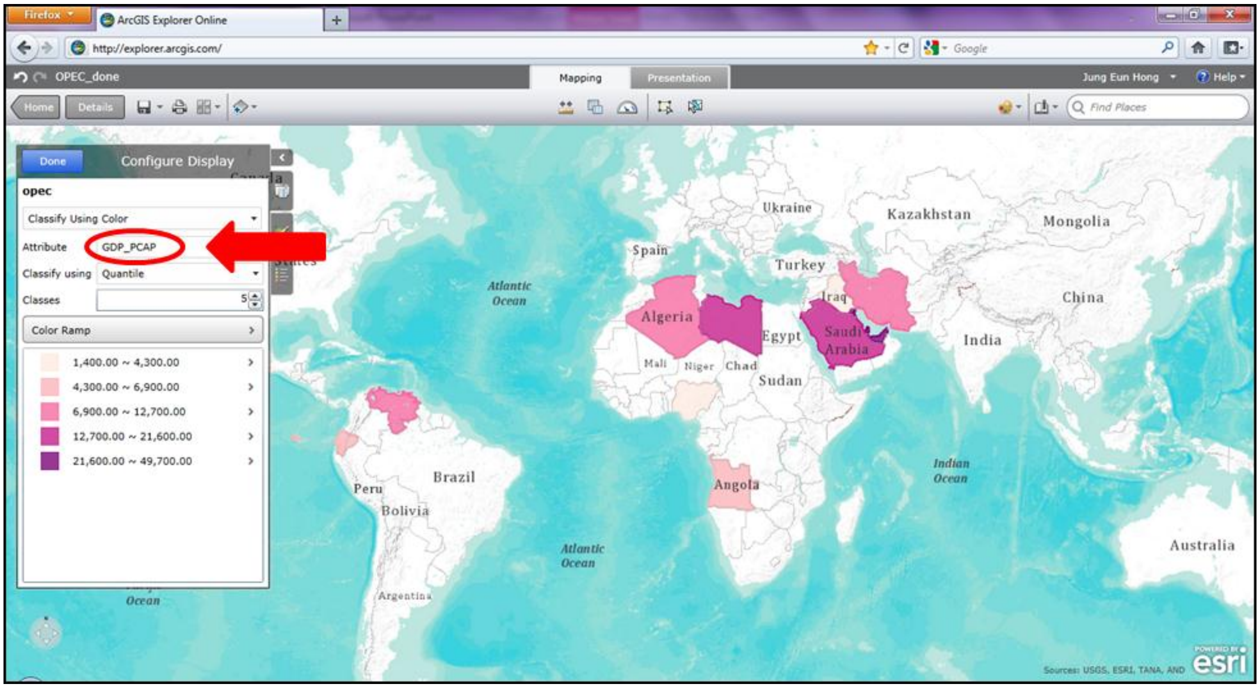
20. Choose one of the sequential color schemes. For more information about the color schemes, click here.
Then click the arrow button to go back to “Configure Display.”



21. Your map may look like the following:



22. You can make various thematic maps by selecting any field of the table in [step **#13**] in the selection of the "Attribute" field. For example, if you choose the "GDP_PCAP" field, you can make a map to show GDP per capita for OPEC countries like the following:



- Discussion questions
  - OPEC members' export rate is only 44%. Can OPEC members control the price of world oil? Why or why not?
  - Are there any conflicts between OPEC and non-OPEC countries such as Russia, Norway, Mexico, Canada, and the UK?
  - Do all of the major oil exporting countries have high GDP per capita? If not, why are there variations between them?
  - What types of government does each OPEC country have?

Natural Resources - Activity 3. Renewable Energy

*** If you have not gone through the preparation of this topic yet, please click here. ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. In this activity, we will cover renewable energy. You might talk about why we need to consider renewable energy. We will mark examples of renewable energy resources on the map with related pictures.

2. We will start a new map. If ArcGIS Explorer Online is not opened now, go to "explorer.arcgis.com." Then click "New Map." Save your map, and give the map a title (refer steps #**1** to #**3** in Activity 1).

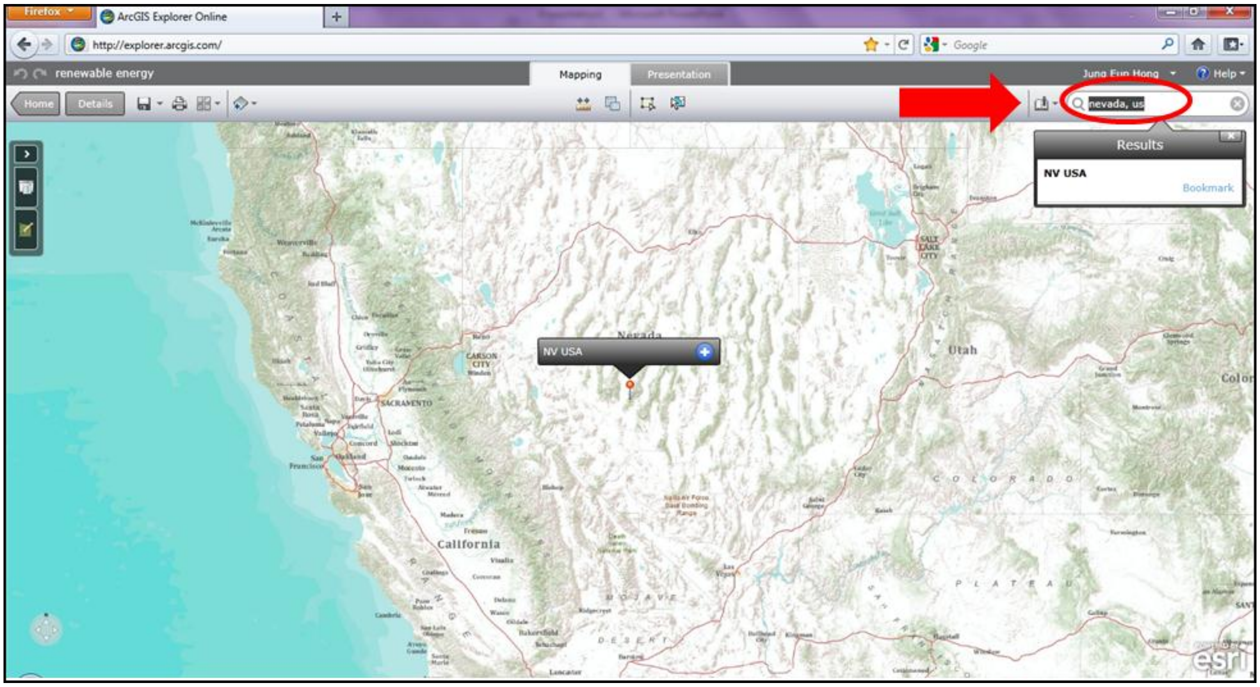
In order to compare locations of major oil-producing countries and countries with renewable energy, you can continue to make a map for this activity on the Activity2 (OPEC) map.

3. The following is a list of renewable energy that we will mark on the map.

Energy Type	Name	Location
Solar	Nellis Solar Power Plant	Nevada, US
Wind	Wind powered generators	Galicia, Spain
Hydro	Gordon Dam	Tasmania, Australia
Geothermal	Nesjavellir Geothermal Power Station	Iceland (64°6'29N, 21°15'23W)
Wave	Pelamis Wave Energy Converter	Orkney, UK
Tide	Tidal stream generator (SeaGen)	Strangford Lough, Ireland

4. Now we will add a point symbol on the map and add a picture on the pop-up window. Let's start with solar energy.

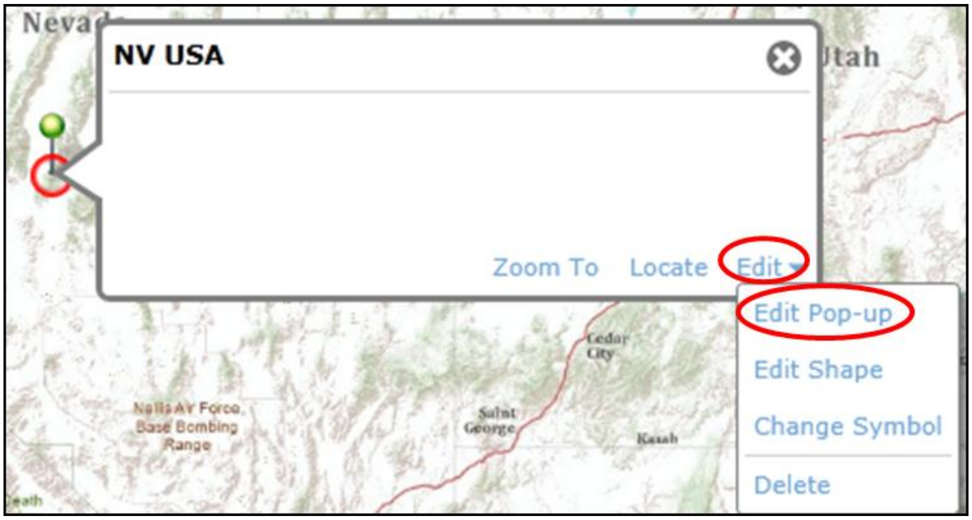
5. Type “Nevada, US” in the “Find Places” box, and hit the enter key.



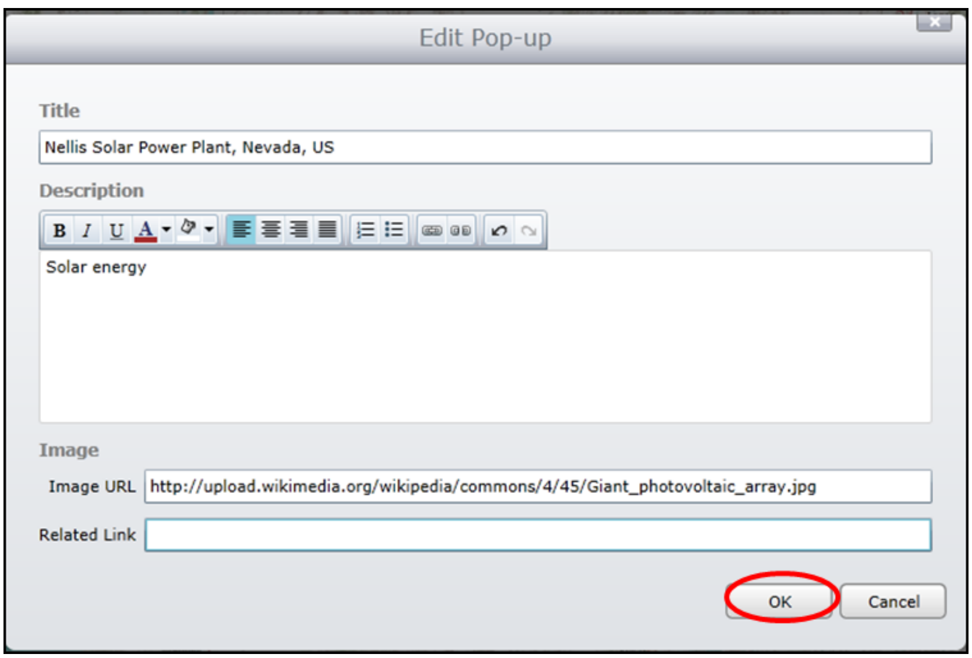
6. Click the “+” sign, and then choose “Map Notes.”

7. Now you can see a green point symbol.

8. Click the point symbol, and then choose “Edit.” Then click “Edit Pop-up.”



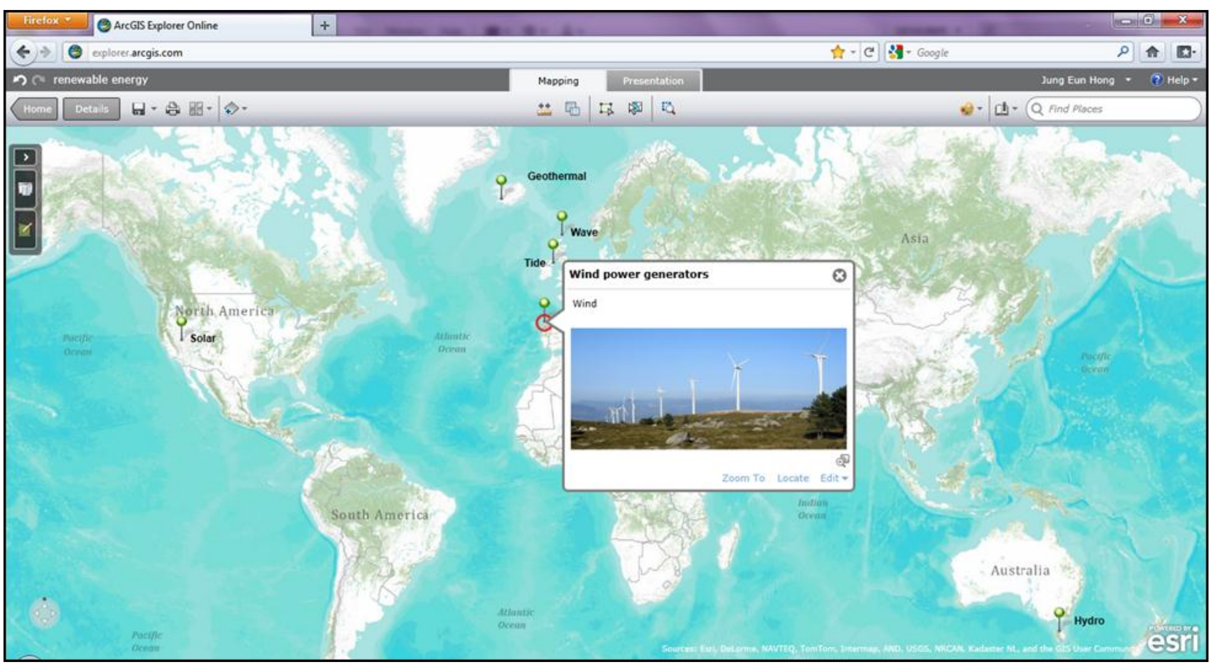
9. Change the title, and add description. You can add a related image and website. If you do not know how to find the URL of an image, please click here.
You can simply search on the web to find related images, or, you can use the images that I provide here: Images of Renewable Energy. Once you are done, click “OK.”



10. Here is my example.

(Image source: By [U.S. Air Force photo/Airman 1st Class Nadine Y. Barclay]() [Public domain], via Wikimedia Commons)

11. Follow the previous steps from #**5** to #**9** for the other renewable energy types. For geothermal energy type, use its latitude and longitude (64°6'29N, 21°15'23W) to find its exact location. Your map may look like the following:



(Image source: By [Arnejohs at en.wikipedia]() [Public domain], via Wikimedia Commons)

- Discussion questions
  - What is renewable energy? What is non-renewable energy?
  - What reasons do advocates give for developing renewable energy?
  - What are advantages and disadvantages using renewable energy?
  - Compare and contrast the locations of major oil producing countries (the map in Activity 1) and renewable energy.
  - Can you think of any other examples of renewable energy?
  - Is renewable energy cost effective compared to importing oil from other countries? How are countries that use renewable energy benefitting from using less oil?

APPENDIX D-3: THE CIVIL WAR
(One of the sample tutorials for 8th grade)

The Civil War

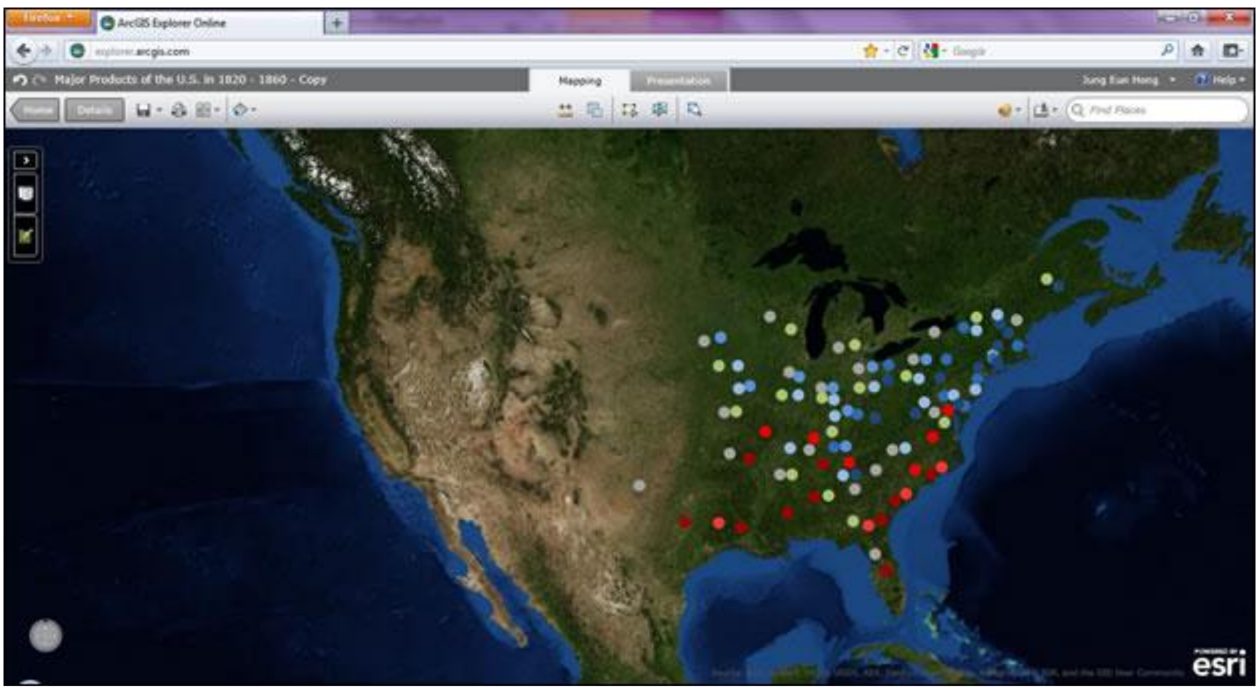
Learning objectives

- To compare and contrast the major products and industries of the North and South in 1820 to 1860, and consider how these differences led to conflicts
- To understand the distribution of slave population in 1860
- To identify Union, Confederate, and Border states in the Civil War era and analyze the locations of major battles

