COMPARATIVE ANALYSIS OF GOOGLE EARTH VERSUS TRADITIONAL PAPER MAPS IN MIDDLE SCHOOL EARTH SCIENCE EDUCATION

by

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ABSTRACT

As GIS becomes more prominent in academic classrooms at all levels of education, the subject of geography and its related disciplines can be approached with a geospatial technology perspective, using new tools and lesson plans. The implementation of Google Earth in classrooms is just one example of this. Research was conducted in eighth grade earth science classrooms, with Google Earth and paper map versions of a Bering Glacier lesson plan, allowing for spatial information to be conveyed in two different ways, while each combatted the spatial weaknesses found in standard middle school curriculum across the nation. With the two-sample *t*-test analyses of pre-tests, worksheets, and post-tests, limited conclusions about Google Earth compared to traditional paper maps can be made. The results indicate that Google Earth is just as useful as traditional paper maps with this particular lesson in the classroom. With the testing complete, connections can then be inferred beyond middle schools. The conclusions from this research paper can be applied to different levels of education while considering varying factors determining learning of geography: distinct types of learning styles, cartographic influences, and the effects of visual aids on learning.

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1. INTRODUCTION

Is Google Earth a significant learning tool in the classroom? Since introduced in 2005, this is the question that arises as the role of computers in primary, secondary, and even tertiary education continues to evolve and as access to personal computers increases (Dodsworth & Nicholson, 2012). With the introduction and increased use of geographic information systems (GIS) in classrooms across the country, instructors are able to convey spatial information in ways unlike ever before (McClurg & Buss, 2007). In the hands of experienced teachers, GIS has the ability to combat geographic weaknesses, such as students' limited spatial comprehension across the nation, as well as invigorate classrooms (Demirci, 2011; Patterson, 2007). While GIS software can be expensive for an educational institute to purchase, Google Earth is readily available via the Internet and thus offers a geography tool at no additional expense.

Google Earth has the ability to display the spatial locations and relations of features on the Earth and with "easy access to spatial and cultural information, Google . . . Earth has provided users with the means to understand their world and their communities of interest" (Dodsworth & Nicholson, 2012). While Google Earth is similar to other GIS programs, it is a virtual globe available at no cost. The program only requires a computer and an Internet connection and has an intuitive user interface, making it ideal and readily available for classrooms at all levels (Patterson, 2007; Green & Mouatt, 2008). There are many lesson plans available to educators for a variety of classroom settings and many of these lessons are available at little to no cost.

The purpose of this research is to analyze the potential of Google Earth by comparing it to traditional paper map methods. A two-day long Bering Glacier lesson (with a Google Earth and paper maps version) was chosen as the main focus of this study, along with a pre-test and post-test for all of the participants. With a case study of eighth-grade students in Oregon, two-sample *t*-tests analysis of pre-tests, lesson worksheets, and post-tests allowed for a comparison of these tools. The research can confirm what is known about Google Earth and its effectiveness as a readily available visual aid in settings beyond the middle school classroom.

This study goes a step further than previous studies by comparing Google Earth to traditional paper maps, with both a qualifying and a quantifying analysis. After analysis, inferences can be made about Google Earth and its effectiveness as an innovative visual aid in middle-school classrooms, as well as other classroom settings. Data collected and analyzed in this research can help answer the following research questions: Is there a significant difference between the outcomes of Google Earth and the paper map lesson chosen for this research? If so, do either Google Earth or paper map activities better help eighth grade middle school classes meet the state standards for earth science in Oregon and the National Geography Standards set forth by the National Geographic Society?

2. VISUAL AIDS IN GEOGRAPHY EDUCATION

Having been around for less than a decade, Google Earth is viewed as an up-and-coming tool in geographic education for the purposes of this research (Dodsworth & Nicholson, 2012). It is a type of visual aid, noted for its association with geography and geographic related disciplines. With a presentation on the background of visual aids, which includes both Google Earth and paper maps, the importance of each of the tools utilized in this study can be addressed. This history explains the methodology chosen and will contrast Google Earth and paper maps to one another in the classrooms that were included in this study.

There are many forms of visual aids in geography, ranging from transparencies and filmstrips to GIS and virtual globes. Both paper maps and Google Earth are examples of the multitude of visual aids used in the geographic discipline. Visual aids assist classrooms in reaching the state of Oregon's eighth grade state earth science standards, as well as the National Geography Standards which are key to the subject of geography.

2.1 Geography in Earth Science Education

Earth science is a required class for all eighth graders in the state of Oregon and similar classes are offered to secondary school students across the nation ("2011-12

Achievement Standards Summary," 2011). By choosing earth science classrooms as the setting for this research, this research is relevant due to the large population involved in earth science education across the United States. The eighth grade earth science standards were reviewed in order to understand the overall goals of the classes sampled. As determined by the state of Oregon's Department of Education, there are four earth science standards to be met at the eighth grade level:

- 8.1 Structure and Function: Systems and their components function at various levels of complexity.
- 8.2 Interaction and Change: Systems interact with other systems.
- 8.3 Scientific Inquiry: Scientific inquiry is the investigation of the natural world based on observations and science principles that includes proposing questions or hypotheses and designing procedures for questioning, collecting, analyzing, and interpreting multiple forms of accurate and relevant data to produce evidence-based explanations and explorations.
- 8.4 Engineering Design: Engineering design is a process of identifying needs, and evaluating proposed solutions ("Standards for Design: Eighth Grade for Science," 2012).

These "standards are statements of what students are expected to know and be able to do" by the end of their academic school year ("Academic Content Standards: Creating Consistency Across Oregon," 2010). Teachers are advised on what to teach their classes in order to ensure all their students' needs are being met as well as increase their academic achievement with these standards.

The lesson used in this project covered all four of these standards, along with geographic standards described in National Geographic's *Geography for Life: National Geography Standards*. A movement to articulate these National Geography Standards began in the late 1980s and became solidified with the implementation of the Clinton administration's Goal 2000 education plan (Boehm & Rutherford, 2004). The Goal 2000 education plan had many propositions, including the establishment of state standards for core subjects (such as geography) nation-wide (Lewis, 1994). These standards have been described as "what every young American should know and be able to do in geography" and with the proposition of establishing the standards at a national level would ensure consistency in all states (Bednarz et al., 1994). Though the National Geography Standards were updated in 2012, the content has remained the same with updates and reorganization (Heffron, 2012).

The National Geography Standards include 18 standards for the grades 5-8, but for the purpose of this research only four of them are pertinent. The four were focused on exclusively because of their congruency with the eighth grade earth science lesson used in this project (Bednarz et al., 1994). The standards focused on are:

- Geography Standard #1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.
- Geography Standard #7: The physical processes that shape the patterns of the Earth's surface.

- Geography Standard #14: How human actions modify the physical environment.
- Geography Standard #15: How physical systems affect human systems.

By contrasting the state of Oregon's eighth grade earth science standard to the standards described in National Geographic's *Geography for Life: National Geography Standards,* it is apparent that earth science classes draw upon concepts very similar to those found in the physical geography subset of the geographic discipline (Bednarz et al., 1994). Due to the fact that geography itself can be difficult to define, it is often common to find geography programs nested with other geosciences, including geology, environmental science, and earth science (Yu et al., 2011). While research took place in earth science classrooms, the material covered by the Bering Glacier lesson in this study was geographic in nature.

2.2 Visual Aids in Geography Education

Visual aids help in all educational disciplines, but they are fundamental to geography in order to let learners understand the spatial and temporal variation across the Earth's landscape (McClurg & Buss, 2007). It is the spatial and temporal facets of a feature that make something geographic in nature. As discussed by Forsaith in *A Handbook for Geography Teachers*, visual aids are significant components "for the basic task in geography teaching is to ensure that children are able to imagine accurately and to interpret correctly the 'conditions of the great world state'" (Forsaith, 1964 p. 143). Before the common use of geospatial technologies, such as GIS and Google Earth, geographic education goals were met with the help of classic geographic tools still used within the discipline today. Through the years teachers have taught geographic concepts using tools such as blackboards, overhead transparencies, pictures, slides, and filmstrips. One tool that has consistently been associated with geography is that of the model. Whether it be a map or a globe, models have been utilized to give a visual to the world being described. Models can display a multitude of features on the landscape, from relief to political boundaries to the complex terrain of a region. Many of these tools, or their contemporary counterparts, are still in use today - including one of the standard globe's relatives, the virtual globe.

2.3 GIS and Virtual Globes in Geography Education

GIS includes any software that allows for manipulation and analysis of georeferenced data (Kulo & Bodzin, 2011). Virtual globes, a specific type of GIS, are digital spherical Earth models displayed on a computer instead of a physical model (Allen, 2007). As technology has allowed for these tools to be more readily available, geospatial technologies, including GIS, global positioning systems (GPS), and virtual globes, have an increased presence (Kulo & Bodzin, 2011). Inquiry-based learning, such as GIS activities, activates student's thinking; therefore spatial literacy enhancement with GIS and virtual globes has been attributed to the simplification of data analysis and acceleration of geographic inquiry (Demirci, 2011; Perkins et al., 2010; Ratinen & Keinonen, 2011). Geospatial technologies have also allowed for users to visualize and analyze spatial and temporal trends that would have otherwise been difficult to discern (Ratinen & Keinonen, 2011).