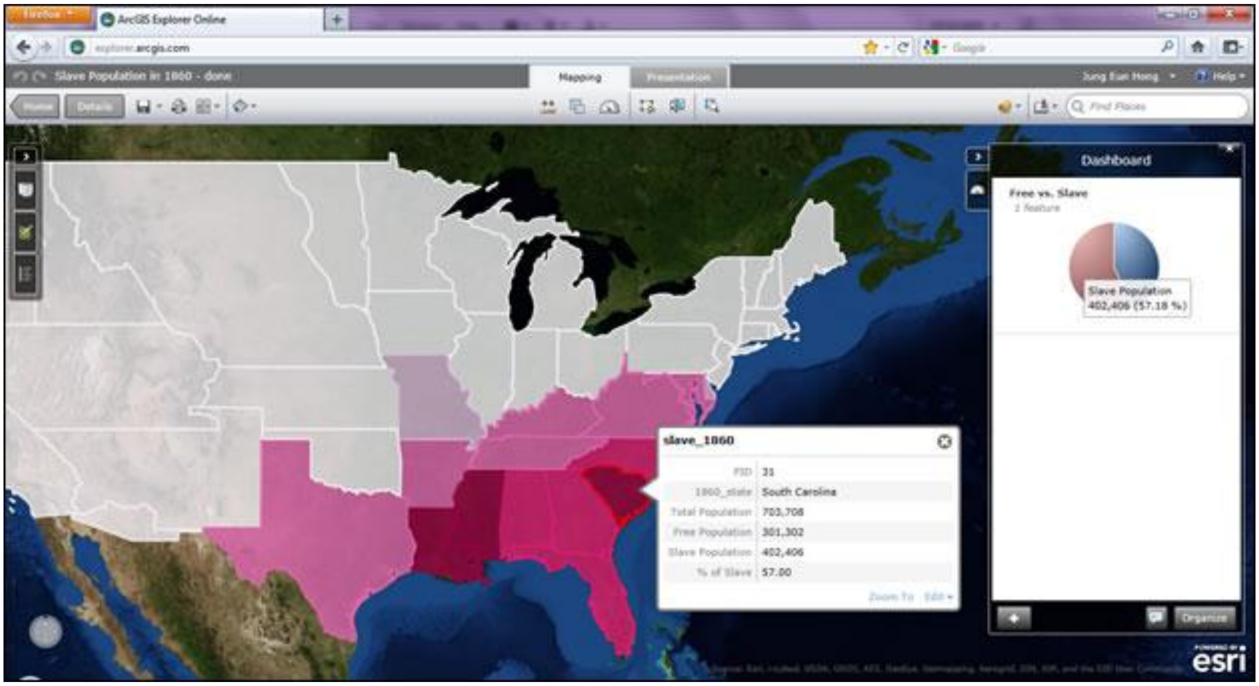
Summary

Preparation: In this activity, ArcGIS Explorer Online is used.

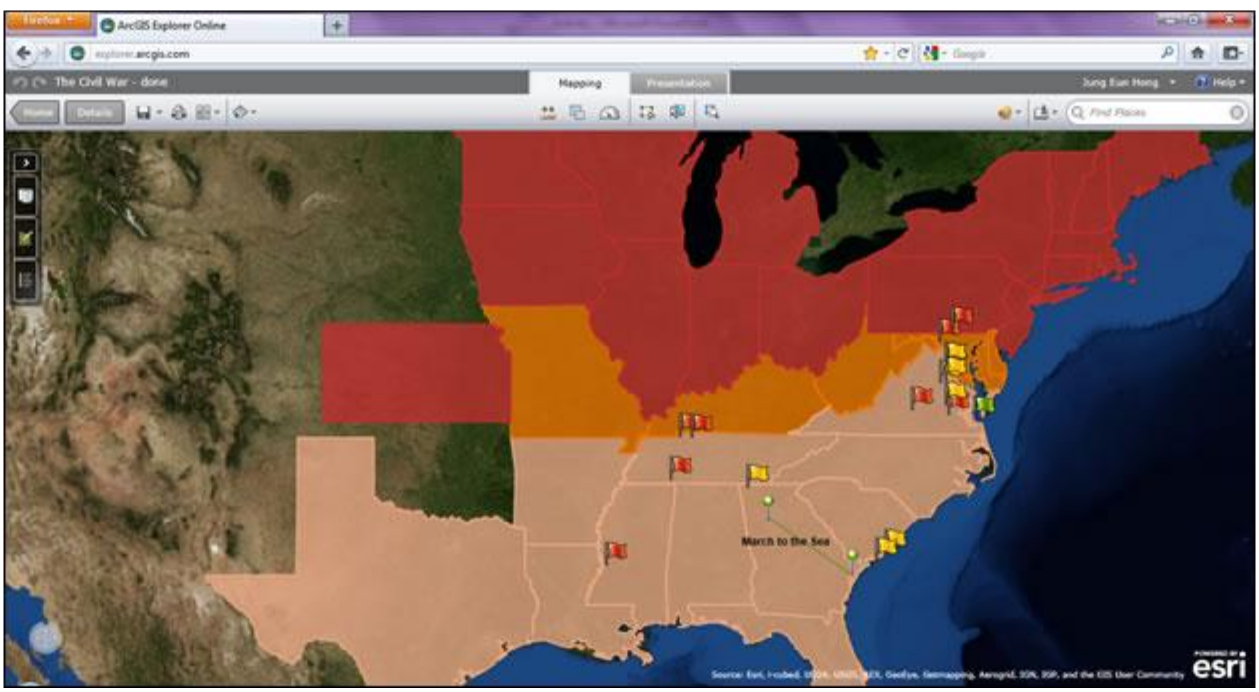
Activity 1: We will make a multi-colored dot map of major products of the North and South in 1820 to 1860.



[Activity 2](#): We will make a [graduated color map](#) of slave population percentages by state in 1860.



[Activity 3](#): We will make a map of Union, Confederate, and Border states in the Civil War era and mark the locations of major battles.



National and Colorado Standards

National/CO	Content Area	Standards
National	Geography	The World in Spatial Terms 1. How to use maps and other geographic representations, tools and technologies to acquire, process and report information from a spatial perspective.
		The World in Spatial Terms 3. How to analyze the spatial organization of people, places, and environments on Earth's surface.
		Human Systems 11. The patterns and networks of economic interdependence on Earth's surface.
		Human Systems 13. How the forces of cooperation and conflict among people influence human control of Earth's surface.
		Uses of Geography 17. How to apply geography to interpret the past.
	History	Historical thinking - 1. Chronological Thinki**ng** B. Identify the temporal structure of a historical narrative or story.
		Historical thinking - 1. Chronological Thinki**ng** C. Establish temporal order in constructing their [students'] own historical narratives.
		Historical thinking - 2. Historical Comprehension G. Draw upon data in historical maps.
		Historical thinking - 2. Historical Comprehension H. Utilize visual and mathematical data.
		Historical thinking - 3. Historical analysis and interpretation C. Analyze cause-and-effect relationships bearing in mind multiple causation.
		US History - Era 4 (Expansion and Reform (1801-1861)) 2. How the industrial revolution, increasing immigration, the rapid expansion of slavery, and the westward movement changed the lives of Americans and led toward regional tensions.
		US History - Era 5 (Civil War and Reconstruction (1850-1877)) 1. The causes of the Civil War.
		US History - Era 5 (Civil War and Reconstruction (1850-1877)) 2. The course and character of the Civil War and its effects on the American people.
Colorado	Geography	1. Use geographic tools to analyze patterns in human and physical

		systems.
		2. Conflict and cooperation occur over space and resources.
	History	1. Formulate appropriate hypotheses about United States history based on a variety of historical sources and perspectives.
		2. The historical eras, individuals, groups, ideas and themes from the origins of the American Revolution through Reconstruction and their relationships with one another.

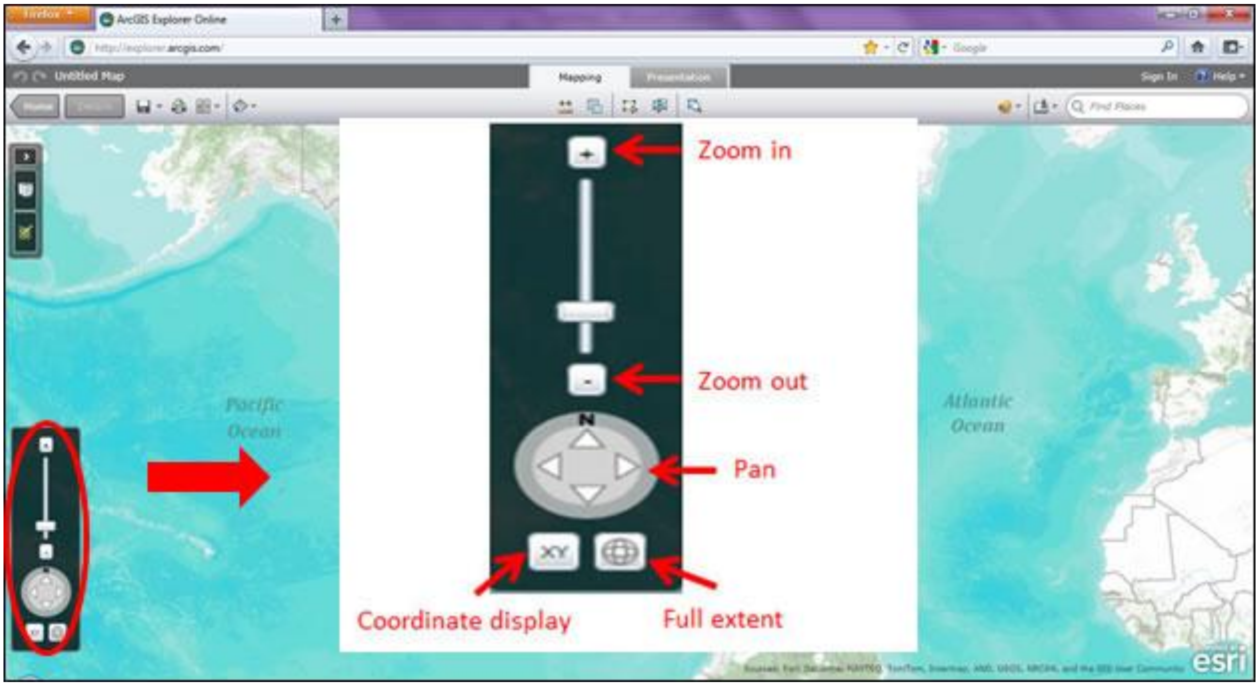
The Civil War - Preparation

*** If you have not read the instruction about how to use the tutorials, please click here. ***

1. Go to "explorer.arcgis.com." If you do not have the lastest version of Microsoft Silverlight, it will ask you to download and install it. Click the link, and follow the instructions. It is mostly clicking yes, yes, and yes.

2. Sign in with your Esri account if you already have it. If you do not, sign up as a new user. The detailed steps how to create a new user account are here.

3. The navigator is at the bottom left of the map. Once you move your mouse cursor over the navigator, you can see it. With the navigator, you can zoom in and out, pan, get coordinates, and see the whole map with "Full extent." If your mouse has a wheel, you can use the wheel to zoom in (scrolling up) and out (scrolling down).



4. If you mouse-over on each icon/button/tool, you can see its name with a brief explanation. Spend some time familiarizing yourself with these controls.

The Civil War - Activity 1. Major Products of North and South in 1820 to 1860

*** If you have not gone through the preparation of this topic yet, please click here. ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. Click this link.

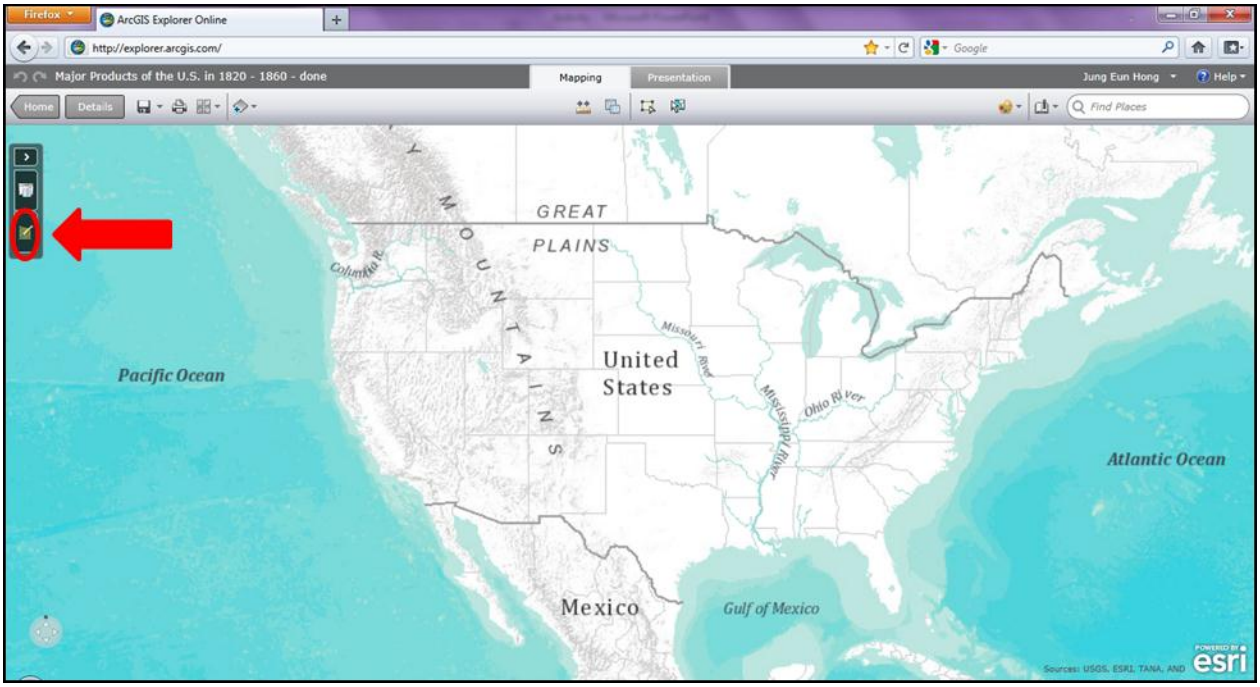
2. This is the prepared map for this activity. Once the map is loaded, save this map in your Esri account using "Save."

3. We will compare nine major products and industries of the U.S. between 1820 and 1860—Cattle, Cotton, Grain, Iron/Steel, Lumber, Mining, Rice/Sugar cane, Textiles, and Tobacco. To create a map, we will use the following information from The American Nation published by Prentice Hall (1998, p.380 and p.389).

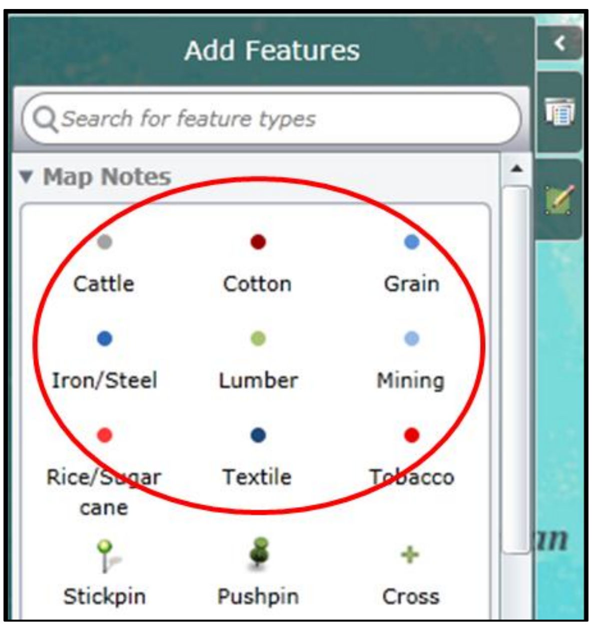
	State	Major Products in 1820 - 1860
North	Connecticut	Cattle, Iron/Steel, and Textiles
	Delaware	Iron/Steel
	Illinois	Cattle, Grain, Lumber, and Mining
	Indiana	Cattle, Grain, Lumber, and Mining
	Iowa	Cattle, Grain, Lumber, and Mining
	Maine	Lumber and Textiles
	Massachusetts	Iron/Steel and Textiles
	Michigan	Cattle and Lumber
	New Hampshire	Cattle and Textiles
	New Jersey	Iron/Steel, Mining, and Textiles
	New York	Cattle, Iron/Steel, Lumber, and Mining

	Ohio	Cattle, Grain, Iron/Steel, Lumber, Mining, and Textiles
	Pennsylvania	Cattle, Grain, Iron/Steel, Lumber, Mining, and Textiles
	Wisconsin	Cattle and Lumber
	Vermont	Mining and Textiles
South	Alabama	Cotton and Lumber
	Arkansas	Cattle and Cotton
	Florida	Cattle and Cotton
	Georgia	Cattle, Cotton, Lumber, Mining, Rice/Sugar cane, and Textiles
	Kentucky	Grain, Iron/Steel, Lumber, Mining, Textiles, and Tobacco
	Louisiana	Cotton and Rice/Sugar cane
	Maryland	Iron/Steel, Mining, Textiles, and Tobacco
	Mississippi	Cattle, Cotton, and Lumber
	Missouri	Cattle, Grain, Lumber, Mining, and Tobacco
	North Carolina	Cotton, Grain, Mining, Rice/Sugar cane, and Tobacco
	South Carolina	Cattle, Cotton, and Rice/Sugar cane
	Texas	Cattle and Cotton
	Tennessee	Cattle, Cotton, Grain, Iron/Steel, Mining, and Tobacco
	Virginia	Cattle, Lumber, Mining, Textiles, and Tobacco

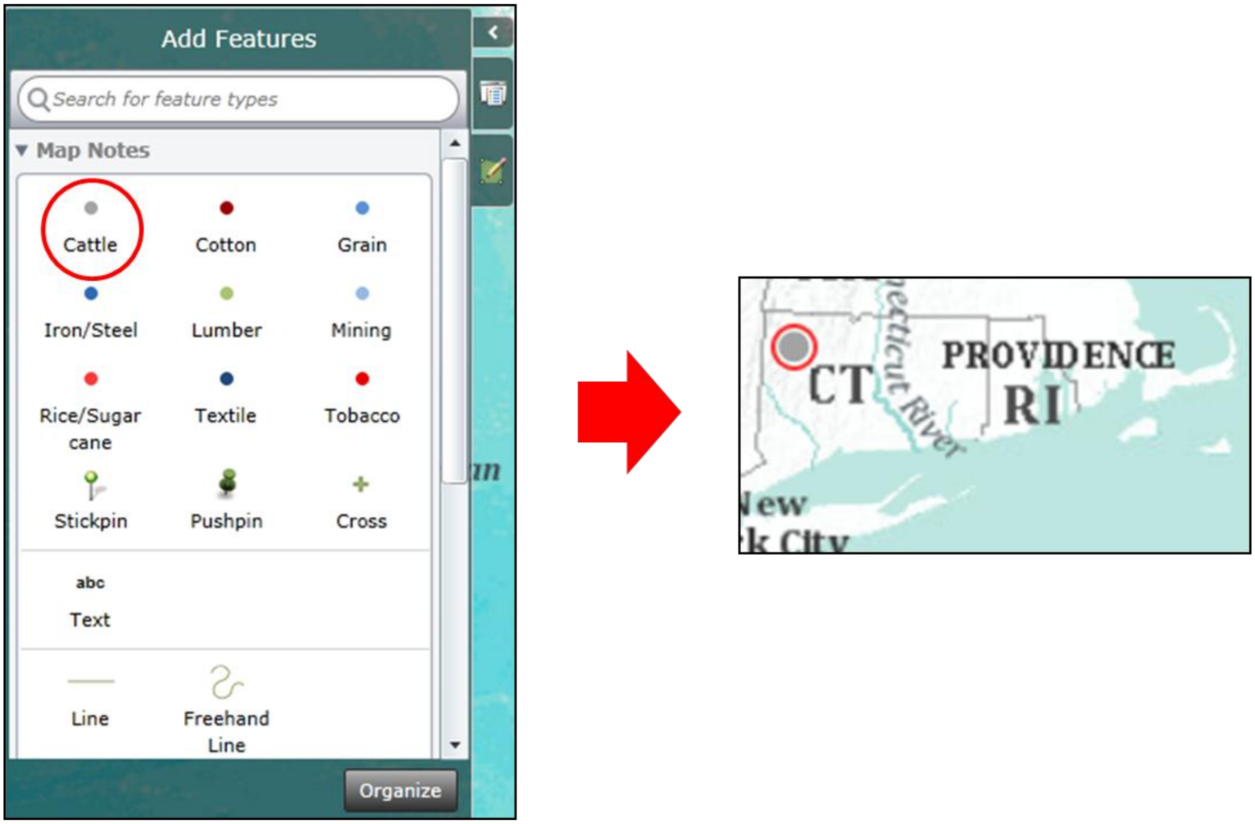
4. Click the “Add Features” tool.



5. Now we are going to make a multi-colored dot map to symbolize these products on the map. I have already created nine different symbols for you to use.

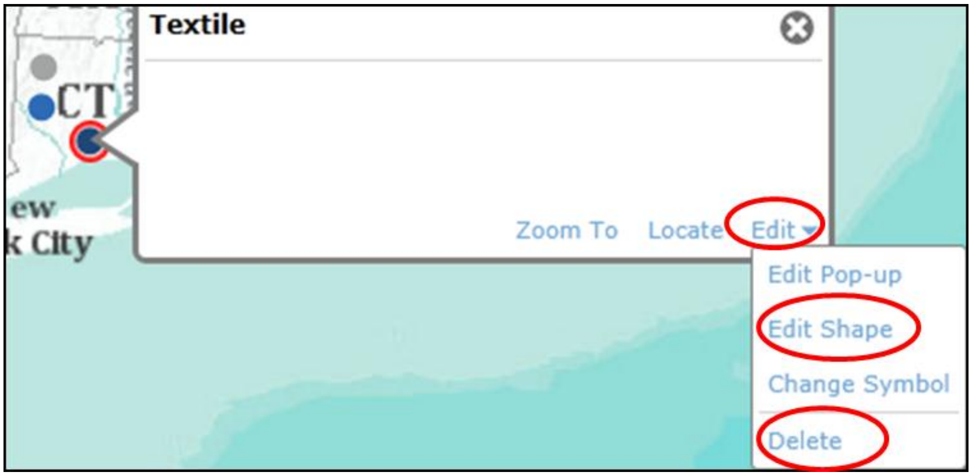


6. Let's start with Connecticut. There were three major products, Cattle, Iron/Steel, and Textiles, in Connecticut at that time. Find Connecticut on the map first. Then click the point symbol for Cattle, and then put it on Connecticut by doing left mouse click. You can put it anywhere inside of Connecticut.

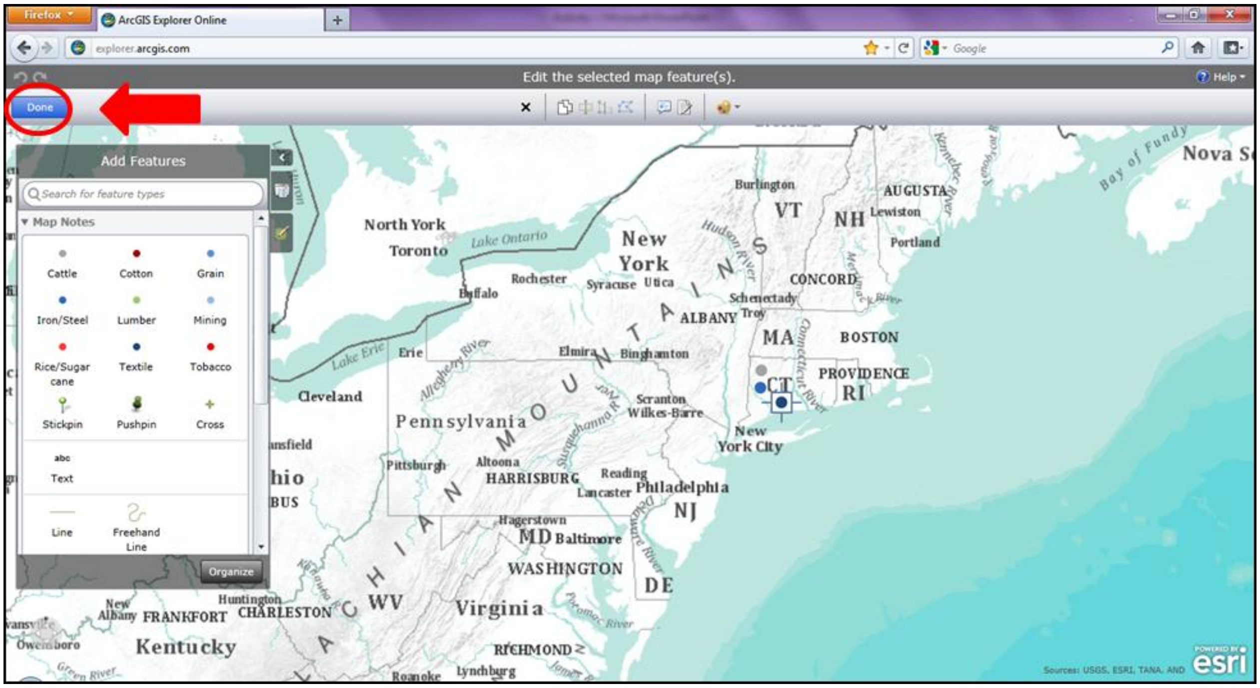


7. Repeat the step #**6** for Iron/Steel and Textiles for Connecticut. Your map may look like the following:

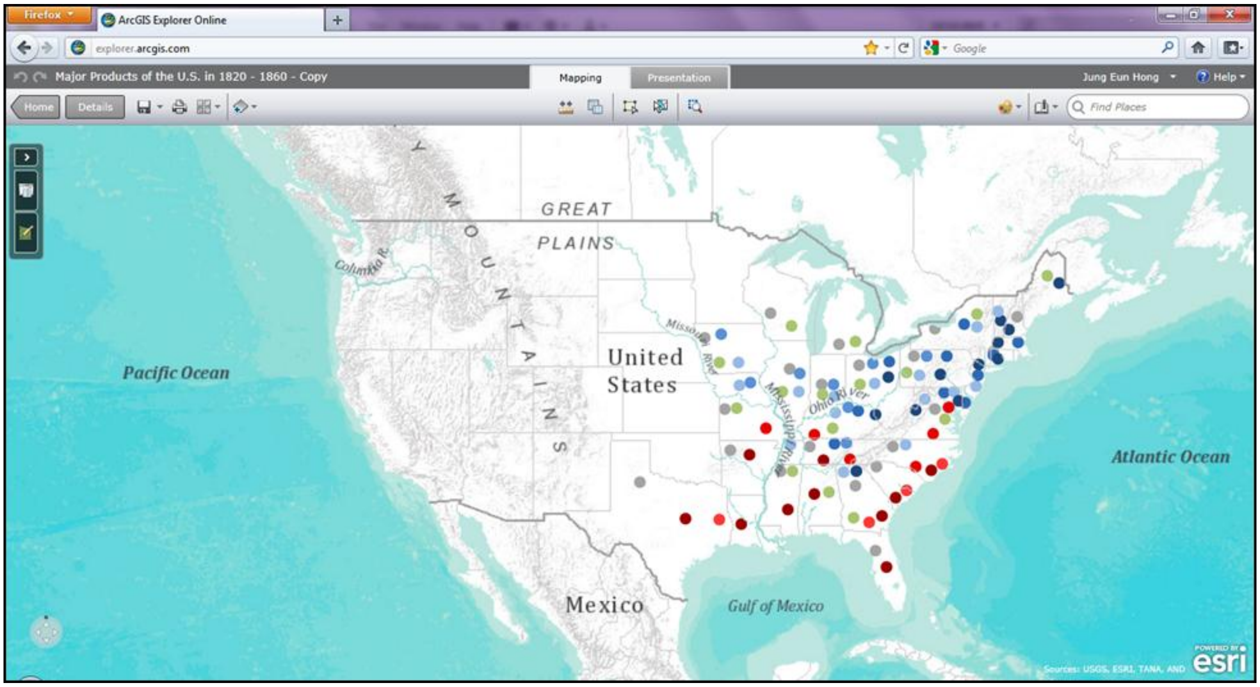
8. Follow the previous steps from #**6** and #**7** for the other states (go to the above table). If you want to move a point symbol, click the symbol. Then click "Edit," and then click "Edit Shape." You will see the white rectangle around the point symbol. Now you can move it to another location. If you want to delete a point symbol, click "Delete."



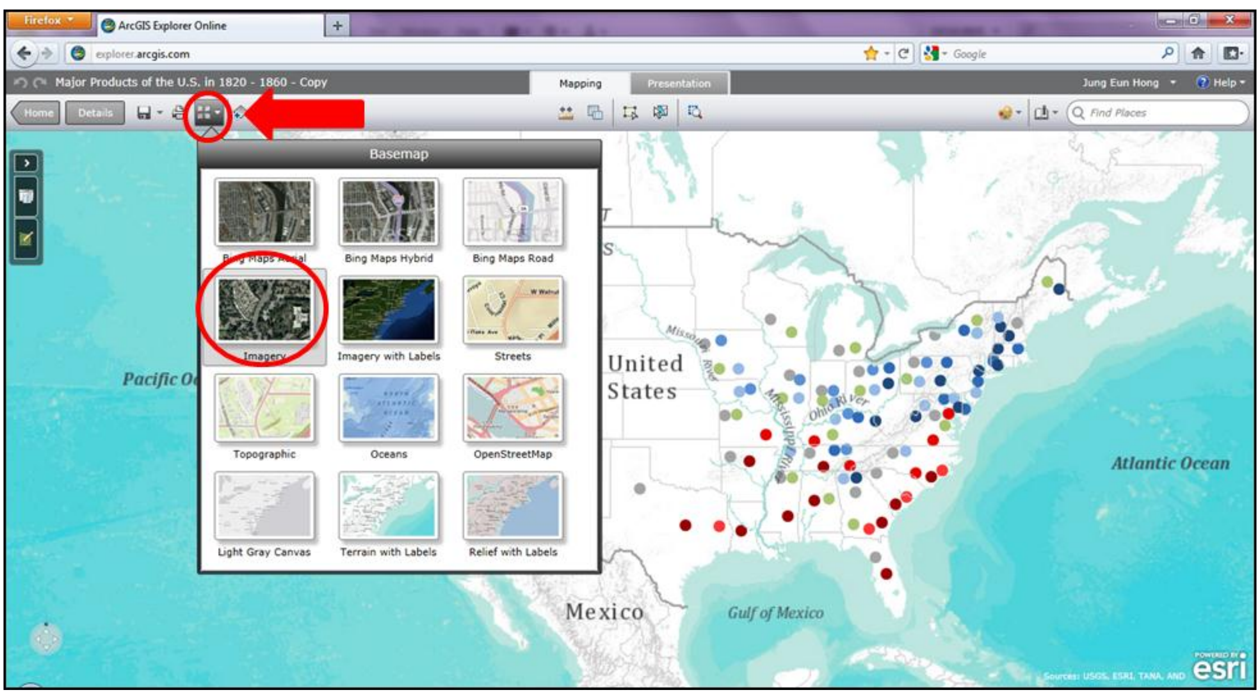
9. Once you have finished moving or deleting a point symbol, click "Done."



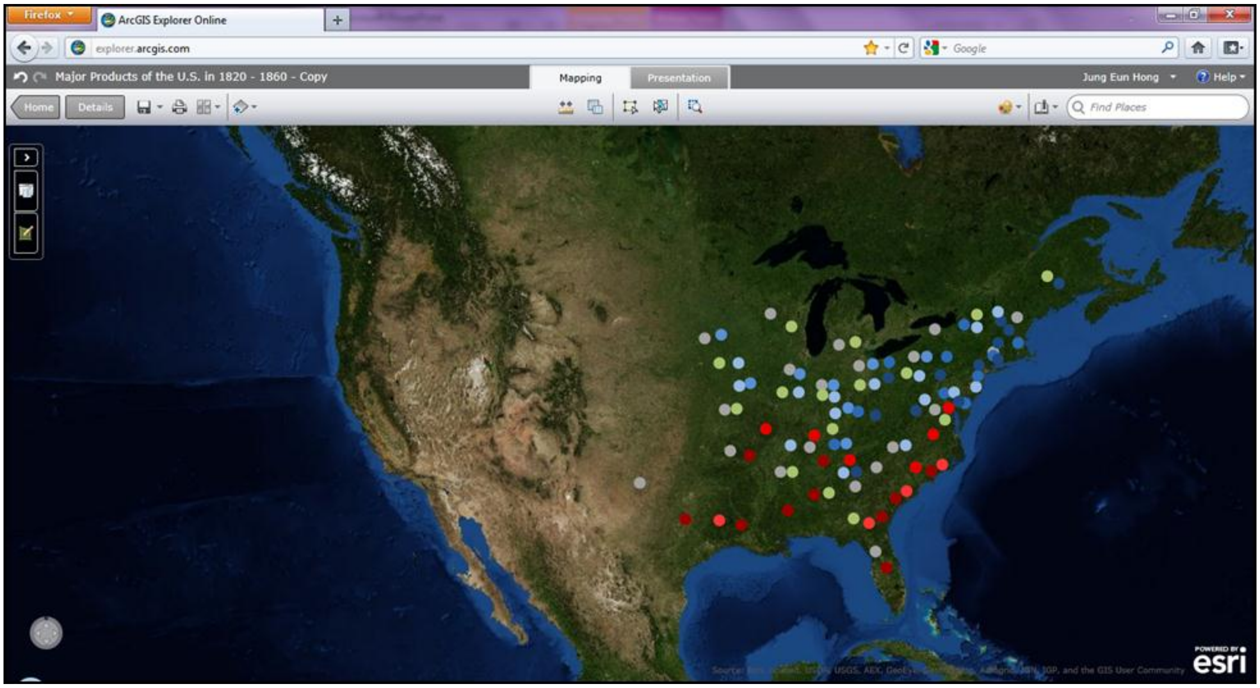
10. Here is my final map.



11. You can change its basemap to "Imagery" to see the pattern more clearly. To do this, click the "Basemap" tool on the main toolbar, and then choose "Imagery."



12. Here is the final map with the "Imagery" basemap.



- Discussion questions
    - What patterns do you see? What factors might account for these patterns?
    - Why are there many **bluish** symbols in the North? Why are there many **reddish** symbols in the South?
    - Which specific products were reasons to maintain the slavery system in the South? Why did these particular products make slavery profitable?
    - Based on this map, what causes contributed to conflicts between the North and the South?