As technology has been implemented in the classroom, research provides explanations for the potential and efficiencies of these new applied technologies. Much of this research has concluded that GIS provides environments that foster creative learning, self-discovery, and "such learning environments motivate and facilitate the acquisition of knowledge by providing an intuitively comprehensible context" (Huang, 2011). Teachers serve as "mediators" or "guides" with GIS in the classroom and GIS-related lessons that address student cognition in order to fully utilize these geospatial technologies (Huang, 2011). The Bering Glacier lesson used in this study helps students actively achieve this goal.

One study involving middle school classrooms in Maine incorporated lesson plans that used global positioning systems (GPS) and GIS to make mental maps. The educational goal was to improve spatial literacy and enhance reasoning techniques by using hands-on, real world activities. Student learning was then assessed and analyzed with the aid of pre- and post-tests, allowing them to assess place-based spatial learning with the assistance of GIS technologies (Perkins et al., 2010). The teacher's objective was to get students involved with hands-on activities to engage them in the real-world applications and improve spatial literacy, which is the understanding of spatial and temporal relationships between people, places, and the environment (Bednarz et al., 1994 p. 34). This allowed for the researchers to conclude that spatial literacy can be improved with the help of geospatial tools, including virtual globes.

In resource-poor regions, computer-based GIS lessons have been modified to paper-based GIS lessons. This allows students in these areas access to the advantages that GIS has to offer. In one specific study that took place in South Africa, paper-based GIS lessons were used in order to convey specific spatial concepts, such as symbolization and data acquisition (Breetzke et al., 2011). With these lessons it was difficult to evaluate the effectiveness of the paper-based GIS, though "the results of the open-ended questionnaire assessing the learners' opinions of the paper-based GIS package were extremely favorable" and there appeared to be an increase in spatial cognition and comprehension (Breetzke et al., 2011).

Similar studies have been conducted with focuses on concepts other than spatial literacy. In a study on environmental education using GIS, the interest was in the use of geospatial technologies in secondary education, where the focus was structural constructivism in the students' learning (Liu & Zhu, 2008). Research has also been conducted on enhancing terrain visualization in university level geomorphology courses in order to visualize physical processes on the landscape

(Allen, 2007). Such research helps illustrate the potential of GIS in the classroom, conveying not only spatial concepts that are intimately tied to geography but also helping other concepts – such as environmental features – that may be found in other academic disciplines as well.

2.4 Google Earth in Geography Education

Google Earth is considered to be a specific type of “virtual globe” in the GIS community; it is a program that allows for its users to “‘browse’ satellite imagery and digital aerial photographs draped over a three dimensional display (3D) representation of the Earth” (Green & Mouatt, 2008 p. 148). Like other forms of GIS, Google Earth has had many impacts, both inside and outside of the classroom. Similar to research involving the concept of virtual globes in general, previous studies have investigated Google Earth specifically in various aspects of education. Such aspects include, but are not limited to, library resources, digital student portfolios, and lesson plans (Blank et al., 2012; Dodsworth & Nicholson, 2012; Guertin et al., 2012). Its wide audience can be attributed to its simple yet powerful ease of use (Green & Mouatt, 2008).

In library research, Google Earth has been used to not only answer research questions, but also as a free and easily accessible program to share information and resources (Dodsworth & Nicholson, 2012). Google Earth also provides a platform for students to create digital portfolios, allowing for them to not only easily share their previous work but also increase their literacy – both geographic and digital (Guertin et al., 2012). In the classroom, Google Earth has been used in a multitude of ways. Such methods include the use of Google Earth in middle school science courses in order to address plate tectonics and other physical processes (Blank et al., 2012). The use of Google Earth in this study addresses both the pros and cons of the Google Earth program in the research design (Patterson, 2007). The methodology of this study was chosen in order to have a lesson plan that incorporated Google Earth and analyzed its potential edge over traditional paper maps.

Google Earth has many advantages over other geographic visual aids, including other forms of GIS. The basic data necessary for Google Earth to run on a given device is hosted by Google itself, not the user (Kerski, 2008). Google Earth provides many supplements and extensions readily available to both students and instructors using the Internet. Similar to other free and low-cost forms of GIS, Google Earth is a free application and easy to use. This encourages students to explore the program during their own free time (Doering & Veletsianos, 2007). Unlike other free and low-cost forms of GIS, Google Earth has a structure geared towards learners' cognition rather than navigation and confusing interfaces (Huang, 2011). Self-exploration opportunities allow students to build up their spatial and temporal skills outside of the classroom, thus increasing their skills overall.

Google Earth's accessibility is not the only advantage over other geographic visual aids; it is the dynamic perspective of the program. As noted by Edward Tufte, a revolutionary in the subject of data visualization, "Despite their quantifying scales and grids, maps resemble miniature pictorial representations of the physical world . . . To go from maps of existing scenery to graphs of . . . measured and collected data was [is] an enormous conceptual step" (1997 p. 14). While Tufte was not describing Google Earth itself, his description of data visualization remains true because the principles of visualization remain unchanged. And unlike standard static maps, Google Earth does not pose the problem that Tufte describes. A student has the potential to look at an aerial photo of his/her house and zoom in and out in order to see the house in relation to the city, state – even a perspective of his/her location on Earth from outer space. With a changing scale, students even have the potential to avoid one of the main "lies" of scale that Mark Monmonier describes in his *How to Lie With Maps* (Monmonier, 1996 p. 5). This classic book details how maps are always full of inaccuracies, both intentional and unintentional, due to the generalization necessary to compress all of the real world's information onto a map. It is the dynamic scale of Google Earth that allows users to see where their spatial data fits into the world and hopefully avoid some of the omissions notoriously associated with maps (Dodsworth & Nicholson, 2012; Monmonier, 1996).

Google Earth has its disadvantages as well. One disadvantage is that it requires a relatively fast, consistent Internet connection (Patterson, 2007); hence the required computer labs for students may not always be available. Google Earth users also have the opportunity to be passive observers, particularly during lessons that use Google Earth tours as a means of conveying information within a lesson (Blank et al., 2012).

These are not the only pitfalls of this program; there are disadvantages to visual aids and Google Earth is no exception. While discussing the use of PowerPoint, Tufte argues that visualization software weakens the users verbal reasoning (2003). While PowerPoint is not the same program as Google Earth, and is in fact not even mapping software, many of the principles apply because they involve visualization on an electronic medium. This is becoming more common as technology use increases throughout the world. Also, Google Earth provides a multitude of information to its users, often more than is sought. The multitude of information includes the default sidebar to the left, the navigation to the upper right, and the program information to the bottom right. (Figure 2.1). While these tools are of potential use, they are not always necessary. This “chartjunk” distracts the user from the necessary information being provided and obscure the information they are visualizing (Tufte, 1983). With the data being cluttered, the true meaning of the task at hand has the potential of being lost.

Lastly, the implementation of Google Earth in the classroom assumes that the instructors are in fact comfortable with using this relatively new technology. There is a “glass half-full” and a “glass half-empty” perspective to GIS in the classroom and this perspective applies to Google Earth as well (Edelson et al., 2008). This point of view addresses that while GIS has large potential in the classroom, it implies teachers have had experience to implement it. Teachers with GIS experience are relatively rare – but many teachers have had experience with Google Earth over other programs, making it more probable for them to want to use this specific type of GIS in their classrooms (Dodsworth & Nicholson, 2012; Edelson et al., 2008).

Figure 2.1. Image of Google Earth when the program is first started. Possibly distracting information to the user (boxed in red) includes: the default sidebar, the navigation, and the program information found respectively on the left, upper right, and bottom left. .

3. METHODS AND PROCEDURES

3.1 Study Site: Eighth Grade Middle School Classrooms

The setting for this study is two public middle schools located in Benton County, Oregon. All eighth grade earth science students were invited to participate in this study. As required by the Institutional Review Board for research on human subjects, the students were sent home with a letter from the researcher, explaining the purpose and methods of study. These letters required a signature of consent from the parents and assent from the students in order to participate in the research (Appendices 1 and 2).

3.1.1 Linus Pauling Middle School

Linus Pauling Middle School was one of the two study sites of this research project. It is one of three middle schools located in the city of Corvallis, Oregon. It serves 699 sixth, seventh, and eighth grade students; slightly greater than 43% of these students receive free or reduced lunches. This information gives insight to the socio-economic background of the students at this school ("Linus Pauling Middle School," 2013). At Linus Pauling Middle School eighth grade earth science classrooms contain up to 35 students; there are eight earth science periods. Jamie Rumage teaches five of these periods and Jenny Allen teaches three. Approximately

260 students were invited to participate in this study, though only 71 gave consent/assent and completed all of the materials for the study.

3.1.2 North Albany Middle School

North Albany Middle School is the second study site of this research project. It is one of five middle schools located in the city of Albany, Oregon. It serves 512 sixth, seventh, and eighth grade students and just over 26% of these students receive free or reduced lunches (“North Albany Middle School,” 2013). One could infer that North Albany Middle School students come from overall more affluent backgrounds than those at Linus Pauling Middle School. At North Albany Middle School, eighth grade earth science classrooms contain up to 35 students and there are five earth science periods. Katy Kelly teaches all five of the periods. Approximately 135 students were invited to participate in this study, though only 55 gave consent/assent and completed all of the materials for the study.