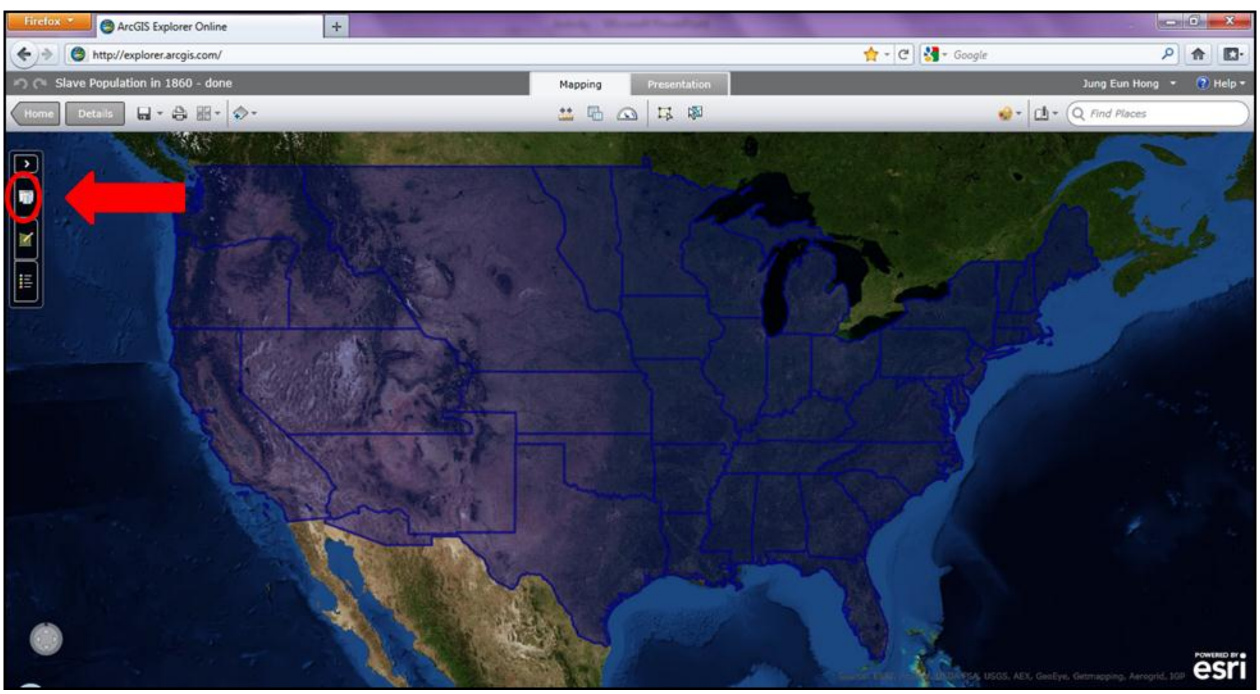
The Civil War - Activity 2. Slave Population in 1860

*** If you have not gone through the preparation of this topic yet, please click [here](). ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. Click [this link]().

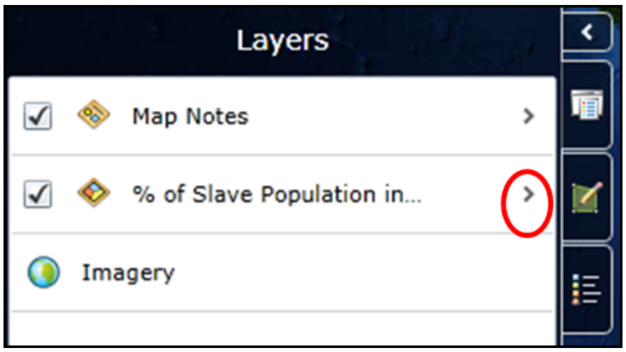
2. This is the prepared map for this activity. Once the map is loaded, save this map in your Esri account using "Save."

3. Click the "Layers" tool.

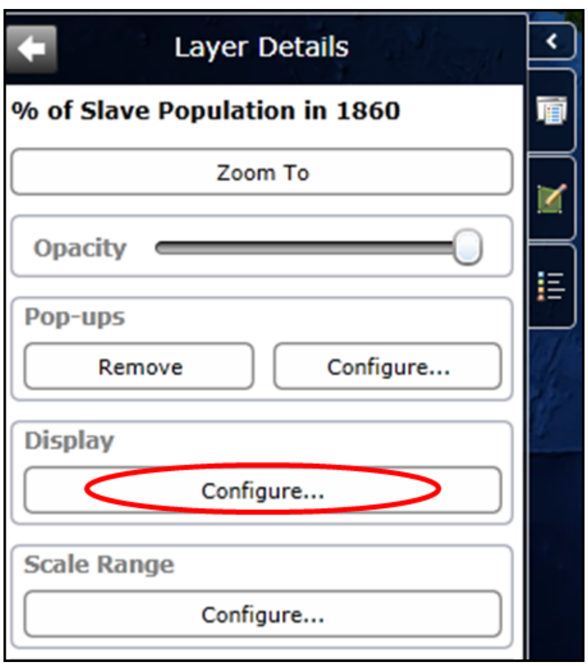


4. This map shows number of slaves in each state in 1860. The slave data source is from The Civil War Home page, and the states map layer is from Esri. If you want to know what a layer is, click here.
In order to see geographical patterns of slave population percentage in 1860, we will change its color scheme.

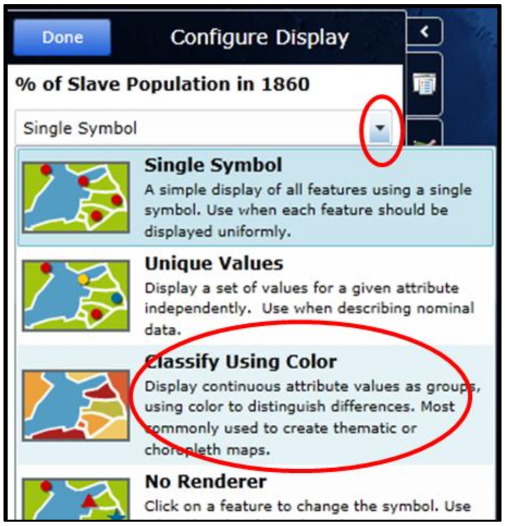
5. Click the details of the ***% of Slave Population in 1860*** layer.



6. In the "Layer Details" window, click "Configure" in the row labeled "Display."

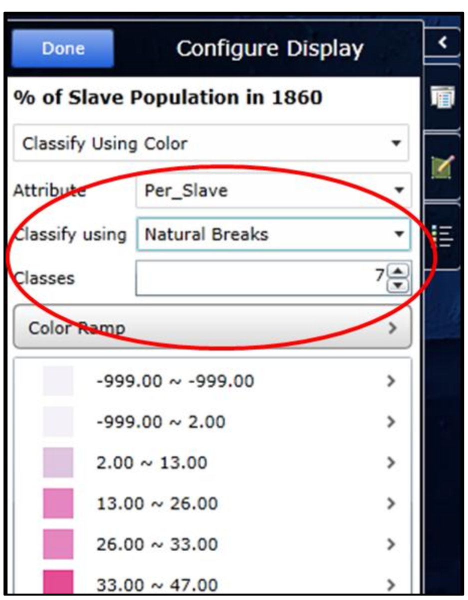


7. Click the drop-down menu of “Single Symbol,” and then choose “Classify Using Color.”

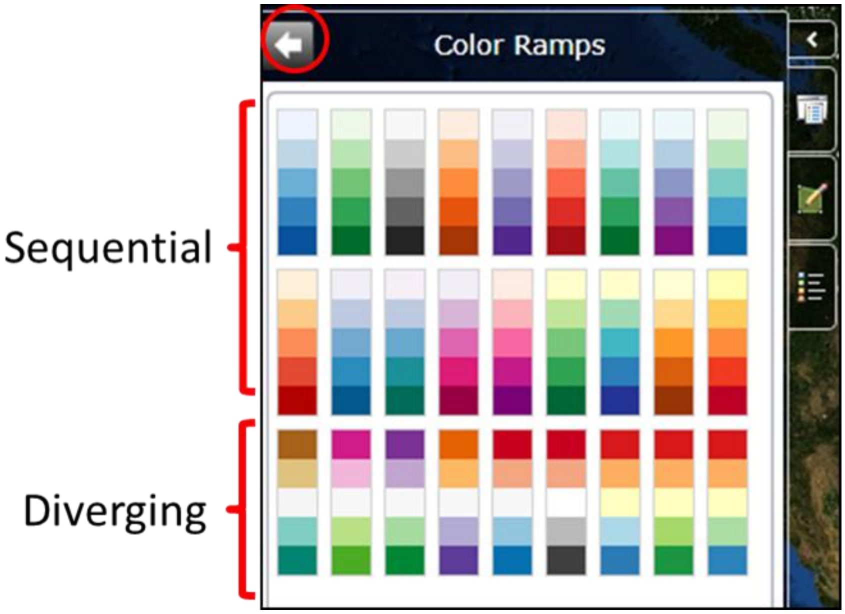


8. Set the “Configure Display” in the following ways. You need to click the drop-down menus for the “Attribute” and “Classify using” fields to choose:
Attribute: “Per_Slave” (% of slave population)
Classify using: “Natural Breaks” (For more information about the classification methods, click here.)
Classes: “7” (Setting the number of classes determines the number of groups in which you will divide your data.)
Then click “Color Ramp.”

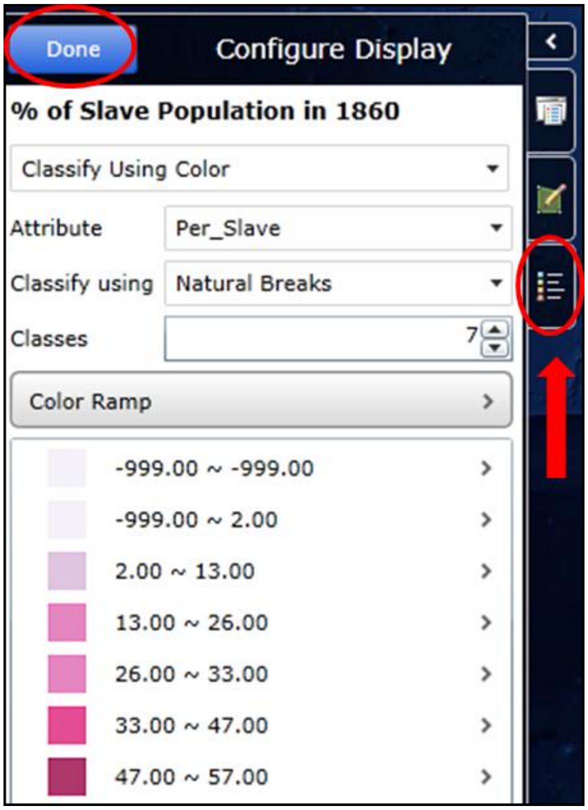
There was no information available for some states and territories, so I put “-999” in the table. When you see “-999” on the legend, please understand that no data is available. Make sure that “0” and “-999” are different. “0” means there was ***no slave*** in a certain state.



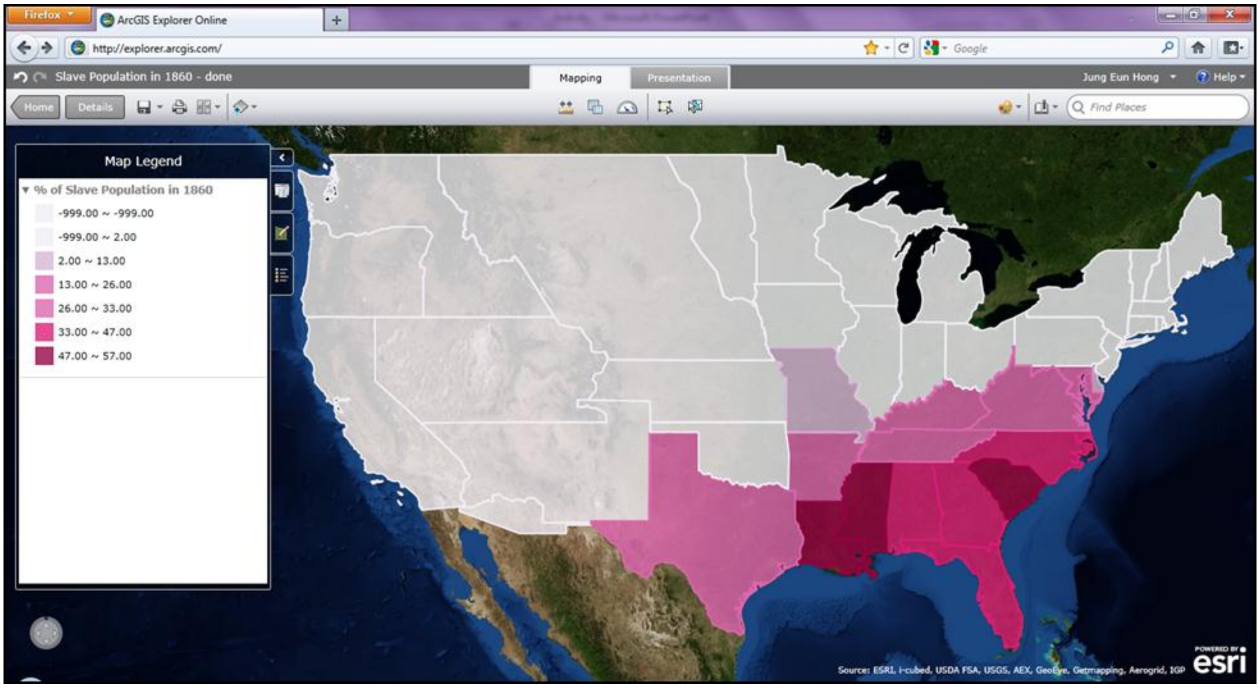
9. Choose one of the sequential color schemes. For more information about the color schemes, click [here]().
Then click the arrow button to go back to "Configure Display."



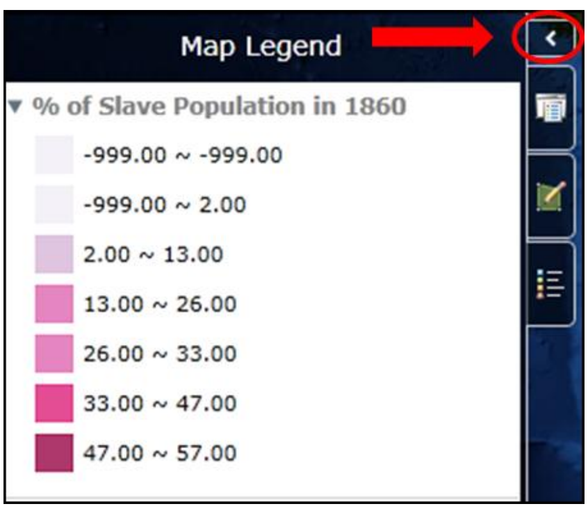
10. Click "Done," and then click "Map Legend."



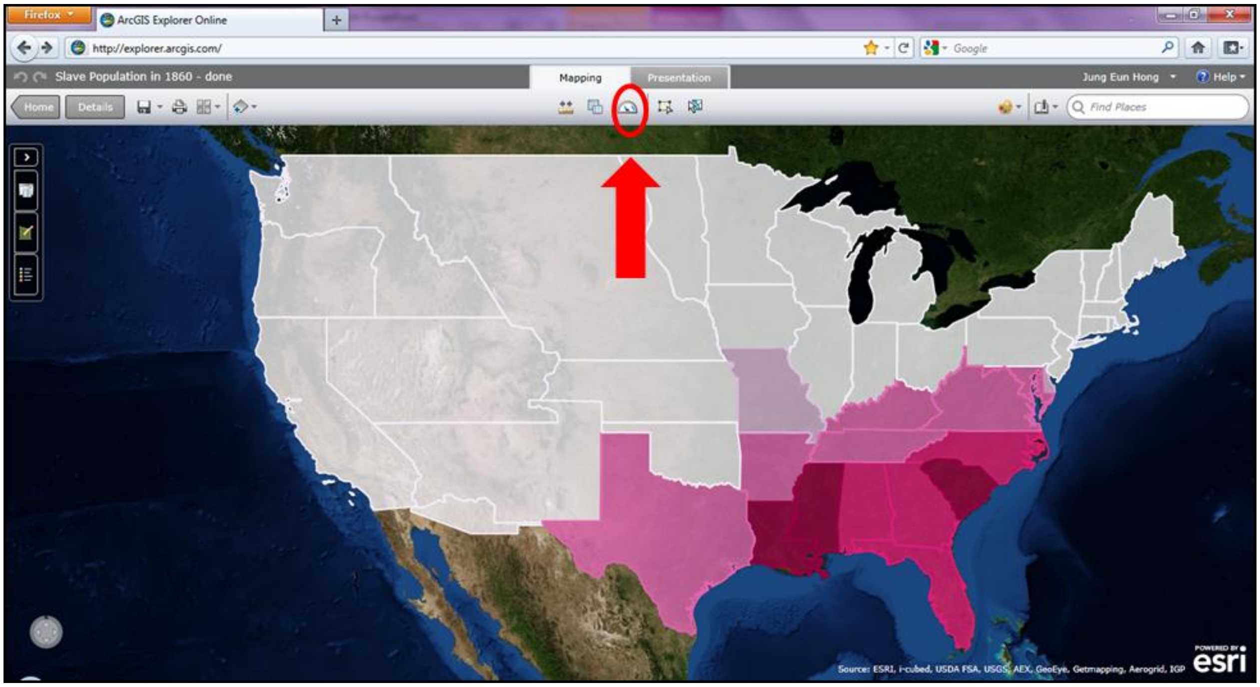
11. Your map may look like the following:



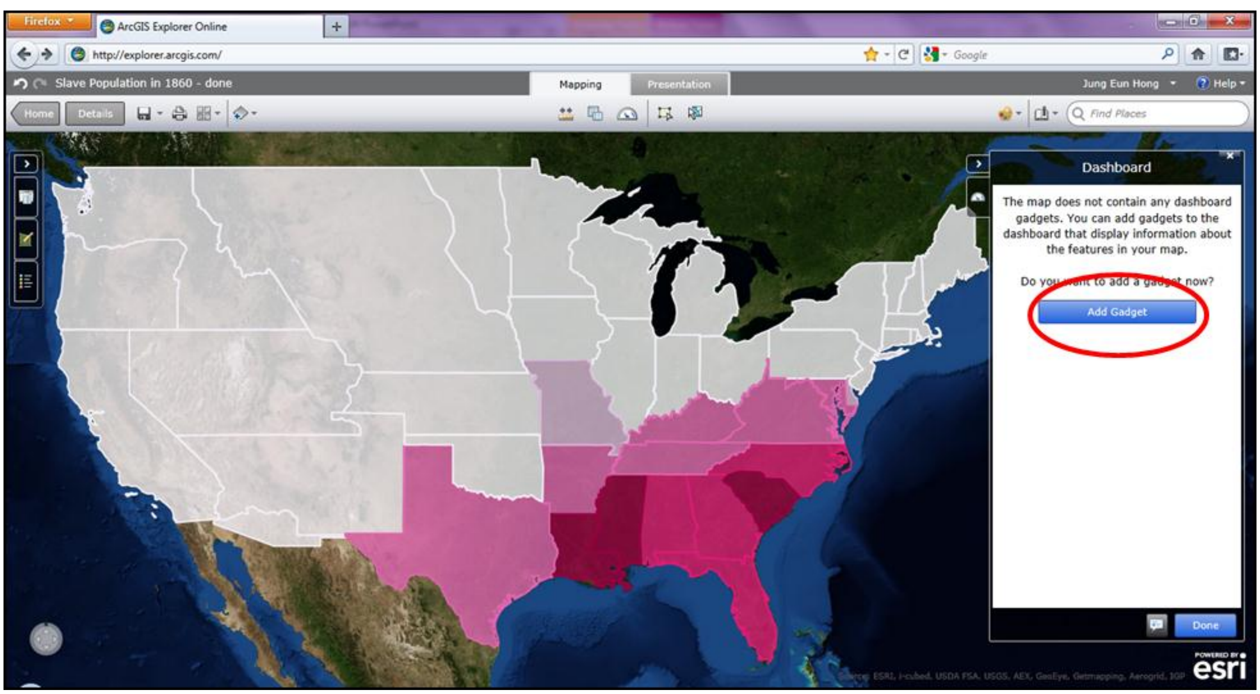
12. Now we will create a dashboard with a pie chart to compare the free and slave populations by state.
Close "Layer Panel."



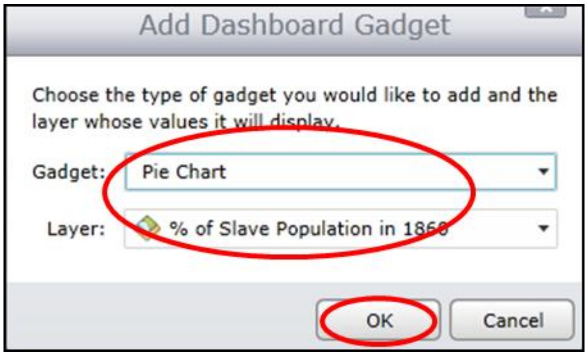
13. Click the “Dashboard” tool on the main toolbar.



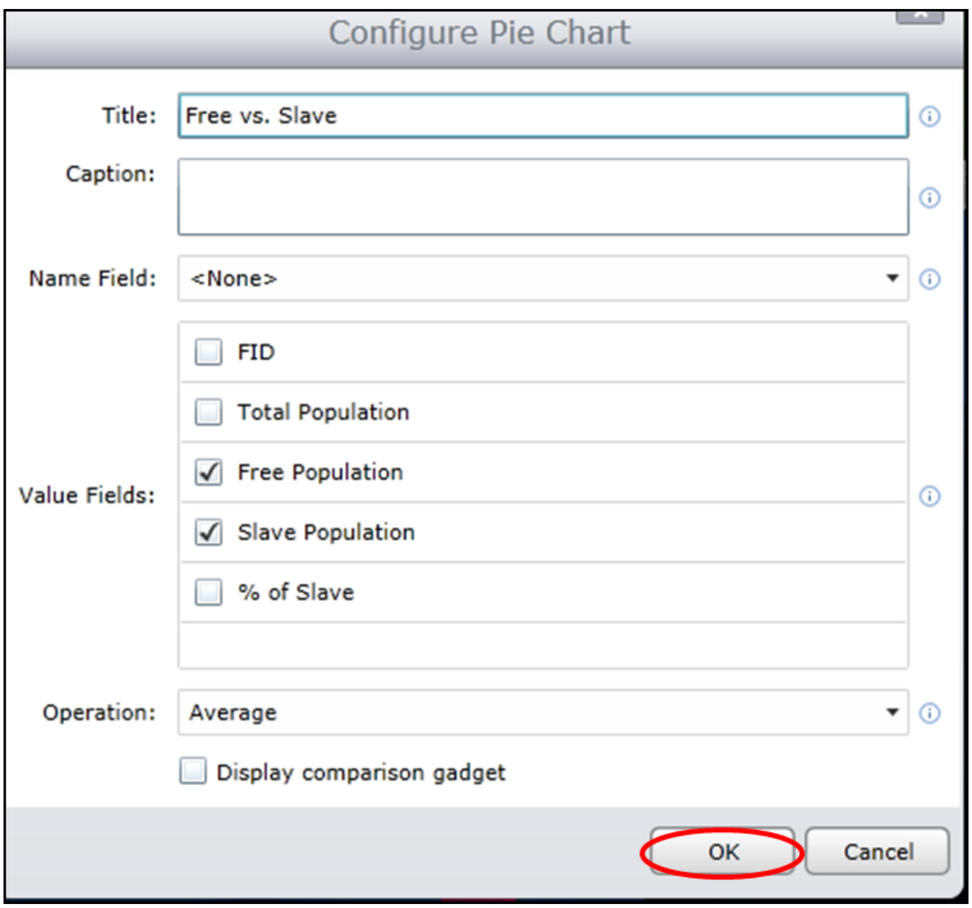
14. The dashboard window will pop up. Position the map in the center. If necessary, zoom in and out to see the entire state at a glance.
Click the “Add Gadget” button.



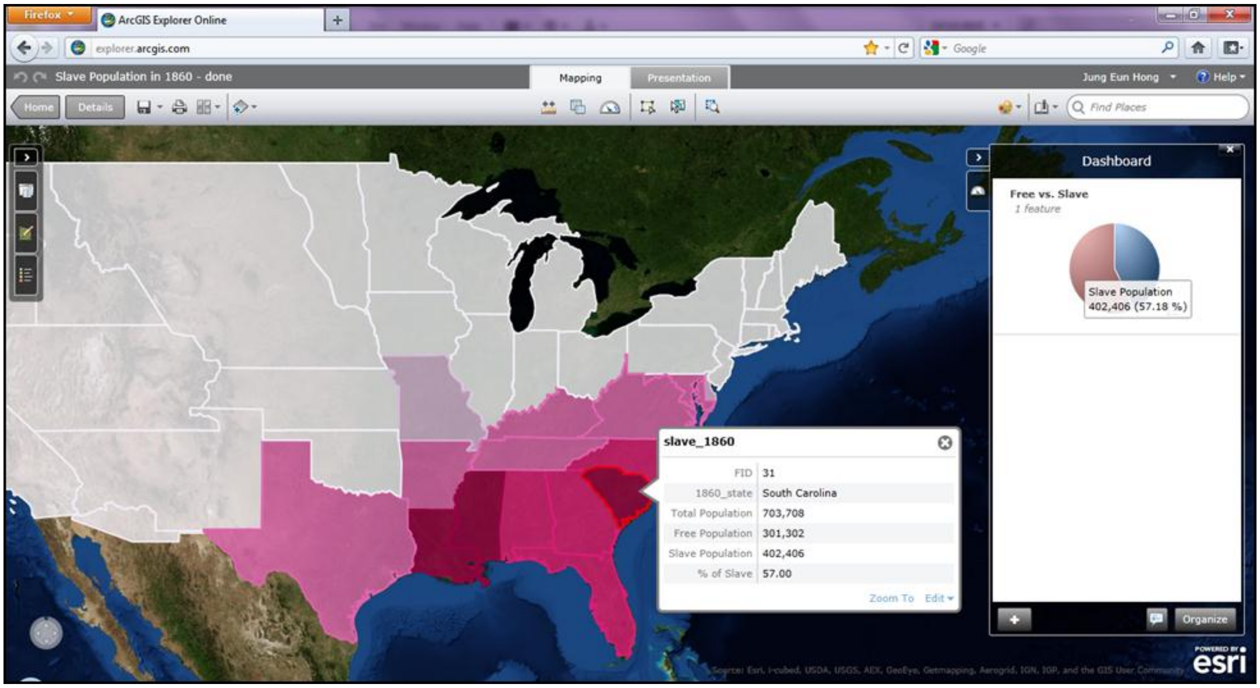
15. We will use the "Pie Chart" gadget for the ***% of Slave Population in 1860*** layer. Click the drop-down menu of the "Gadget" field, and choose "Pie Chart." The ***% of Slave Population in 1860*** layer is already chosen as a default setting. Then click "OK."



16. Fill out "Configure Pie Chart" as the following. You might need to click the drop-down menus to select. Once you are done, click "OK."



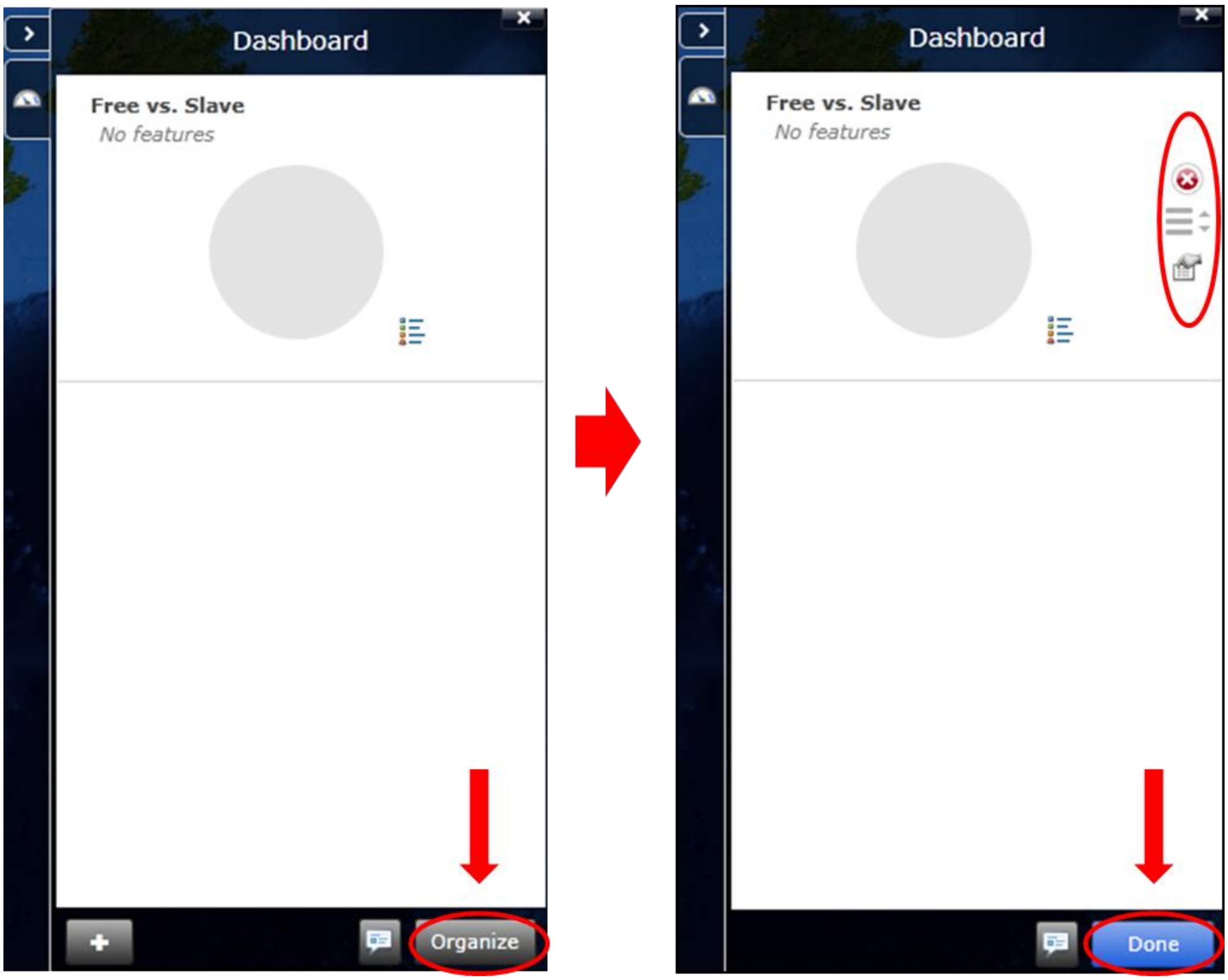
17. Once you click any state, you can see the composition of free and slave population in the state in the pie chart. If you do mouse-over on the pie chart, you can see in its description that the blue portion represents the free population, and the red portion represents the slave population. Also, you can see its pop-up window.



18. There are five fields in the pop-up.

Field	Meaning
1860_state	Name of the state in 1860
Total Population	Total population (free + slave)
Free Population	Total free population
Slave Population	Total slave population
% of Slave	Percentage of slave population out of total population

19. If you want to edit the gadget, click the "Organize" button. There are three options—"Remove," "Drag to re-order," and "Properties." If you click "Properties," you can see "Configure Pie Chart" again (refer to step #**16**). Once you have finished editing your gadget, you need to click "Done."



- Discussion questions
  - What patterns do you see? Why might these patterns exist?
  - What do ***vivid color*** states represent? What do ***light color*** states represent?
  - Why did Louisiana, Mississippi, and South Carolina have higher percentages of slaves?
  - Which states might have been most interested in seceding from the Union?
  - Why were there so many slaves in southern states compared to northern states? (connect to major economy)

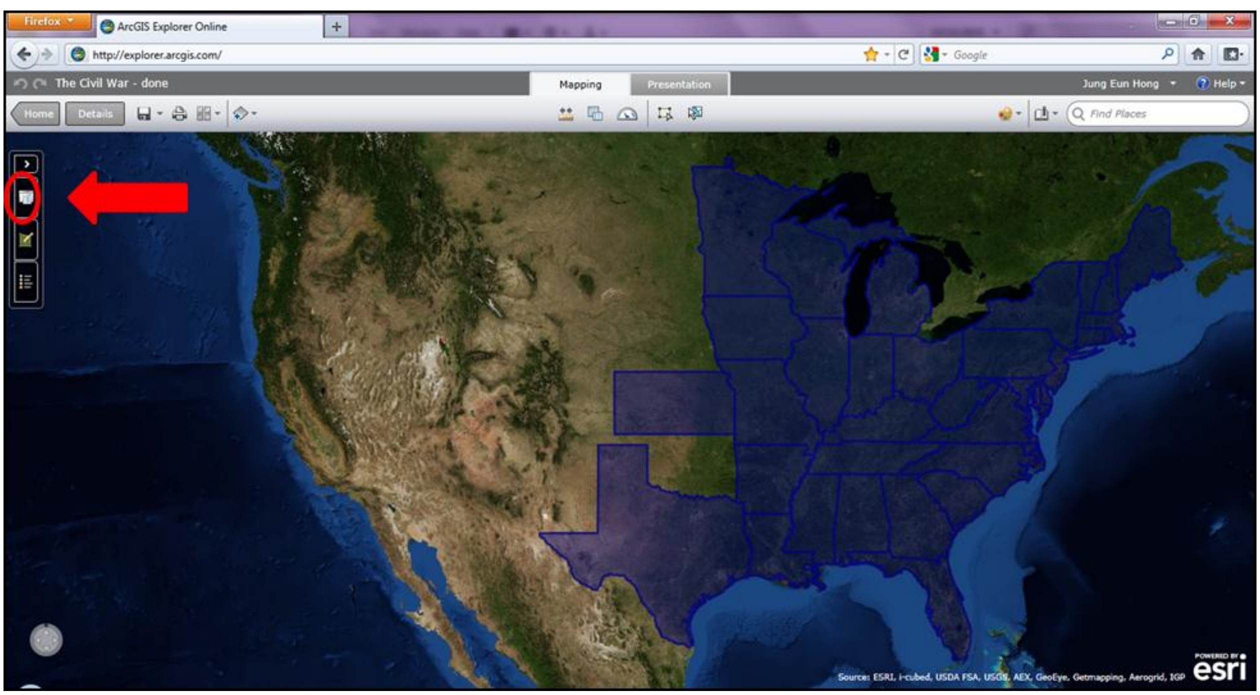
The Civil War - Activity 3. The Union vs. Confederate States

*** If you have not gone through the preparation of this topic yet, please click here. ***
*** The red circle(s) on the screen shots indicate the location of the tool or button you must use. ***

1. Click this link.

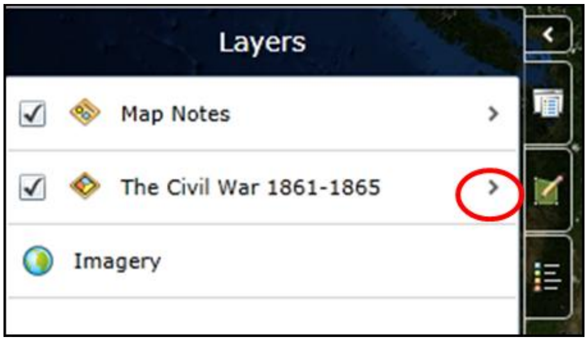
2. This is the prepared map for this activity. Once the map is loaded, save this map in your Esri account using "Save."