3.2 The Bering Glacier Lesson

The focus of the worksheet lesson utilized in this study is the Bering Glacier, located along the south-central coast of Alaska (Figure 3.1). The Bering Glacier is North America’s largest glacier: it is 180 kilometers long, extends from the Gulf of Alaska to 2445 meters above sea level, and is 4773 square kilometers in size (Tangborn, 2012). In the past 200 years, "the Bering Glacier began to retreat from its maximum Neoglacial position" though there have been at least six surges of "substantial amplitude and duration" in this time period (Tangborn, 2012). Because the Bering Glacier is so dynamic and significant to both the studies of geography and earth science in the United States, it was a pertinent subject to explore in the lesson chosen for this study.

A pre-existing Google Earth lesson plan was chosen in order to create a contrasting lesson for the classes using paper maps to those using Google Earth (Nelson, 2012). This lesson was created by Peder Nelson, a senior research faculty assistant at Oregon State University's Department of Forestry, and Joan Swafford, an eighth grade earth science teacher at Jefferson Middle School in Jefferson, Oregon. The lesson was created for the Oregon Science Teachers Association and had never been used prior to this study. The lesson was readily available through the university's web site and included a KMZ file, a compressed Keyhole Markup Language file specific for Google Earth, and a corresponding worksheet (Appendix 3).

The KMZ file contains both natural and false color Landsat images of the Bering Glacier from September of 1986, 1996, 2006, and 2010 (Figures 3.2 and 3.3). These images were georeferenced so they appear as layers in Google Earth when the KMZ file is opened (Figure 3.4). The worksheet has students examine both the natural color and false color images of the Bering Glacier by visually comparing them to one another. They then measure the start of the glacier, at the Bagley Icefield, to the terminus, where the glacier ends (Figure 3.5). The worksheet has two main components: the first part includes questions about the Landsat images. The image questions include the date the images were taken, the differences between the natural color and false color images for each year, and how the Bering Glacier has changed from 1986 to 2010 – along with the changes that occurred in the years in between. The second part of the worksheet includes analysis questions about the Bering Glacier and then questions about glaciers in general. The analysis section includes questions that ask which year was the glacier largest, what could explain the changes in the glacier, and how this relates to the rest of Earth.

3.2.1 Google Earth Version

The classes that used the Google Earth version used a lesson that was very similar to the lesson provided by Peder Nelson and Joan Swafford (Appendix 4). The revisions made were minimal in order to make the lesson more consistent with that of the paper map version used in the other classes. Similar to what was written in the original lesson, glacier measurements were made using the ruler tool in Google Earth (Figure 3.6).

3.2.2 Paper Maps Version

The classes that used the paper maps version used a lesson that was rewritten in order to use the lesson provided with paper maps instead of Google Earth (Appendix 5). Such revisions included using a physical ruler and colored pencils instead of the ruler tool in Google Earth, similar to many of the adaptations utilized in paper-based GIS activities (Breetzke et al., 2011). Using a ruler involved converting the centimeters measured on paper to kilometers in the "real world." In order to mitigate this, a representative fraction was provided to the paper map users. Analysis questions remained the same for the paper maps Bering Glacier lesson.

Screen shots were taken of the KMZ file open in Google Earth in order to create a hard copy packet of both the natural and false color Landsat images from 1986, 1996, 2006, and 2010 (Appendix 6). Two reference maps were also created for this packet, in order to provide spatial reference for the location of this glacier (Appendix 6). Using colored pencils, measurements were recorded on tracing paper on the packet images in order to measure the glacier in Alaska (Figure 3.7).

3.3 Data Collection: In the Classroom

Data collection took place in each classroom for two days. At Linus Pauling Middle School, periods were just under 50 minutes long. At North Albany Middle School, periods were 45 minutes long.

3.3.1 Pre-Test

A 16-question pre-test was distributed to the students prior to the start of the lesson at both middle schools (Appendix 7). This pre-test was modeled after an example presented in a dissertation about geography education and web-based GIS by Dr. Lynn Songer (2007). The first 14 questions were multiple-choice, asking demographic information about the students, as well as questions about map use, computers, and GIS. The last two questions were short-answer and were about glacier characteristics and significance.

3.3.2 The Bering Glacier Lesson at Linus Pauling Middle School

At Linus Pauling Middle School, it was originally intended that all eight earth science classes be included in the study. Four of the classes were to use paper maps for their lesson and the other four classes were to use Google Earth for their lesson. A random number generator was used to determine which classes would be using paper maps and which classes would be using Google Earth.

After the pre-test, it became apparent that technology filters at the school were preventing the KMZ files from loading properly despite a trial run that had been tested prior to the data collection. Due to time constraints of the classrooms needing to stay on schedule, only Jamie Rumage's five classes completed the lesson. All of her classes used the paper map version of the lesson only instead of the half paper maps, half Google Earth plan that had been originally intended.

At the start of the lesson, there was a brief introduction to glaciers and Landsat imagery. This served as a review for the students as they had covered similar material earlier in the academic year. Students then worked on their worksheets individually, though they were allowed to collaborate with one another and ask questions to both their teacher and the researcher (who was present in the classroom for the entire lesson).

3.3.3 The Bering Glacier Lesson at North Albany Middle School

At North Albany Middle School, all five earth science classes were included in the study. Two of the classes used paper maps for their lesson and the other three classes used Google Earth for their lesson. Similar to what was intended at Linus Pauling Middle School, a random number generator was used to determine which classes would use paper maps and which classes would use Google Earth.

After the pre-test, the paper map classes started the lesson and the Google Earth classes went to the school computer lab in the library. Though technology filters were not an issue at North Albany Middle School, as they had been at Linus Pauling Middle School, a significant amount of time was needed to load all of the data with the KMZ files. Because of this, the teacher and the researcher (who was once again present in the classroom for the entire lesson) loaded Google Earth and the KMZ files prior to the start of the classes using Google Earth.

Similar to what took place at Linus Pauling Middle School, at the start of the lesson there was a brief introduction to glaciers and Landsat imagery in order to serve as a review for the classes. Students then worked on the worksheets individually, though they were allowed to talk to each other and ask questions to both their teacher and the researcher.

3.3.4 Post-Test

A 16 question post-test was distributed to the students after the worksheets had been completed at the end of the lesson at both middle schools (Appendix 7). The post-test was identical to the pre-test; the intent here was to observe differences in responses to the last two questions about glacial characteristics and significance.

3.4 Analysis

The analysis of the data took place using the raw worksheet scores from the students and the results of their responses for pre-test and post-test questions 15 and 16, which were the two free response questions included in the pre-test and post-test.

The worksheet was graded on a 36-point scale and then converted to percentage in order to evaluate. Each short-answer question was worth 1 point and the questions regarding the differences between the natural color and false colored images were worth 3 points: one point for noting the differences between colors, one point for noting what the colors mean, and one point for giving a specific example. For the second half of the analysis section two points were given for the correct years in the first two questions. The following six questions were nine points total, one point per possible explanation.

Both the pre-test and post-test responses were graded on a six-point scale rubric, where each question response could get up to three points total. For question 15:

15. Describe a glacier. (This might include characteristics, features, or where they could be found).

One point was for the characteristics of a glacier, one point for describing where glaciers are found, and one point for describing other characteristics of a glacier. For question 16:

16. Glaciers are important because…

One point was for a description of how glaciers store water, one point was for how they are an indicator of climate change, and one for any other reason glaciers are important.

A two-sample *t*-test, an analysis that is often used when testing significance in the classroom, was then used to calculate the significance of the pre-test, the worksheet, and the post-test results (Huang, 2011). A standard p-value of 0.5 was used when calculating the results. The value of *t* was calculated using the following equation:

$$t = \frac{\hat{x}_1 - \hat{x}_2}{\sqrt{\frac{{s_1}^2}{n_1} + \frac{{s_2}^2}{n_2}}}$$

In this equation $\hat{x}$ denotes the score, s denotes the standard deviation, and n denotes the sample population. The degree of freedom was calculated using the following equation:

$$df' = \frac{\left(\frac{{s_1}^2}{n_1} + \frac{{s_2}^2}{n_2}\right)^2}{\frac{\left(\frac{{s_1}^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{{s_2}^2}{n_2}\right)^2}{n_2 - 1}}$$

In this equation $\hat{x}$, s, and n denote the same variables as described in the equation for *t*. This is a modification of the Welch-Satterthwaite, used when variances are unequal, such as with a two-sample *t*-test, in order to provides accurate results (Sauro & Lewis, 2012 p. 72).

Figure 3.1. Location of the Bering Glacier, along the south-central coast of Alaska.

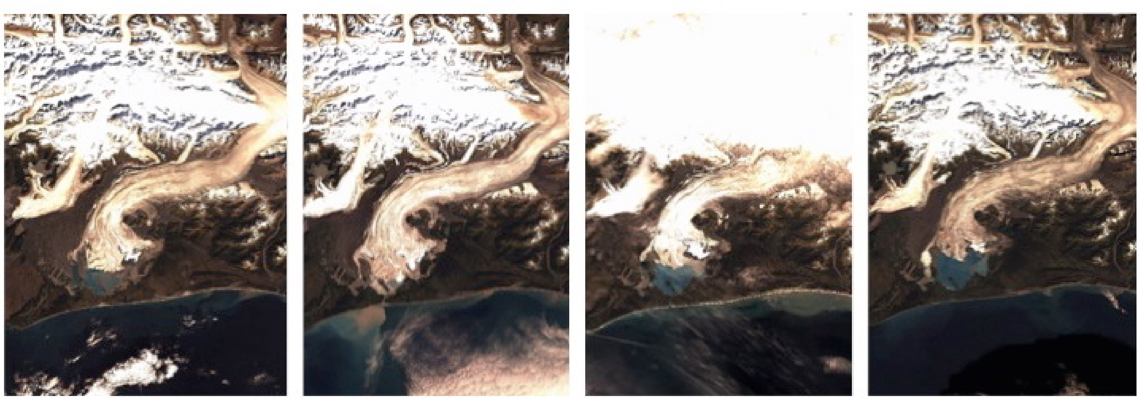

Figure 3.2. Natural color Bering Glacier Landsat images from (left to right) September of 1986, 1996, 2006, and 2010.

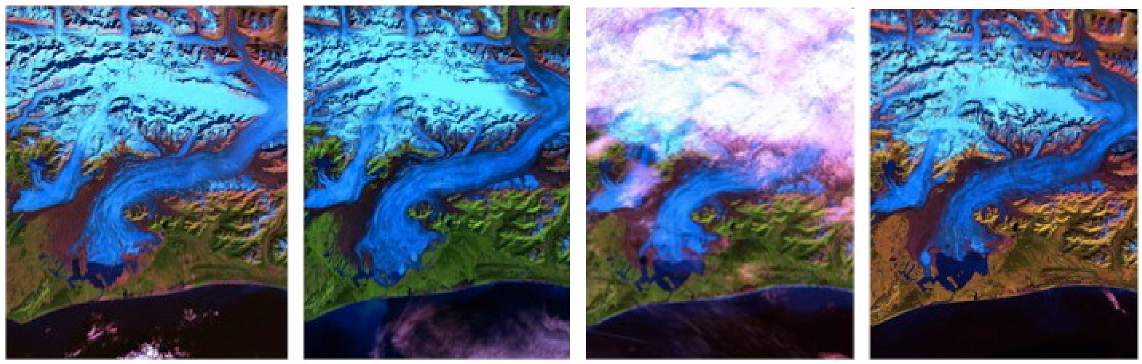

Figure 3.3. False color Bering Glacier Landsat images from (left to right) September of 1986, 1996, 2006, and 2010.

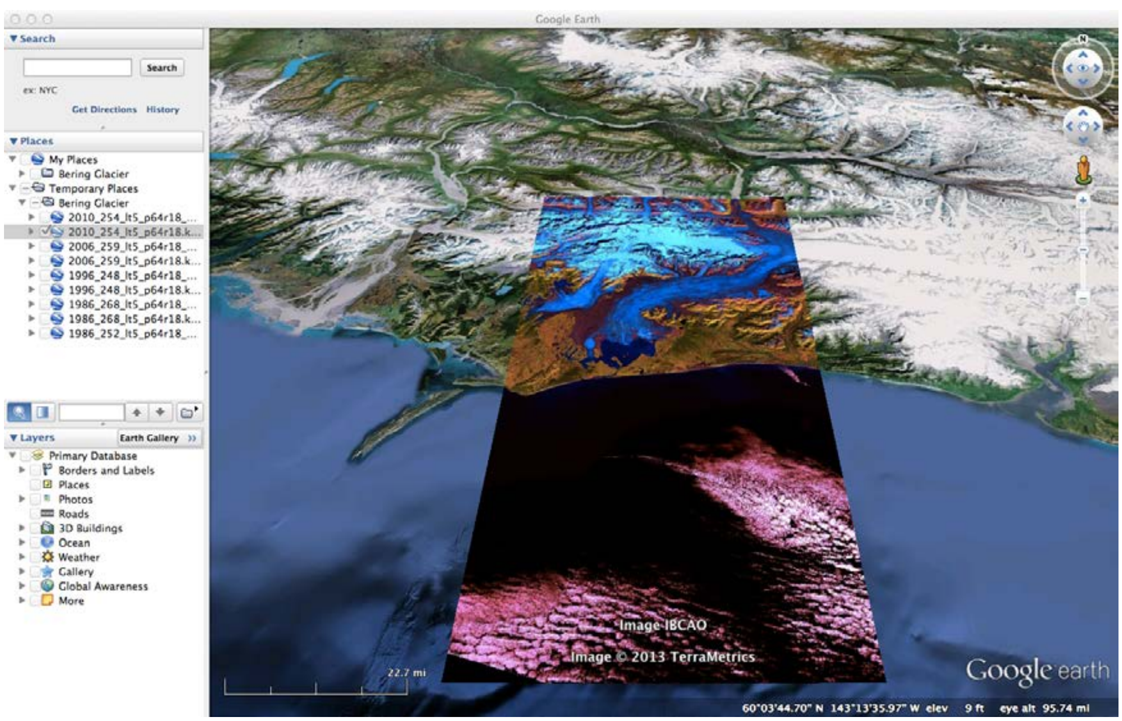

Figure 3.4. The Bering Glacier KMZ displayed in Google Earth.

Figure 3.5. The Bering Glacier outlined in Google Earth as it leaves the Bagley Icefield; the terminus is the southwestern edge of the red outline.

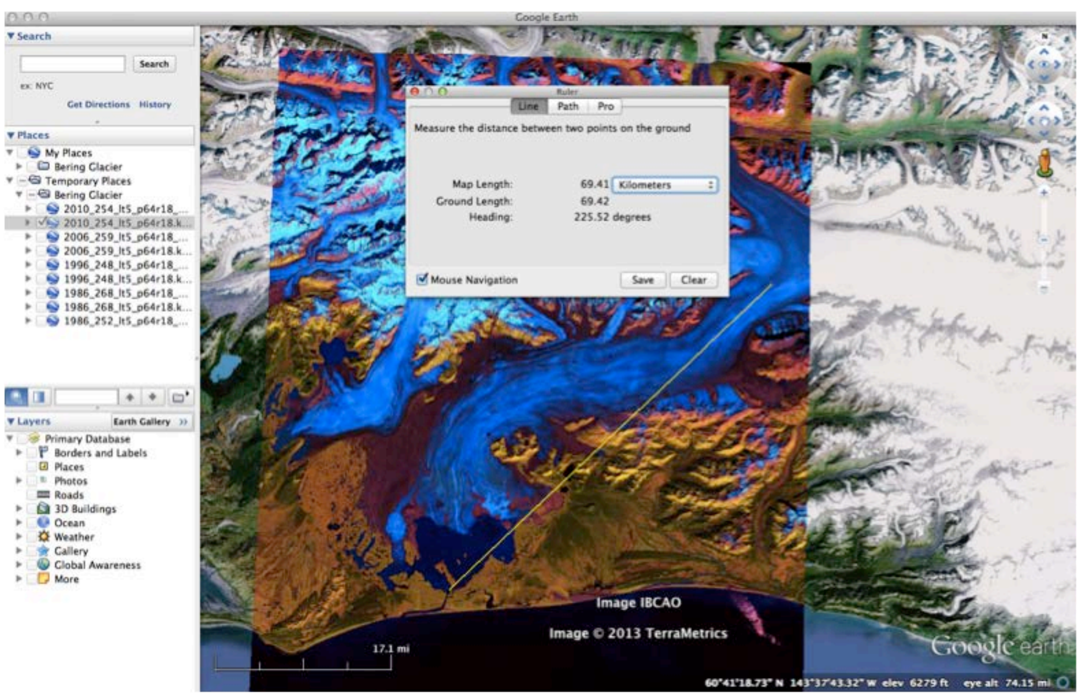

Figure 3.6. Bering Glacier measurement using the ruler tool for the Google Earth version of the lesson.

Figure 3.7. Bering Glacier measurement using a ruler for the paper map version of the lesson.

4. RESULTS

There were 123 student participants in this study. Seventy-one were students at Linus Pauling Middle School; they all completed the Bering Glacier lesson using paper maps. The remaining 52 participants were students at North Albany Middle School; 17 of these students used paper maps to complete the Bering Glacier Lesson and the remaining 35 used Google Earth.

4.1 Pre-Test and Post-Test Results

4.1.1 Student Demographic Information

The first five questions of the pre-test and post-test were questions that revealed demographic information about the student participants (Table 4.1). These questions were asked on the pre-test and post-test in order to get background information about the student and to gauge if there were any significant trends in the demographic information among the participants. All of the students were between the ages of 13 and 15 years old and over 60% of the participants were female in every group tested, while just under 40% were male. Over 90% of the participants had travelled outside the state of Oregon within the past five years and over one-third of the participants had travelled outside the United States within the past five years. Most of the students were not fluent in another language beyond

English.