3. Click the "Layers" tool.



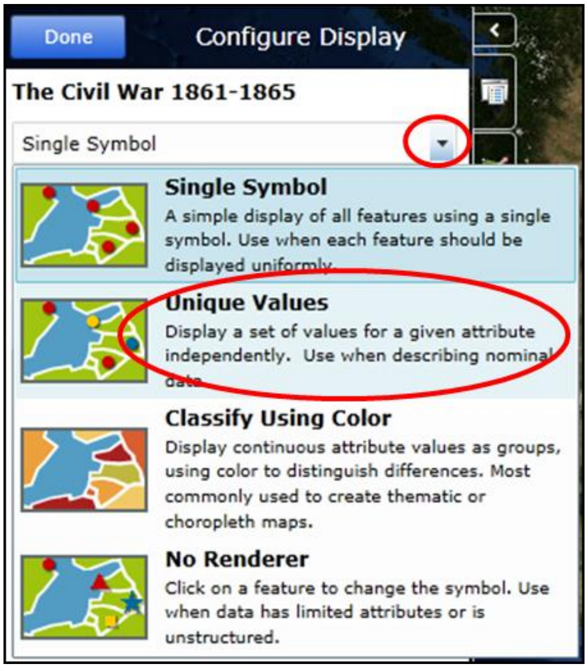
4. This map shows all of the states that were part of the United States from 1861 to 1865. We will change the color scheme to show which ones were Union, Confederate, and Border states. The states map layer is from Esri. If you want to know what a layer is, click here.

5. Click the details of ***The Civil War 1861-1865*** layer.



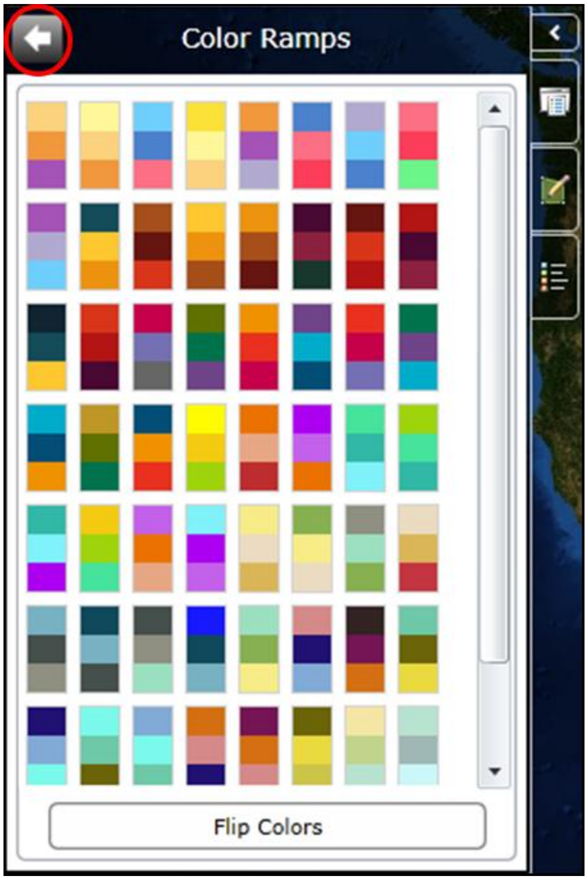
6. In the "Layer Details" window, click "Configure" in the row labeled "Display."

7. Click the drop-down menu of "Single Symbol," and then choose "Unique Values." Read its definition below. For more information about "Unique Values," click here.

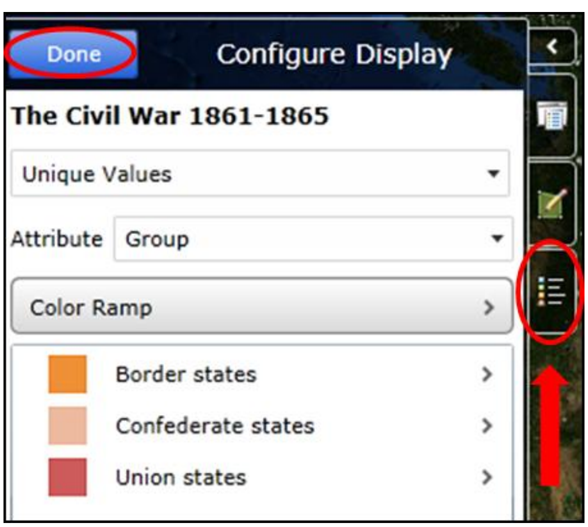


8. Make sure that the field of "Attribute" is set to "Group." Then click "Color Ramp."

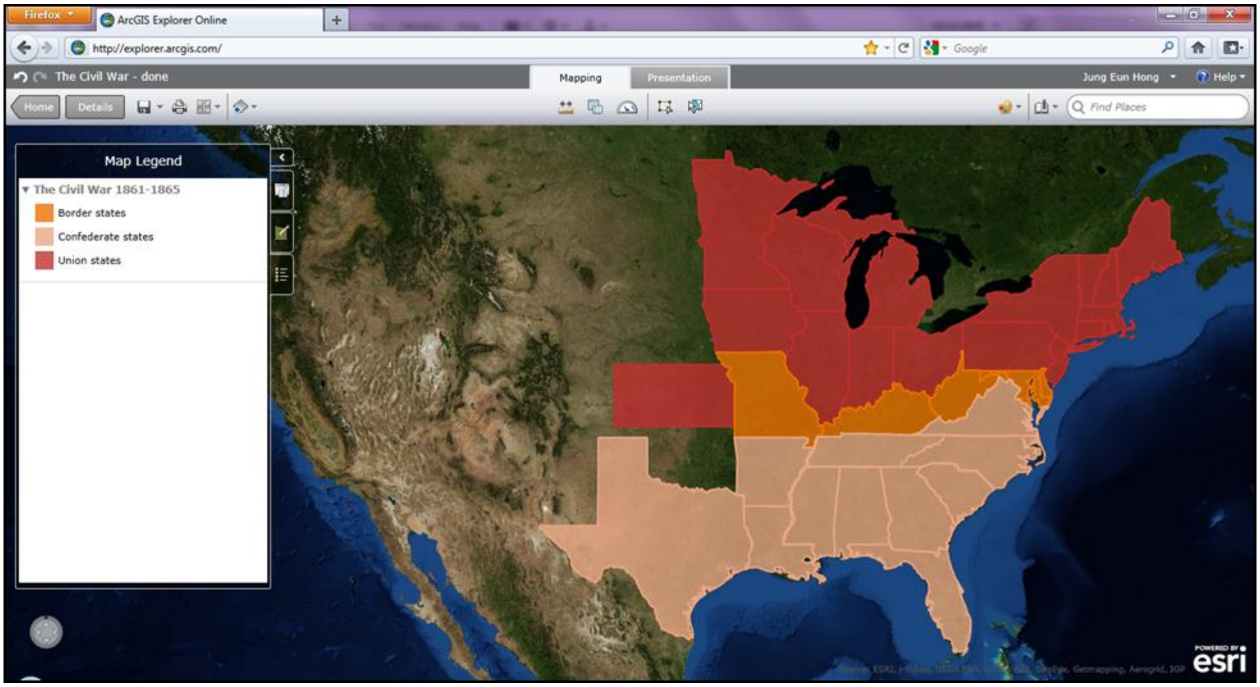
9. Choose one color scheme you want. Once you are done, click the arrow button to go back to "Configure Display."



10. Click "Done." Then click "Map Legend."



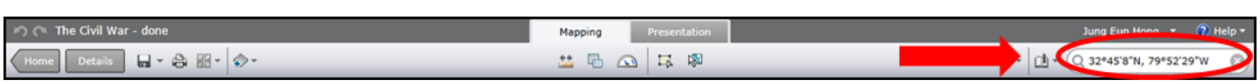
11. Your map may look like the following:



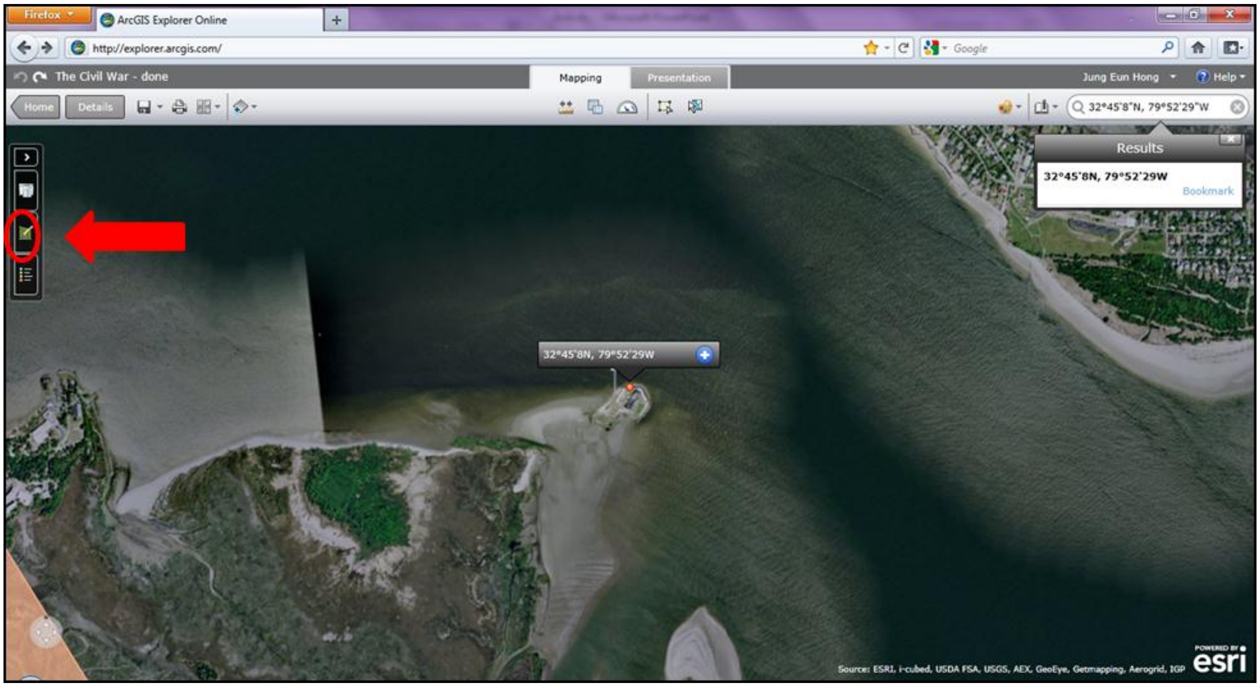
12. Now we will mark major battlefields on the map using a point symbol. The following table is a list of battlefields. The information is from *History Alive!* published by TCI (2005, p.307). You need to search their locations using today's locations. For "March to the Sea," we will use a line feature to draw the marching line.

Battle	Today's location	Date	Victory
Fort Sumter	32°45'8N, 79°52'29W	Apr. 12-14, 1861	Confederate
1st Bull Run	Manassas, VA	Jul. 21, 1861	Confederate
Fort Henry	Fort Henry, TN	Feb. 6, 1862	Union
Fort Donelson	Dover, TN	Feb. 13-16, 1862	Union
Hampton Roads	Hampton, VA	Mar. 8-9, 1862	Indecisive or draw
Shiloh	Shiloh, TN	Apr. 6-7, 1862	Union
Seven Days' Battle	Richmond, VA	Jun. 25-Jul. 1, 1862	Confederate
2nd Bull Run	Manassas, VA	Aug. 29-30, 1862	Confederate
Antietam	Sharpsburg, MD	Sept. 17, 1862	Union
Fredericksburg	Fredericksburg, VA	Dec. 11-15, 1862	Confederate
Chancellorsville	Spotsylvania, VA	May 1-4, 1863	Confederate
Vicksburg	Vicksburg, MS	May 19-Jul. 4, 1863	Union
Gettysburg	Gettysburg, PA	Jul. 1-3, 1863	Union
Fort Wagner	32°43'7N, 79°53'5W	Jul. 18 - Sept. 7, 1863	Confederate
Chickamauga	Chickamauga, GA	Sept. 19-20, 1863	Confederate
March to the Sea	Atlanta, GA to Savannah, GA	Sept. to Dec. 1864	
Petersburg	Petersburg, VA	Jun. 1864 – Apr. 1865	Union
Appomattox Courthouse	Appomattox, VA	Apr. 9, 1865	Union

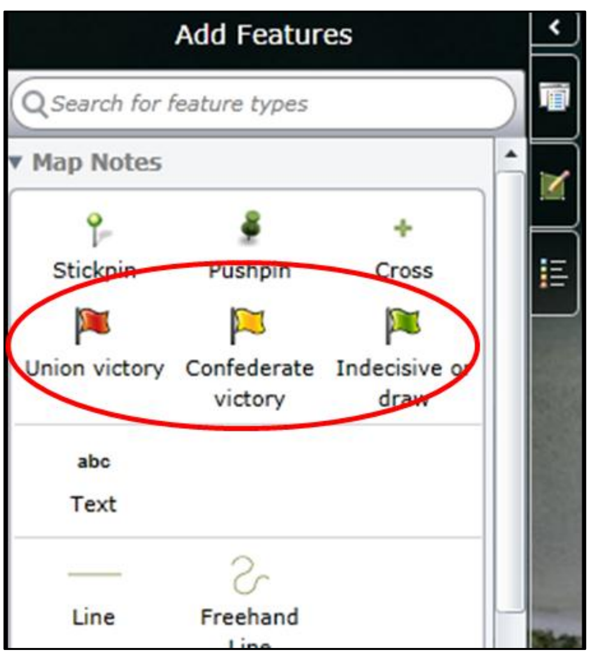
13. Let's find Fort Sumter on the map. Copy and paste today's location (lat/long) in the "Find Places" box. Then hit the enter key.



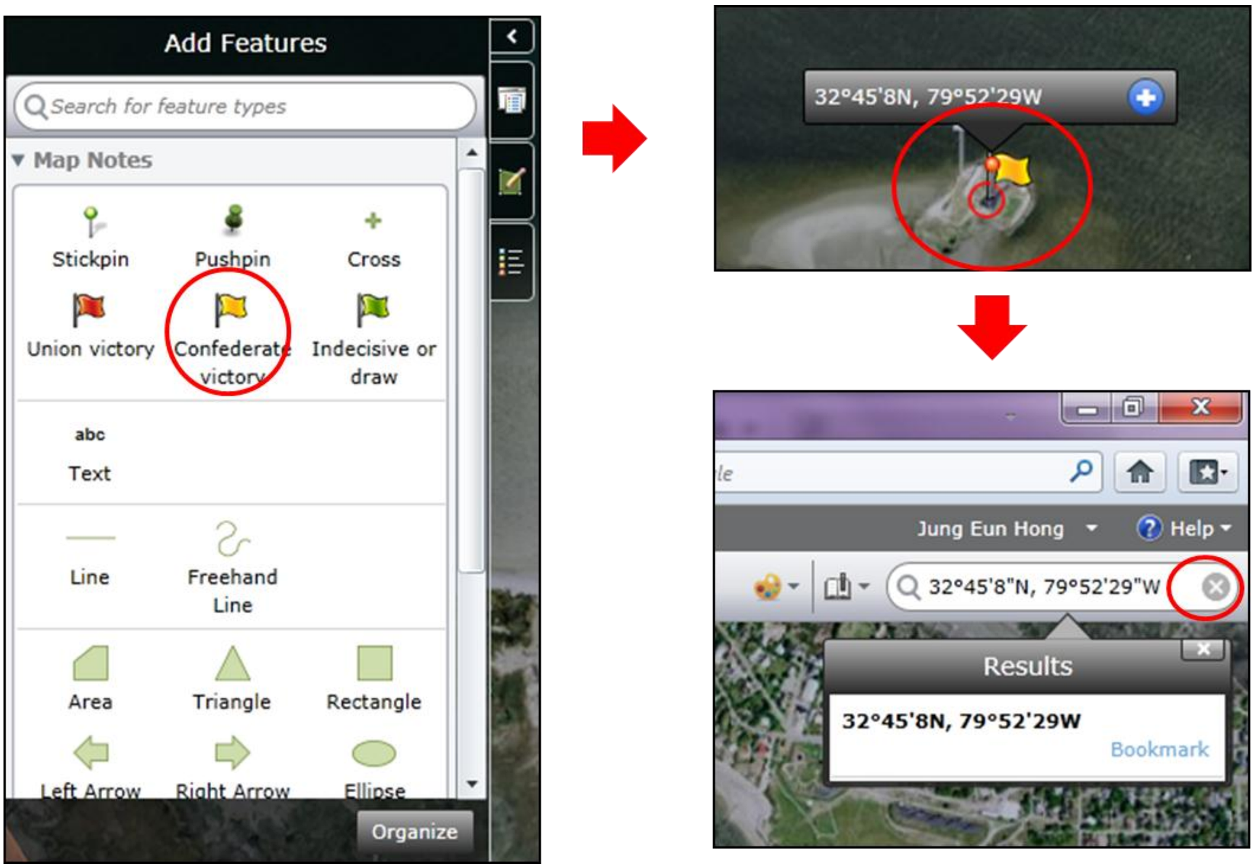
14. Click the "Add Features" tool.