4.1.2 Student Lifestyle Information

The next nine questions, pre-test and post-test questions six through 14, were questions that revealed lifestyle information about the student participants (Table 4.2). These questions were asked on the pre-test and post-test in order to obtain background information about the student and to gauge if there were any strong trends related to lifestyle among the participants. Much of the information provided by the students involved facets of their everyday life. The questions concerning Internet use and map-use had the potential to reveal if students were doing well on the lesson because of previous experience. Every student participant used the Internet for at least one hour a week and 16% of the participants used the Internet over 12 hours a week. This question included Internet use that was both recreational and academic, though 20% responded that they used the Internet almost daily for academic use. About one-third of the students were classified as avid videogame users (playing more than 12 hours a week), one-third were moderate videogame users (playing between one and 12 hours a week), and the remaining third stated they never play videogames. The majority of the students claimed to be average when it came to rating their basic computer skills.

Concerning map use, which includes both paper electronic forms of maps, 7% of the participants claimed using maps daily and at least 40% used maps once a month.

While over half of the students were unsure if they had ever used GIS software before, over 70% had used Google Earth before – though most of them use Google Earth about once a month.

4.1.3 Pre-Test and Post-Test Glacier Question Results

The results of the pre-test and post-test revealed that most students had a very basic idea of what a glacier was prior to the lesson, though few were able to explain why glaciers are important (Table 4.3). When asked to describe a glacier on the pre-test, over 46% of the students received a 0 or a 1 score on their pre-test – meaning over 53% received the score of a 2 or a 3. All were able to go into more detail about glaciers after the lesson, with only over 18% receiving a 0 or a 1 score on their post-test – meaning that over 80% received a score of a 2 or a 3. The following is a description of a glacier that would have received a score of a 3: "A glacier is a big permanent piece of ice found on the ground at high elevations or near the poles. They are formed when ice and snow accumulate for many years." The following, an explanation as to why glaciers are important, would have received a score of 3: "Glaciers are important because they are a source of water for many people. They are also useful for people who want to know about the earth's past weather. Glaciers are disappearing and scientists care because of how they relate to global warming."

Using a standard p-value of 0.5 in a two-sample t-test, it was determined that there was a significant difference in the results of question 15 in the pre-test and post-test overall. There was a significant learning gain earned at North Albany Middle School, regardless of whether paper maps or Google Earth were used; this trend did not occur at Linus Pauling Middle School (Table 4.4).

When asked to explain why glaciers are important in the pre-test 74% of the students could give a basic explanation, receiving a 0 or a 1 score on their pre-test and just over 24% went beyond that and received a score of a 2 or a 3 (Table 4.3). In the post-test, 35% of the students received a 0 or a 1 and 65% received a 2 or a 3.

Using a standard p-value of 0.5 in a two-sample t-test, it was determined that there was an overall significant difference in the results of question 16 in the pre-test and post-test (Table 4.5). There was a significant knowledge gain regardless of whether the students used Google Earth or paper maps to complete the worksheet or were a student at Linus Pauling Middle School or North Albany Middle School.

4.2 Worksheet Results

4.2.1 Overall Results

Overall, the student participants scored between 30% and 90% on their worksheets (Figure 4.1). The average scores were between 70% and 80% with the expected outliers on either side of the mean, and two extraneous outlier worksheets with scores below 40%.

Using a standard *p*-value of 0.5 in a two-sample *t*-test, it was determined that there was no significant difference in the raw worksheet scores, regardless of whether the students used Google Earth or paper maps to complete the worksheet or if they were a student at Linus Pauling Middle School or North Albany Middle School (Table 4.6).

4.2.2 Student Lifestyle Information and Results

In order to differentiate the results, responses to specific lifestyle questions were examined by sorting the responses and then analyzing the corresponding pre-test, worksheet score, and post-test scores. The specific pre-test and post-test questions analyzed further included questions 6, 8, and 10.

6. How many hours a week do you use the Internet?

a) 1 - 4
b) 5 - 8
c) 9 – 12
d) More than 12
e) Never

8. How often do you use maps? (Paper or electronic – such as phone, tablet, or computer)

a) Daily, or almost daily
b) 2-3 times a week
c) Once a week
d) Once a month
e) Never

10. Have you used Google Earth before?

a) Yes *b) No*

A standard *p*-value of 0.5 in a two-sample *t*-test, in order to determine the possible significance with regard to the student responses.

For question 6 regarding Internet use, just under 38% of the participants reported using the Internet between five and 12 hours a week. For question 15 there was a significant difference among the participants who used the Internet greater than 12 and for question 16 there was a significant difference all participants (Table 4.7). Because of the inconsistent significance results in regards to Internet use, it can be inferred that Internet is a not a significant factor in the outcome of the Bering Glacier lesson.

For question 8 regarding paper maps, despite the fact that just under 50% of the participants claimed to use maps at least once a week, the results of this question tell that there was no significant difference between frequent and infrequent map users. The only exception is found in question 16 of the pre-test and post-test, where those who used maps once a week to monthly appeared to score higher (Table 4.8). Those who used maps more than once a week did not score higher though, leading to the conclusion that there is no significance to map use.

For question 10 regarding Google Earth use, there was not a significant difference among participants who used Google Earth and those who did not use Google Earth

(Table 4.9). This was due to the fact that non-previous Google Earth users had significance in their pre-test and post-test scores for question 15 and not question 16. The opposite was true for previous Google Earth users: they had significance in their pre-test and post-test scores for question 16 and not question 15. To explore this further worksheet scores were then analyzed, determining that previous Google Earth users had worksheet scores significantly higher than those students that had never used Google Earth prior to this lesson (Table 4.10).

Figure 4.1. Breakdown of student worksheet scores by type of lesson they completed.

Table 4.1. Student demographic information provided by questions 1-5 of the pre-test and post-test.

		Total Sample (n)	All	LPMS: Paper Maps	NAMS: Paper Maps & Google Earth	NAMS: Paper Maps	NAMS: Google Earth
1	**Age**						
	13	111	53.15%	52.05%	43.75%	37.50%	43.33%
	14	111	45.95%	47.95%	54.17%	56.25%	56.67%
	15	111	0.90%	0.00%	2.08%	6.25%	0.00%
2	**Gender**						
	Male	112	39.29%	39.68%	38.78%	31.25%	39.39%
	Female	112	60.71%	60.32%	61.22%	68.75%	60.61%
3	**In the past five years, have you traveled outside the state of Oregon?**						
	Yes	105	94.29%	96.49%	91.67%	93.75%	90.63%
	No	105	5.71%	3.51%	8.33%	6.25%	9.38%
4	**In the past five years, approximately how many times have you traveled outside of the United States?**						
	None	111	41.44%	38.10%	45.83%	46.67%	45.45%
	One	111	14.41%	14.29%	14.58%	26.67%	9.09%
	Two	111	10.81%	11.11%	10.42%	6.67%	12.12%
	Three or More	111	33.33%	36.51%	29.17%	20.00%	33.33%
5	**How many languages can you speak fluently other than English?**						
	None	112	70.54%	61.90%	81.63%	81.25%	81.82%
	One	112	21.43%	28.57%	12.24%	18.75%	9.09%
	Two	112	5.36%	7.94%	2.04%	0.00%	3.03%
	Three or More	112	2.68%	1.59%	4.08%	0.00%	6.06%

All values expressed as a percent of the total number of student sampled

Table 4.2. Student lifestyle information provided by questions 6-14 of the pre-test and post-test.

		Total Sample (n)	All	LPMS: Paper Maps	NAMS: Paper Maps & Google Earth	NAMS: Paper Maps	NAMS: Google Earth
6	**How many hours a week do you use the Internet?**						
	1-4	89	41.57%	25.81%	42.86%	37.50%	45.45%
	5-8	89	17.98%	40.32%	26.53%	37.50%	21.21%
	9-12	89	23.60%	22.58%	14.29%	6.25%	18.18%
	More than 12	89	16.85%	11.29%	16.33%	18.75%	15.15%
	Never	89	0.00%	0.00%	0.00%	0.00%	0.00%
7	**How frequently do you look up information on the Internet as part of class or research assignments?**						
	Daily, or almost daily	110	23.64%	24.59%	22.92%	18.75%	25.00%
	2-3 times a week	110	31.82%	32.79%	31.25%	43.75%	25.00%
	Once a week	110	30.00%	29.51%	31.25%	31.25%	31.25%
	Once a month	110	13.64%	13.11%	14.58%	6.25%	18.75%
	Never	110	0.91%	0.00%	2.08%	0.00%	0.00%
8	**How often do you use maps? (Paper or electronic – such as phone, tablet, or computer)**						
	Daily, or almost daily	129	7.75%	7.50%	8.16%	6.25%	9.09%
	2-3 times a week	129	10.08%	8.75%	12.24%	6.25%	15.15%
	Once a week	129	24.81%	21.25%	30.61%	37.50%	27.27%
	Once a month	129	40.31%	45.00%	32.65%	31.25%	33.33%
	Never	129	17.05%	17.50%	16.33%	18.75%	15.15%
9	**Have you ever used Geographic Information System (GIS) software before?**						
	Yes	112	12.50%	14.29%	10.20%	6.25%	12.12%
	No	112	32.14%	23.81%	42.86%	31.25%	48.48%
	Unsure	112	55.36%	61.90%	46.94%	62.50%	39.39%
10	**Have you used Google Earth before?**						
	Yes	152	70.39%	98.41%	50.56%	100.00%	85.71%
	No	152	29.61%	1.59%	49.44%	0.00%	14.29%

All values expressed as a percent of the total number of student sampled

		Total Sample (n)	All	LPMS: Paper Maps	NAMS: Paper Maps & Google Earth	NAMS: Paper Maps	NAMS: Google Earth
11	**Why have you used Google Earth before?**						
	For a class assignment	112	37.50%	60.32%	8.16%	6.25%	9.09%
	To look up where something is	112	59.82%	84.13%	28.57%	6.25%	27.27%
	For personal use	112	65.18%	69.84%	59.18%	6.25%	57.58%
	I don't use Google Earth	112	2.68%	1.59%	4.08%	6.25%	6.06%
12	**How often do you use Google Earth?**						
	Daily, or almost daily	113	0.88%	0.00%	2.00%	0.00%	3.03%
	2-3 times a week	113	3.54%	4.76%	2.00%	0.00%	3.03%
	Once a week	113	8.85%	7.94%	10.00%	6.25%	12.12%
	Once a month	113	69.91%	80.95%	56.00%	68.75%	51.52%
	Never	113	16.81%	6.35%	30.00%	25.00%	30.30%
13	**How many hours a week do you play videogames?**						
	1-4	112	33.04%	30.16%	36.73%	18.75%	45.45%
	5-8	112	18.75%	25.40%	10.20%	6.25%	12.12%
	9-12	112	6.25%	4.76%	8.16%	6.25%	9.09%
	More than 12	112	8.93%	7.94%	10.20%	12.50%	9.09%
	Never	112	33.04%	31.75%	34.69%	56.25%	24.24%
14	**Compared to other students, how would you rate your ability to make the computer to do what you want it to do?**						
	Much lower than average	110	3.64%	3.17%	4.26%	6.25%	3.23%
	Lower than average	110	7.27%	7.94%	6.38%	0.00%	9.68%
	Average	110	49.09%	55.56%	40.43%	50.00%	35.48%
	Better than average	110	30.91%	23.81%	40.43%	37.50%	41.94%
	Much better than average	110	9.09%	9.52%	8.51%	6.25%	9.68%

All values expressed as a percent of the total number of student sampled

Table 4.3. Student responses to pre-test and post-test questions 15 and 16.

	Total Sample (n)	All	LPMS: Paper Maps	NAMS: Paper Maps & Google Earth	NAMS: Paper Maps	NAMS: Google Earth
Question 15 Reults: Describe a glacier (This might include characteristics, features, or where they could be found).						
Pre-Test Score						
0	64	3.13%	1.59%	2.22%	6.25%	0.00%
1	64	43.75%	19.05%	35.56%	31.25%	37.93%
2	64	25.00%	57.14%	53.33%	43.75%	58.62%
3	64	28.13%	22.22%	8.89%	18.75%	3.45%
Post-Test Score						
0	101	0.00%	0.00%	0.00%	0.00%	0.00%
1	101	18.81%	24.59%	10.00%	7.14%	11.54%
2	101	58.42%	54.10%	65.00%	42.86%	76.92%
3	101	22.77%	21.31%	25.00%	50.00%	11.54%
Question 16 Results: Glaciers are important because…						
Pre-Test Score						
0	108	24.07%	22.22%	26.67%	31.25%	24.14%
1	108	50.93%	49.21%	53.33%	43.75%	58.62%
2	108	20.37%	25.40%	13.33%	12.50%	13.79%
3	108	4.63%	3.17%	6.67%	12.50%	3.45%
Post-Test Score						
0	100	2.00%	1.67%	2.50%	7.14%	0.00%
1	100	33.00%	36.67%	27.50%	35.71%	23.08%
2	100	47.00%	38.33%	60.00%	42.86%	69.23%
3	100	18.00%	23.33%	10.00%	14.29%	7.69%

All values expressed as a percent of the total number of student sampled

Table 4.4. Pre-test and post-test question 15 *t*-test values.

	x_1	x_2	s_1	s_2	n_1	n_2	t-Value	df	p-Value	Significance
All Paper Maps and Google Earth	1.80	2.04	0.69	0.65	108	101	2.59	206.98	1.66	Yes
All Paper Maps (LPMS and NAMS)	1.95	2.05	0.70	0.70	78	81	0.90	156.65	1.66	No
LPMS Paper Maps	2	1.96	0.7	0.68	63	61	0.32	121.97	1.66	No
NAMS Paper Maps	1.75	2.42	0.74	0.57	15	20	2.91	25.46	2.06	Yes
NAMS Google Earth	1.65	2	0.55	0.56	29	20	2.16	40.56	2.02	Yes

$_1$ denotes Pre-Test Question 15, $_2$ denotes Post-Test Question 15

Table 4.5. Pre-test and post-test question 16 *t*-test values.

	x_1	x_2	s_1	s_2	n_1	n_2	*t*-Value	df'	*p*-Value	Significance
All Paper Maps and Google Earth	1.06	1.81	0.80	0.75	108	101	1.00	206.98	1.66	No
All Paper Maps (LPMS and NAMS)	1.09	1.80	0.82	0.81	78	81	4.97	156.69	1.66	Yes
LPMS Paper Maps	1.09	1.83	0.78	0.80	63	61	4.64	121.77	1.66	Yes
NAMS Paper Maps	1.06	1.64	0.99	0.79	15	20	1.79	28.26	1.70	Yes
NAMS Google Earth	0.97	1.84	0.73	0.52	29	20	3.84	44.95	1.68	Yes

$_1$ denotes Pre-Test Question 16, $_2$ denotes Post-Test Question 16

Table 4.6. Student worksheet scores *t*-test values.

	x_1	x_2	s_1	s_2	n_1	n_2	*t*-Value	df'	*p*-Value	Significance
All Paper Maps$_1$, All Google Earth$_2$	74.30	70.34	14.05	10.39	45	11	1.05	20.01	1.73	No
NAMS Paper Maps$_1$, NAMS Google Earth$_2$	70.60	70.34	13.73	10.39	11	11	0.05	18.63	1.73	No
LPMS Paper Maps$_1$, NAMS Paper Maps$_2$	75.5	70.6	16.51	13.73	34	11	1.14	11.49	1.8	No

Table 4.7. Significance of student pre-test and post-test scores, sorted by their response to question *6: How many hours a week do you use the Internet?*

Question 6 Response	x_1	x_2	s_1	s_2	n_1	n_2	*t-Value*	df	*p-Value*	Significance
1-4 hours/week	1.83	1.97	0.63	0.63	37	37	0.91	72.00	2.00	No
5-8 hours/week	2.03	2.16	2.86	2.86	38	38	0.19	74.00	2.00	No
9-12 hours/week	1.81	1.90	0.64	0.64	21	21	0.46	40.00	2.02	No
>12 hours/week	1.62	19.50	0.72	0.72	15	15	68.24	28.00	2.05	Yes
Never	0.00	0.00	0.00	0.00	0	0	0.00	0.00	0	No

Question 16 Results: Glaciers are important because…

Question 6 Response	x_1	x_2	s_1	s_2	n_1	n_2	*t-Value*	df	*p-Value*	Significance
1-4 hours/week	0.97	1.59	0.73	0.73	37	37	3.60	72.00	2.00	Yes
5-8 hours/week	1.14	2.03	0.50	0.50	38	38	7.68	74.00	2.00	Yes
9-12 hours/week	1.14	1.95	0.69	0.69	21	21	3.81	40.00	2.02	Yes
>12 hours/week	0.77	13.42	0.79	0.79	15	15	43.68	28.00	2.05	Yes
Never	0.00	0.00	0.00	0.00	0	0	0.00	0.00	0	No

$_1$ denotes Pre-Test resposne, $_2$ denotes Post-Test response

Table 4.8. Significance of student pre-test and post-test scores, sorted by their response to question 8: *How often do you use maps?*

Question 8 Response	x_1	x_2	s_1	s_2	n_1	n_2	*t*-Value	df	*p*-Value	Significance
Daily	1.80	1.88	0.42	0.64	10	10	0.31	15.56	1.75	No
2-3 times/week	2.09	2.18	0.54	0.60	11	11	0.37	19.76	1.73	No
1 time/week	1.97	2.14	0.71	0.64	31	31	0.99	59.42	2.02	No
Monthly	1.86	1.92	0.72	0.66	43	43	0.44	83.50	1.99	No
Never	1.58	1.92	0.90	0.67	13	13	1.07	22.15	1.71	No

Question 16 Results: Glaciers are important because…

Question 8 Response	x_1	x_2	s_1	s_2	n_1	n_2	*t*-Value	df	*p*-Value	Significance
Daily	1.10	1.38	0.57	0.52	10	10	1.13	17.85	1.74	No
2-3 times/week	1.27	1.91	0.90	0.83	11	11	1.72	19.86	1.73	No
1 time/week	0.97	2.05	0.95	0.65	31	31	5.21	53.23	2.02	Yes
Monthly	1.02	1.77	0.72	0.67	43	43	5.00	83.60	1.99	Yes
Never	1.17	1.75	0.83	1.06	13	13	1.56	22.79	2.08	No