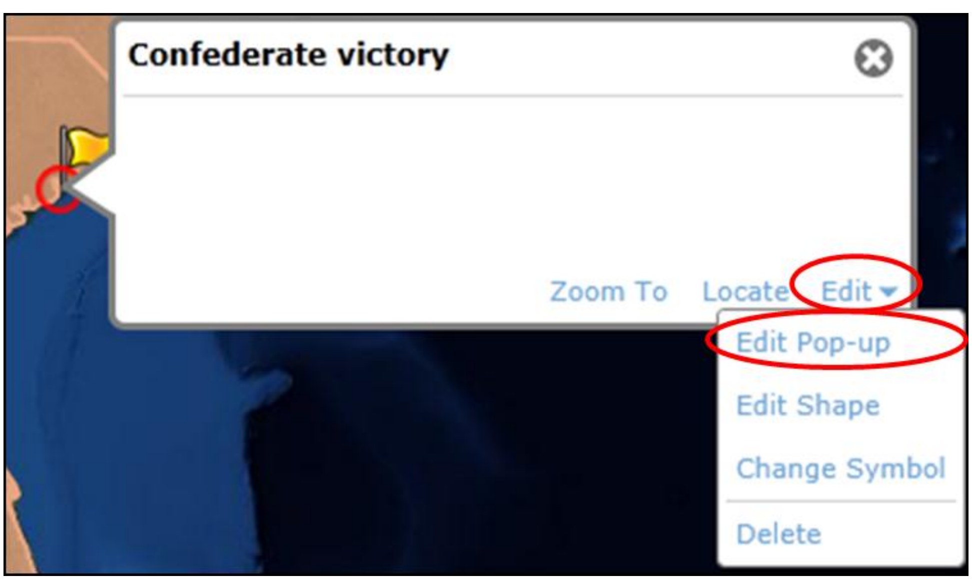
15. I already created three point symbols for this activity. The red flag is for battles with Union victory, and the yellow flag is for battles with Confederate victory. The green flag is for battles with indecisive outcomes or ending in a draw. As you can see in the above table, the Confederates won at Fort Sumter. Therefore, you need to use the yellow flag.



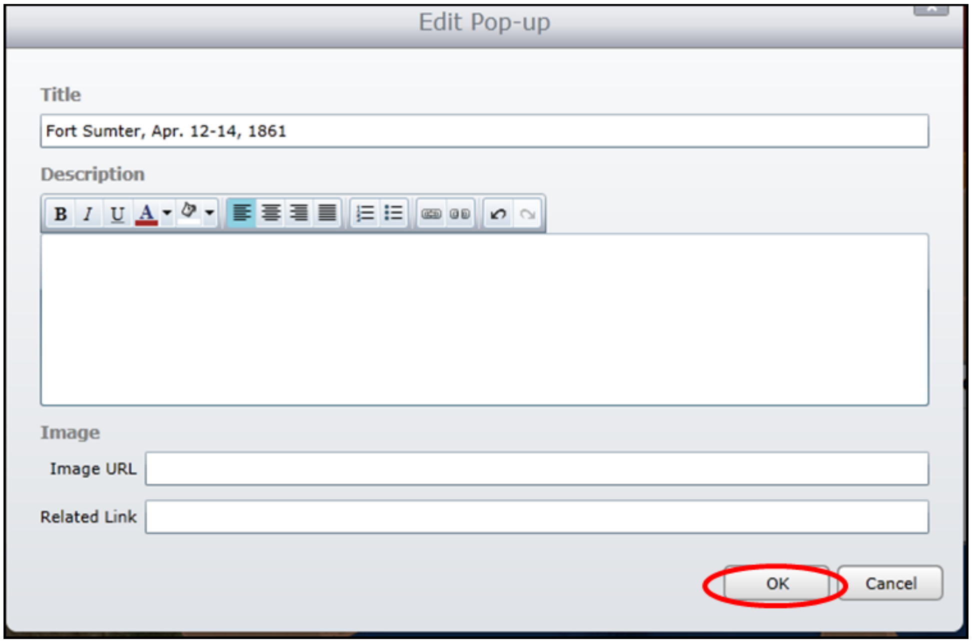
16. Click the yellow flag symbol, and then put it on the exact location we just found using the "Find Places" function. Then click the "x" mark in the "Find Places" box to delete the searched location of Fort Sumter.



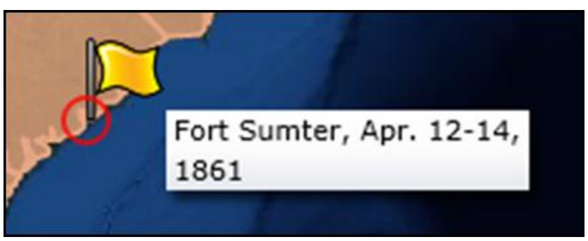
17. Click the flag symbol that you just added, and then choose "Edit." Then click "Edit Pop-up."



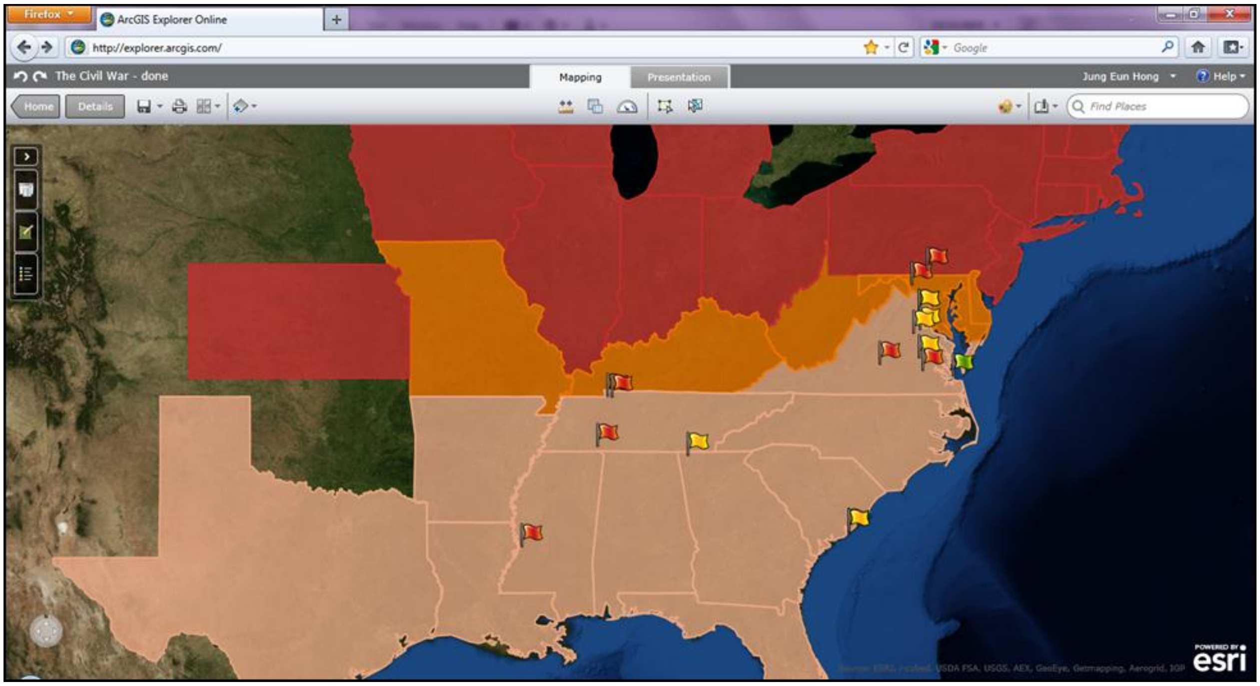
18. Change its title to "Fort Sumter, Apr. 12-14, 1861." You can add more information if you like in the description box. Then click "OK."



19. If you do mouse-over on the flag symbol, you will see its battle name and date.



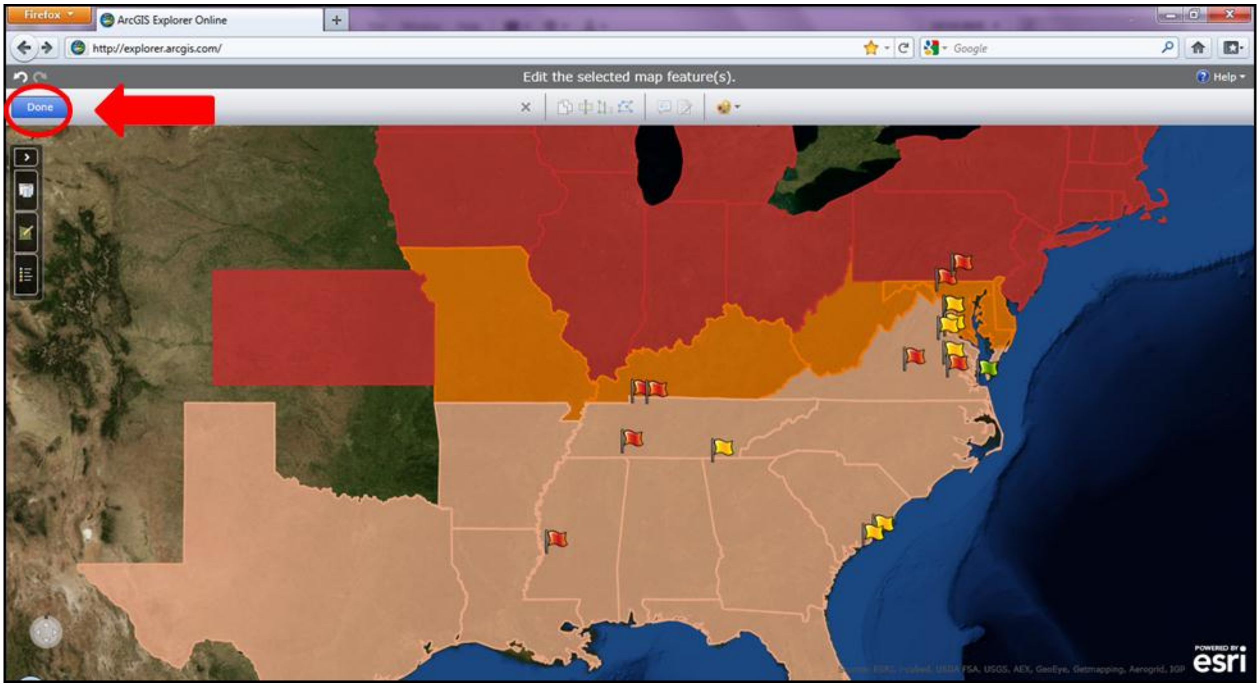
20. Follow the previous steps from #**13** to #**18** for the other battles except “March to the Sea.” Your map may look like the following:



21. If two flags overlap because their locations are too close, we need to move the point symbols apart. Click the overlapped flag symbol (i.e. Fort Wagner), and then click “Edit.” Then click “Edit Shape.”

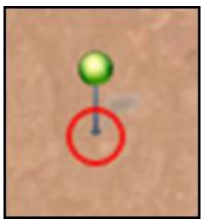
22. Now you can see the white rectangle of the flag symbol, which means it is now movable. Move the flag symbol until you can see the other flag symbol. The locations of Fort Henry and Fort Donelson are pretty close. Move one of them, too.

23. Once you are done, click "Done."

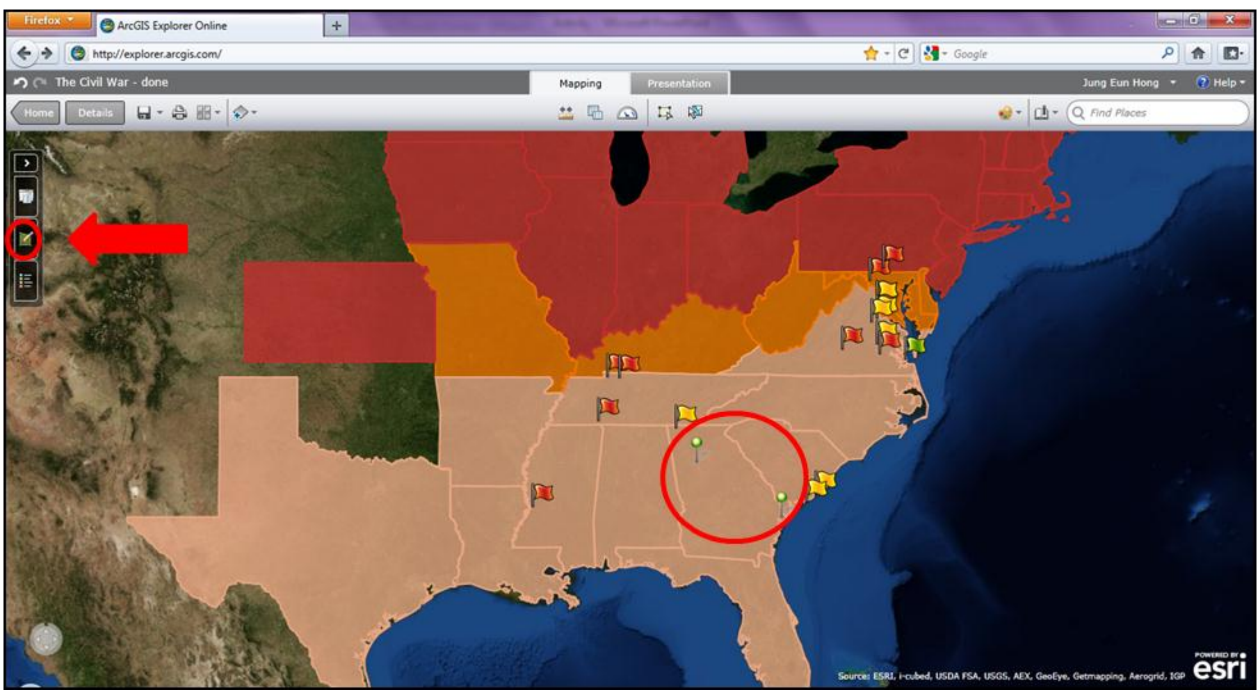


24. Let's mark "March to the Sea." We need to find the locations of Atlanta, GA, and Savannah, GA. First, find "Atlanta, GA" in the "Find Places" box (refer to step **#13**). The map shows you its location.
Click the "+" sign, and then choose "Map Notes."

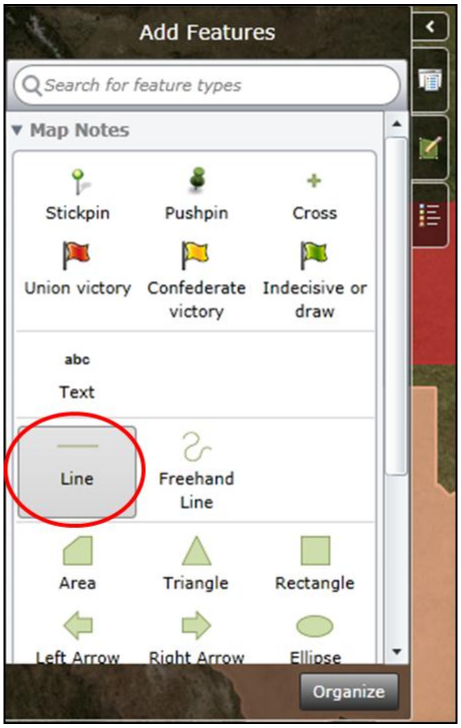
25. Now you can see a green point symbol.



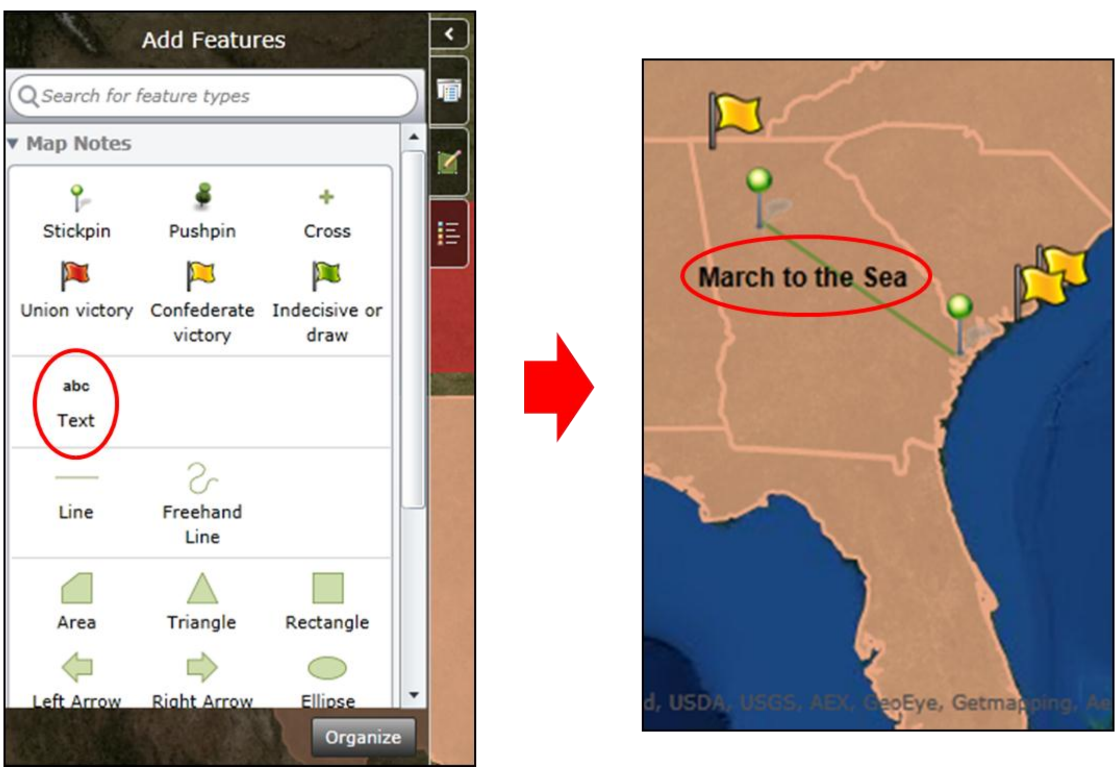
26. Follow the previous steps from **#24** and **#25** for Savannah, GA. Your map will have two point symbols like the following. Click the "Add Features" tool.