$_1$ denotes Pre-Test resposne, $_2$ denotes Post-Test response

Table 4.9. Significance of student pre-test and post-test scores, sorted by their response to question 10: *Have you used Google Earth before?*

Question 10 Response	x_1	x_2	s_1	s_2	n_1	n_2	t-Value	df'	p-Value	Significance
Yes	1.89	2.00	0.70	0.66	10	10	0.35	211.07	166.00	No
No	1.50	2.00	0.58	0.00	11	11	2.87	4.00	2.13	Yes

Question 16 Results: Glaciers are important because…

Question 10 Response	x_1	x_2	s_1	s_2	n_1	n_2	t-Value	df'	p-Value	Significance
Yes	1.06	1.84	0.81	0.74	10	10	2.27	17.86	1.74	Yes
No	1.00	1.25	0.82	0.50	11	11	0.87	16.58	1.74	No

$_1$ denotes Pre-Test resposne, $_2$ denotes Post-Test response

Table 4.10. Significance of student worksheet scores, based off of their response to question 10: *Have you used Google Earth before?*

x_1	x_2	s_1	s_2	n_1	n_2	t-Value	df'	p-Value	Significance
24.58	23.50	4.45	0.71	107	5	2.03	28.76	1.70	Yes

5. DISCUSSION AND CONCLUSION

Data gathered from this study suggest that Google Earth and paper maps are both successful means of conveying the same data; there was no significant difference between the worksheet scores among the Google Earth and paper maps classes. This is consistent with previous research which has stated that paper maps are of use in areas without access to geospatial technologies because, with proper implementation, the same results can be yielded from two different implementations of the same lesson (Breetzke et al., 2011). Due to the outcomes of this research, it is apparent that both Google Earth and paper map activities can better help 8th grade middle school instructors meet the Oregon State standards for earth science and national geography standards set forth by National Geographic.

Though not every participant submitted a completed pre-test, worksheet, and post-test, all of the data provided was utilized in this study for analysis (Appendix 8). There was an overall significant difference among students' pre-test and post-test scores. When the pre-test and post-test data was broken down by school, the significant difference was found at North Albany Middle School, not Linus Pauling Middle School. This could be attributed to various factors, such as previous material covered earlier in the school year or the difference in teaching styles between the two teachers. Looking at the pre-test and post-test, there was no strong correlation among Internet use, map use, or previous use of Google Earth. This implies that despite the diverse backgrounds of the student participants, there was no discernable difference in the learning outcomes of the Bering Glacier lesson presented to them.

5.1 Reflection

While both paper maps and Google Earth are effective means of communication when trying to convey the geographic and earth science concepts presented with this lesson, there were advantages and disadvantages to both the Google Earth and the paper maps lessons. There are also weaknesses within the lesson itself that should also addressed.

5.1.1 Reflection: Google Earth Lesson

While Google Earth has many advantages and is promising as a tool in education, there were disadvantages when used with the particular Bering Glacier lesson chosen for this study. In order to open the KMZ files on Google Earth, technology filters must be limited on the computers in order for the files to load properly. If there are high technology filters in place, the KMZ files will not load properly and this may be problematic. This situation occurred at Linus Pauling Middle School but not at North Albany Middle School. Even without filters, the data can take a substantial amount of time to load properly

With Google Earth loaded properly and the directions explicitly stated in the worksheet instructions, many students still had difficulty navigating between the layers that represented the false color and natural color Landsat images overlay on the Google Earth display. Some students also had some trouble using the ruler tool in order to measure on Google Earth. Once students were acquainted with the KMZ files and the worksheet, Google Earth allowed for students to easily switch back and forth between the different Landsat images provided in the KMZ file.

5.1.2 Reflection: Paper Maps Lesson

Paper maps have been used in schools for a long time though Landsat images, such as those used in the Bering Glacier lesson, have only been available online a bit longer than Google Earth itself. The paper maps lesson had some disadvantages when used in the particular Bering Glacier lesson chosen for this study. When printed as a hard copy the paper map images appeared over-saturated, making the images more difficult to see than on the computer screens with Google Earth. Due to the over-saturation, measurements had to be made on tracing paper (not the images included in the packet itself) in order to see what was being measured. This then made it difficult for students to ensure they were starting from the same start point on the Bering Glacier with every image. It was also more difficult to compare among the images on the paper maps, having to physically flip the pages instead of turning layers on and off.

It should be noted that there were advantages to the paper maps as well. Students appeared to feel more comfortable using a ruler and colored pencils when making measurements than those who used the measure tool on Google Earth, most likely because these were tools they have been familiar with for years. With the proper materials, the paper maps were assured to work unlike the KMZ file with Google Earth.

5.1.3 Reflection: The Bering Glacier Lesson Overall

The average scores on the Bering Glacier were between 60% and 90% for the Google Earth and paper map students. For the images, the terminus could have been made more obvious, perhaps with an example, and the simple differences between natural and false color imagery should be briefly described. While some of the students had prior knowledge of the concept of false color imagery, it would have been helpful to have an explanation of what false color imagery provides specifically for the Bering Glacier with an abundance of water in snow, ice, cloud, and ocean forms – where each appears as a different shade of blue or purple.

Regarding the questions provided in the Bering Glacier lesson, the comparison questions between the false color and natural color images were repetitive (occurring four times within the lesson). These questions could have been more straightforward and specific to that year's images. An example question could be: What appears in the 1996 false color image that did not appear in the 1996 natural color image? The lesson itself was very structured and highly controlled. While a longer lesson would have allowed for more variation among students, it would have been more difficult to interpret the particular images. This also would have allowed for step-by-step connections to be made to other glaciers beyond the Bering Glacier. For the purposes of this study, the lesson provided everything that was necessary to compare paper maps and Google Earth to one another.

5.2 Further Research

Focusing on middle-school earth science classrooms in this study allowed for spatial information to be conveyed in new ways and for the identification of strengths and weaknesses, such as limited spatial comprehension, in geography, (and related subjects) curriculums. Research following this study could include building upon this Bering Glacier lesson and working with a larger sample for longer than two days, in order to build an entire unit (as opposed to a single lesson). The pre- and post-tests could then be elaborated on in order to better gauge the students' learning. In other research, a lesson other than this Bering Glacier lesson could be utilized as well. Starting with a paper map lesson that is then adapted for Google Earth could help focus on geographic visualization beyond what Google Earth provides.

5.3 Conclusion

Along with the introduction of geospatial technologies, such as Google Earth, in the classroom came research that investigated the significance of these tools. Both geography and earth science are visually-dependent subjects in academia, leading to research on the use of these technologies in the classroom in recent years (McClurg & Buss, 2007). With properly trained teachers, GIS in the classroom has allowed for an increase in spatial literacy in classrooms (Huang, 2011). Even in instances where computer-based GIS wasn't available, paper-based GIS was used in order to help convey spatial concepts that are intimately tied to geography (Breetzke et al., 2011). This study went a step further than previous research by comparing the computer-based GIS program, Google Earth, to the paper maps with both qualifying and quantifying analysis.

Data gathered in this study provides insight into Google Earth's effectiveness in the classroom. Although a rather small study, it illustrates how paper maps and Google Earth appear to be equally as effective. This research also illustrates how inquiry-based learning has the potential to enhance spatial literacy and illuminate trends that may have previously been unnoticed, such as changes along the Bering Glacier (Demirci, 2011; Perkins et al., 2010; Ratinen & Keinonen, 2011). As GIS becomes more prominent in academic classrooms at all levels, the subject of geography can be approached in new ways. The utilization of Google Earth in this research is one such example.

With the data collection and analysis completed, connections can be drawn beyond the middle school classroom by applying the findings to different levels of education while taking into account some significant factors of geography learning: varying learning styles, cartographic influences, and the effects of visual aids on learning. The final determining factors are the teachers' familiarity with using programs such as Google Earth, the objectives of the planned lesson, anticipated outcomes and available resources. Google Earth provides an alternative and, at times, more interesting means of introducing geographic concepts to students of all ages.

REFERENCES

2011-12 Achievement Standards Summary. (2011). *Oregon Department of Education*. Retrieved May 30, 2013, from http://www.ode.state.or.us/teachlearn/real/documents achievementstandards.pdf.

Academic Content Standards: Creating Consistency Across Oregon. (2010). *Oregon Department of Education*, (December). Retrieved from http://www.ode.state.or.us/pubs/eii/academiccontentstandardsprimer.pdf.

Allen, T. R. (2007). Digital Terrain Visualization and Virtual Globes for Teaching Geomorphology. *Journal of Geography*, *106* (6), 253–266.

Bednarz, S. W., Bettis, N. C., Boehm, R. G., DeSouza, A. R., Downs, R. M., Marran, J. F., Morril, R. W., et al. (1994). *Geography for Life: National Geography Standards 1994*. Washington D.C.: National Geographic Research and Exploration.

Blank, L. M., Plautz, M., Almquist, H., Crews, J., & Estrada, J. (2012). Using Google Earth to Teach Plate Tectonics and Science Explanations. *Science Scope*, *35* (9), 41–49.

Boehm, R. G., & Rutherford, D. J. (2004). Implementation of National Geography Standards in the Social Studies: A Ten-Year Retrospective. *The Social Studies*, *95* (6), 228–230.