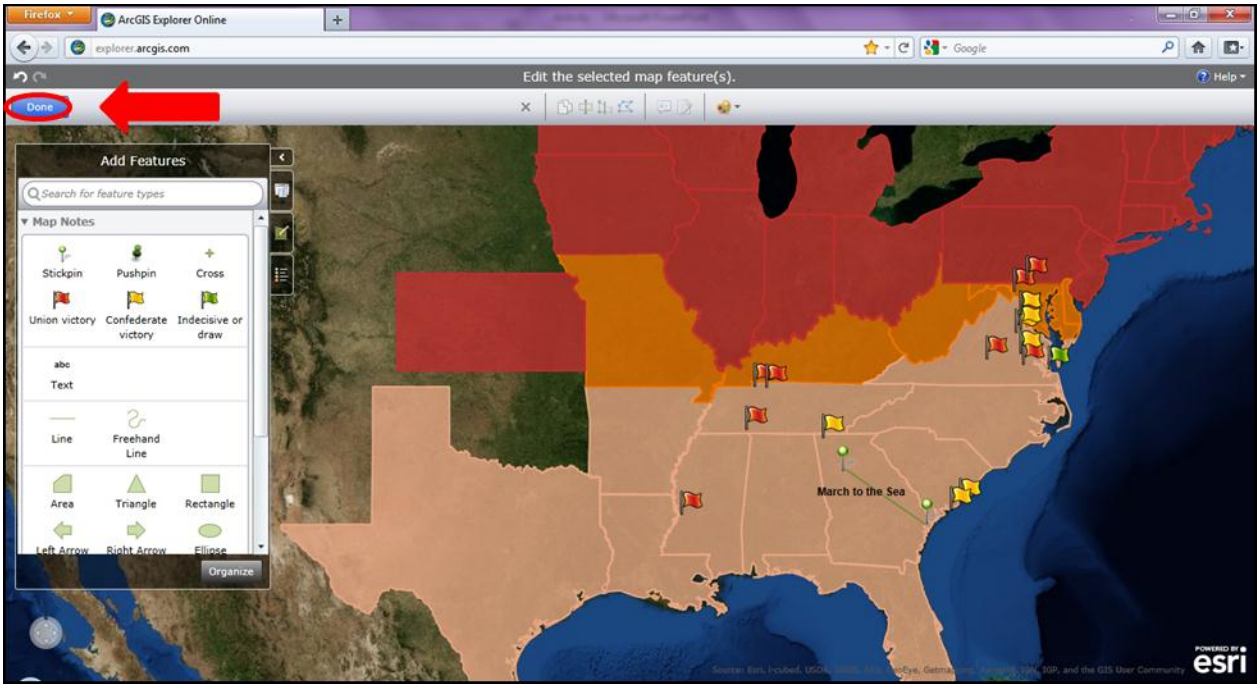
27. Click the “Line” tool.



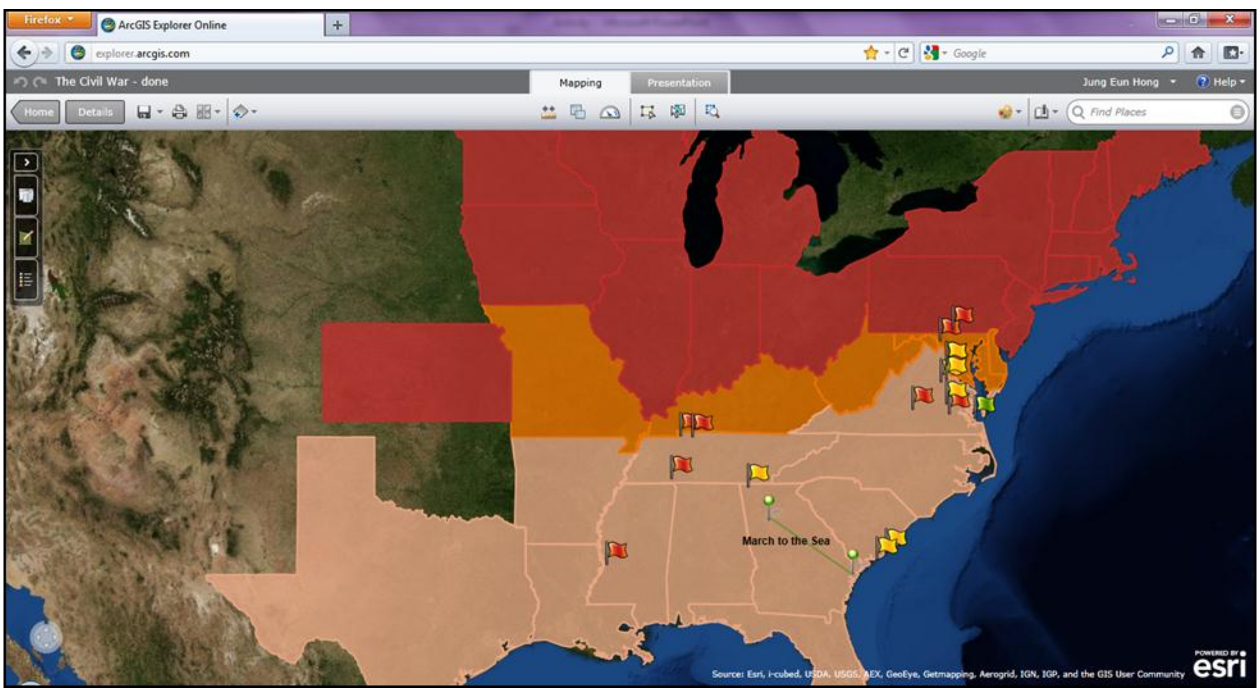
28. Connect Atlanta and Savannah with the “Line” tool. At Savannah, you need to do double-click to finish drawing a line. Using the “Text” tool, you can add description like the following:



29. Once you are done, click “Done.”



30. This is my final map.



- Discussion questions
    - (Map in step #**11**) Why did the Border states choose not to join the Confederacy?
    - (Map in step #**30**) Describe the geographic patterns of the battles over time. Where did they take place in the early (1861-1862), middle (1863), and the later (1864-1865) parts of the war?
    - Why did the battles in 1863 take a place along Mississippi river? What was the goal of the Union troops?
    - What happened during "March to the Sea?" What was its purpose?

APPENDIX E

PARTICIPANT INFORMED CONSENT FORMS

APPENDIX E-1: USER NEEDS ANALYSIS

Web-based GIS for middle school teachers: Using online mapping applications to promote teacher adoption

Principal Investigator Hong, Jung Eun

PARTICIPANT INFORMED CONSENT FORM

May 13th, 2011

Please read the following material that explains this research study. Signing this form will indicate that you have been informed about the study and that you want to participate. We want you to understand what you are being asked to do and what risks and benefits—if any—are associated with the study. This should help you decide whether or not you want to participate in the study.

CONTACT INFORMATION

You are being asked to take part in a research project conducted by Jung Eun Hong, a graduate student in the University of Colorado at Boulder's Department of Geography, 260 UCB, Boulder, CO 80309-0260. This project is being done under the direction of Professor Kenneth E. Foote, Department of Geography, 260 UCB. Jung Eun Hong can be reached at 720-333-7031. Professor Kenneth E. Foote can be reached at 303-492-6760.

PROJECT DESCRIPTION

This research study is about training geography and social studies middle school teachers in Colorado. The key issue explored in this research is whether the latest Web-based systems lower the barriers to using mapping and GIS applications in the classroom. That is, whether there are ways to help teachers quickly get started with these technologies and to easily customize lesson plans and activities rather than develop their own from scratch.

You are being asked to be in this study because you are an appropriate subject of this study, a middle school teacher who teaches geography and/or social studies.

100 participants will be invited to participate in this research study.

PROCEDURES

Taking part in this study is completely **voluntary**. You do not have to participate if you don't want to. You may also leave the study at any time. If you leave the study before it is finished, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled.

Description of Procedures
If you agree to take part in this study, you will be asked to:

A. User needs analysis
   You will be asked to preferred virtual globes that you want to learn, useful mapping techniques and course topics which you want to develop with GIS technologies. Also, general information about course preparation, teaching methods, and your needs will be collected and analyzed

Time Commitment to Complete Research Procedures
Participating in this step should take about one hour of your time.

Research Location
Participation will take place at your preferred locations such as a coffee shop in your local area.

Audio Recordings
Participation in this research may include audio taping. These tapes will be used for analyzing your opinions of GIS technology as an instructional tool, and will be retained for two years.

Those individuals who will have access to these tapes will be only the researcher.

RISKS AND DISCOMFORTS

There are no foreseeable risks for participating in this study.

BENEFITS

You may not receive any direct benefit from taking part in this study. However, your participation in this study may help us learn the way to encourage middle school teachers to overcome difficulties of new geo-spatial technologies and to challenge unfamiliar technical skills.

ENDING YOUR PARTICIPATION

You have the right to withdraw your consent or stop participating at any time. You have the right to refuse to answer any question(s) or refuse to participate in any procedure for any reason. Refusing to participate in this study will not result in any penalty or loss of benefits to which you are otherwise entitled.

CONFIDENTIALITY

We will make every effort to maintain the privacy of your data. There is no personal identifier such as name or social security number. The data will be stored in the researcher's external hard drive for at least two more years, and only the researchers will have the right to access to the data. The hand-written data will be converted to electronic version by the researcher. The questionnaires will be collected and stored as anonymously.

Other than the researchers, only regulatory agencies such as the Office of Human Research Protections and the University of Colorado at Boulder Institutional Review Board may see your individual data as part of routine audits.

QUESTIONS?

If you have any questions regarding your participation in this research, you should ask the investigator before signing this form. If you should have questions or concerns during or after your participation, please contact Jung Eun Hong at 720-333-7031.

If you have questions regarding your rights as a participant, any concerns regarding this project or any dissatisfaction with any aspect of this study, you may report them -- confidentially, if you wish -- to the Institutional Review Board, 3100 Marine Street, Rm A15, 563 UCB, (303) 735-3702.

AUTHORIZATION

I have read this paper about the study or it was read to me. I know the possible risks and benefits. I know that being in this study is voluntary. I choose to be in this study. I know that I can withdraw at any time. I have received, on the date signed, a copy of this document containing 3 pages.

Name of Participant (printed) ____

Signature of Participant ____________________________ Date ______________.
(Also initial all pages of the consent form.)

APPENDIX E-2: TUTORIAL DEVELOPMENT

Web-based GIS for middle school teachers: Using online mapping applications to promote teacher adoption

Principal Investigator Hong, Jung Eun

PARTICIPANT INFORMED CONSENT FORM

May 13th, 2011

Please read the following material that explains this research study. Signing this form will indicate that you have been informed about the study and that you want to participate. We want you to understand what you are being asked to do and what risks and benefits—if any—are associated with the study. This should help you decide whether or not you want to participate in the study.

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PROJECT DESCRIPTION

This research study is about training geography and social studies middle school teachers in Colorado. The key issue explored in this research is whether the latest Web-based systems lower the barriers to using mapping and GIS applications in the classroom. That is, whether there are ways to help teachers quickly get started with these technologies and to easily customize lesson plans and activities rather than develop their own from scratch.

You are being asked to be in this study because you are an appropriate subject of this study, a middle school teacher who teaches geography and/or social studies.

100 participants will be invited to participate in this research study.

PROCEDURES

Taking part in this study is completely **voluntary**. You do not have to participate if you don't want to. You may also leave the study at any time. If you leave the study before it is finished, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled.

<u>Description of Procedures</u>

If you agree to take part in this study, you will be asked to:

A. Tutorial development
   You will be asked to participate in designing user interface and determining appropriate technical levels and terms.

Time Commitment to Complete Research Procedures
Participating in this step should take about one hour of your time.

Research Location
Participation will take place at your preferred locations such as a coffee shop in your local area.

RISKS AND DISCOMFORTS

There are no foreseeable risks for participating in this study.

BENEFITS

You may not receive any direct benefit from taking part in this study. However, your participation in this study may help us learn the way to encourage middle school teachers to overcome difficulties of new geo-spatial technologies and to challenge unfamiliar technical skills.

ENDING YOUR PARTICIPATION

You have the right to withdraw your consent or stop participating at any time. You have the right to refuse to answer any question(s) or refuse to participate in any procedure for any reason. Refusing to participate in this study will not result in any penalty or loss of benefits to which you are otherwise entitled.

CONFIDENTIALITY

We will make every effort to maintain the privacy of your data. There is no personal identifier such as name or social security number. The data will be stored in the researcher's external hard drive for at least two more years, and only the researchers will have the right to access to the data. The hand-written data will be converted to electronic version by the researcher. The questionnaires will be collected and stored as anonymously.

Other than the researchers, only regulatory agencies such as the Office of Human Research Protections and the University of Colorado at Boulder Institutional Review Board may see your individual data as part of routine audits.

QUESTIONS?

If you have any questions regarding your participation in this research, you should ask the investigator before signing this form. If you should have questions or concerns during or after your participation, please contact Jung Eun Hong at 720-333-7031.

If you have questions regarding your rights as a participant, any concerns regarding this project or any dissatisfaction with any aspect of this study, you may report them -- confidentially, if you wish -- to the Institutional Review Board, 3100 Marine Street, Rm A15, 563 UCB, (303) 735-3702.

AUTHORIZATION

I have read this paper about the study or it was read to me. I know the possible risks and benefits. I know that being in this study is voluntary. I choose to be in this study. I know that I can withdraw at any time. I have received, on the date signed, a copy of this document containing 3 pages.

Name of Participant (printed) ____

Signature of Participant ____________________________ Date ______________.
(Also initial all pages of the consent form.)

APPENDIX E-3: EVALUATION

Web-based GIS for middle school teachers: Using online mapping applications to promote teacher adoption

Principal Investigator Hong, Jung Eun

PARTICIPANT INFORMED CONSENT FORM

Nov. 04th, 2011

Please read the following material that explains this research study. Signing this form will indicate that you have been informed about the study and that you want to participate. We want you to understand what you are being asked to do and what risks and benefits—if any—are associated with the study. This should help you decide whether or not you want to participate in the study.

CONTACT INFORMATION

You are being asked to take part in a research project conducted by Jung Eun Hong, a graduate student in the University of Colorado at Boulder's Department of Geography, 260 UCB, Boulder, CO 80309-0260. This project is being done under the direction of Professor Kenneth E. Foote, Department of Geography, 260 UCB. Jung Eun Hong can be reached at 720-333-7031. Professor Kenneth E. Foote can be reached at 303-492-6760.

PROJECT DESCRIPTION

The purpose of this research is training social studies middle school teachers. The key issue explored in this research is whether the latest Web-based systems lower the barriers to using mapping and GIS applications in the classroom. That is, whether there are ways to help teachers quickly get started with these technologies and to easily customize lesson plans and activities rather than develop their own from scratch.

You are being asked to be in this study because you are an appropriate subject of this study, a middle school teacher who teaches social studies.

PROCEDURES

Taking part in this study is completely **voluntary**. You do not have to participate if you don't want to. You may also leave the study at any time. If you leave the study before it is finished, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled.

Description of Procedures

If you agree to take part in this study, you will be asked to:

A. User survey

i. Complete the tutorials
   You need to complete the step-by-step tutorials for one topic to create Web-based maps.
ii. Answer the questionnaires
   You will be asked to answer the questions such as technology background, features in the tutorials, and usefulness of mapping tools.

Time Commitment to Complete Research Procedures
Participating should take at least one hour of your time to complete one topic and filling out the questionnaires.

Research Location
You can participate in the user testing anywhere you are available.

Data from web analytics such as the number of visitors, geographic locations, and time spent for each activity will be also collected.

This study involves 1 follow-up interview. The follow-up survey will be conducted in April, 2012. The participants will be asked by e-mail to identify whether they use Web-based maps as one of teaching tools in the classroom.

RISKS AND DISCOMFORTS

There are no foreseeable risks for participating in this study.

BENEFITS

You may not receive any direct benefit from taking part in this study. However, your participation in this study may help us learn the way to encourage middle school teachers to overcome difficulties of new geo-spatial technologies and to challenge unfamiliar technical skills.

ENDING YOUR PARTICIPATION

You have the right to withdraw your consent or stop participating at any time. You have the right to refuse to answer any question(s) or refuse to participate in any procedure for any reason. Refusing to participate in this study will not result in any penalty or loss of benefits to which you are otherwise entitled.

CONFIDENTIALITY

We will make every effort to maintain the privacy of your data. The data will be stored in the researcher’s external hard drive for at least two more years, and only the researchers will have the right to access to the data.

Other than the researchers, only regulatory agencies such as the Office of Human Research Protections and the University of Colorado at Boulder Institutional Review Board may see your individual data as part of routine audits.

At the end of the survey, I will ask if I can contact you with follow-up questions. Again, this information will be maintained privately.

QUESTIONS?

If you have any questions regarding your participation in this research, you should ask the investigator before signing this form. If you should have questions or concerns during or after your participation, please contact Jung Eun Hong at 720-333-7031.

If you have questions regarding your rights as a participant, any concerns regarding this project or any dissatisfaction with any aspect of this study, you may report them -- confidentially, if you wish -- to the Institutional Review Board, 3100 Marine Street, Rm A15, 563 UCB, (303) 735-3702.

AUTHORIZATION

I have read this paper about the study or it was read to me. I know the possible risks and benefits. I know that being in this study is voluntary. I choose to be in this study. I know that I can withdraw at any time.

If you understand the statements above, and freely consent to participate in the study, click on the "Survey" button to begin the survey.