Breetzke, G., Eksteen, S., & Pretorius, E. (2011). Paper-Based GIS : A Practical Answer to the Implementation of GIS Education into Resource-Poor Schools in South Africa. *Journal of Geography 110* (4), 148–157.

Demirci, A. (2011). Using Geographic Information Systems (GIS) at Schools Without a Computer Laboratory. *Journal of Geography*, *110* (2), 49–59.

Dodsworth, E., & Nicholson, A. (2012). Academic Uses of Google Earth and Google Maps in a Library Setting. *Information and Technology Libraries*, *31* (2).

Doering, A., & Veletsianos, G. (2007). An Investigation of the Use of Real-Time , Authentic Geospatial Data in the K – 12 Classroom. *Journal of Geography*, *106* (6), 217–225.

Edelson, D. C., Smith, D. A., & Brown, M. (2008). Beyond Interactive Mapping: Bringing Data Analysis with GIS into the Social Studies Classroom. In A. J. Milson & M. Alibrandi (Eds.), *Digital Geography: Geospatial Technologies in the Social Studies Classroom*. Charlotte, North Carolina: Information Age Publishing Inc.

Forsaith, D. M. (1964). *Handbook for Geography Teachers*. (M. Long, Ed.) (Fifth edition). London, England: University of London Institute of Education.

Green, D. R., & Mouatt, J. (2008). The Digital Globe: Using Google Earth for Virtual Fieldings in Coastal Environments. In A. J. Milson & M. Alibrandi (Eds.), *Digital Geography: Geospatial Technologies in the Social Studies Classroom*. Charlotte, North Carolina: Information Age Publishing Inc.

Guertin, B. L., Stubbs, C., Millet, C., Lee, T., & Bodek, M. (2012). Enhancing Geographic and Digital Literacy With a Student-Generated Course Portfolio in Google Earth. *Journal of College Science Teaching*, *42* (2).

Heffron, S. G. (2012). GFL2! The Updated Geography for Life: National Geography Standards, Second Edition. *The Geography Teacher*, *9* (2).

Huang, K. H. (2011). A GIS-Interface Web Site : Exploratory Learning for Geography. *Journal of Geography 110* (4), 158–165.

Kerski, J. (2008). The World at the Student's Fingertips: Internet-Based GIS Education Opportunities. In A. J. Milson & M. Alibrandi (Eds.), *Digital Geography: Geospatial Technologies in the Social Studies Classroom*. Charlotte, North Carolina: Information Age Publishing Inc.

Kulo, V. A., & Bodzin, A. M. (2011). Integrating Geospatial Technologies in an Energy Unit. *Journal of Geography*, *110* (6), 239–251.

Lewis, A. C. (1994). Goals 2000. *Education Digest*, *60* (1).

Linus Pauling Middle School. (2013). *The Oregonian Schools Guide*. Retrieved May 3, 2013, from http://schools.oregonlive.com/school/Corvallis/Linus-Pauling-Middle-School/.

Liu, S., & Zhu, X. (2008). Designing a Structured and Interactive Learning Environment Based on GIS for Secondary Geography Education. *Journal of Geography*, *107* (1), 12–19.

McClurg, P. A., & Buss, A. (2007). Professional Development: Teachers Use of GIS to Enhance Student Learning. *Journal of Geography*, *106* (2), 79–87.

Monmonier, M. (1996). *How to Lie With Maps* (Second edition). Chicago, Illinois: The University of Chicago Press.

Nelson, P. (2012). Education using Landsat Time-Series. Retrieved May 20, 2013, from http://people.oregonstate.edu/~nelsonpe/education.html.

North Albany Middle School. (2013). *The Oregonian Schools Guide*. Retrieved May 3, 2013, from http://schools.oregonlive.com/school/Greater-Albany-Public/North-Albany-Middle-School/.

Patterson, T. C. (2007). Google Earth as a (Not Just) Geography Education Tool. *Journal of Geography*, *106* (4), 37–41.

Perkins, N., Hazelton, E., Erickson, J., & Allan, W. (2010). Place-Based Education and Geographic Information Systems: Enhancing the Spatial Awareness of Middle School Students in Maine. *Journal of Geography*, *109* (5), 213–218.

Ratinen, I., & Keinonen, T. (2011). Student-teachers' use of Google Earth in problem-based geology learning. *International Research in Geographical & Environmental Education*, *20* (4), 345–358.

Sauro, J., & Lewis, J. R. (2012). *Quantifying the User Experience: Practical Research for User Statistics*. Waltham, Massachusetts: Morgan Kauffman.

Songer, L. C. (2007). *Comparative Impacts of Web-Based GIS on Student Content Knowledge, Geography Skills, and Self-Efficacy in Introductory Human Geography*. University of Oregon.

Standards for Design: Eighth Grade for Science. (2012). *Oregon Department of Education*. Retrieved May 2, 2013, from http://www.ode.state.or.us/teachlearn/real/standards/sbd.aspx.

Tangborn, W. (2012). Mass balance, runoff and surges of the Bering Glacier, Alaska. *The Cryosphere Discussions*, *6* (6), 5095–5117.

Tufte, E. (1983). *The Visual Display of Quantitative Information*. Cheshire, Connecticut: Graphics Press.

Tufte, E. (1997). *Visual Explanations*. Cheshire, Connecticut: Graphics Press.

Tufte, E. (2003). *The Cognitive Style of PowerPoint*. Cheshire, Connecticut: Graphics Press.

Yu, J., Huynh, N. T., & Mcgehee, T. L. (2011). Vertical Integration of Geographic Information Sciences: A Recruitment Model for GIS Education. *Journal of Geography*, *110* (5), 191–199.

APPENDICES

Appendix 1. Letter of consent/assent for Linus Pauling Middle School.

OSU Oregon State University

College of Earth, Ocean, and Atmospheric Sciences

CONSENT/ASSENT FORM

Project Title:	**Comparative Analysis of Google Earth Versus Traditional Methods in Middle School Education**
Principal Investigator:	**Laurence Becker**
Student Researcher:	**Jillian Edstrom**
Version Date:	**02/25/2013**

Dear Students and Guardians of Linus Pauling Earth Science students,

This letter contains information to help you or your student decide to be in a research study about Google Earth in education. Student participation in this study is voluntary. Please read the form carefully and feel free to ask the researcher Jillian Edstrom, Ms. Rumage, or Ms. Allen any questions you may have.

The purpose of this study is to fulfill the research paper requirements for a geography master's degree at Oregon State University for the researcher, Jillian. The research paper is about comparing Google Earth versus paper maps in 8th grade classrooms. This study will take place in all Linus Pauling earth science classrooms and all students are invited to participate. Up to 260 students will be invited to take part in this study.

If the Linus Pauling student chooses to participate, there will be a pre-test and a post-test about their background with maps and Google Earth. Then there will be a three day lesson about glaciers with Ms. Rumage and Ms. Allen. At the end of the lesson, there will be a follow-up test like the pre-test.

Jillian will take notes during the lesson and there will be no photos or video taken during the study. The risks in this study are minimal, though there is a risk that we could accidentally disclose the information that identifies your child. To avoid this, the information that you or your child provide during this study will be kept private to the extent permitted by law. Research records will be stored securely and only researchers will be able to see the records. Federal regulatory agencies and the Oregon State University Institutional Review Board (also known as "IRB", a group that reviews and approves research studies) may look at and copy records about this research. Some of these records could have information that describes the student participant but to help keep privacy, all data will be treated in a confidential manner.

There are potentially many potential benefits to this study, including whether students learn better with Google Earth or paper maps. It should be noted though that this study is not designed to directly benefit you or your child and that there will not be financial reimbursement for participating.

Oregon State University	IRB Study # 5616	Expiration Date 2/24/2013

College of Oceanic & Atmospheric Sciences

Linus Pauling earth science students do not have to participate in this study. If the student chooses not to participate, the same glacier lesson will be completed but the assignment will not be collected and there will be no pre-test or post-test. In the pre-test and post-test the student is encouraged to answer all of the questions.

If you have any questions the project or would like to view the final research paper, please feel free to call Jillian at or email her at If you have questions about your child's rights or welfare as a participant, please contact the Oregon State IRB Office, at or by email at

Your signature indicates that this study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Thank you!
Jillian Edstrom

Do not sign after the expiration date: 2/24/2014

____
Student Participant's Name (printed)

____
Signature of Student Participant Date

____
Guardian's Name (printed)

____
Signature of Guardian Date

Oregon State University	IRB Study # 5616	Expiration Date 2/24/2014

Appendix 2. Letter of consent/assent for North Albany Middle School.

OSU Oregon State University

College of Earth, Ocean, and Atmospheric Sciences

CONSENT/ASSENT FORM

Project Title:	**Comparative Analysis of Google Earth Versus Traditional Methods in Middle School Education**
Principal Investigator:	**Laurence Becker**
Student Researcher:	**Jillian Edstrom**
Version Date:	**03/11/2013**

Dear Students and Guardians of North Albany Middle School Earth Science students,

This letter contains information to help you or your student decide to be in a research study about Google Earth in education. Student participation in this study is voluntary. Please read the form carefully and feel free to ask the researcher Jillian Edstrom or Mrs. Kelly any questions you may have.

The purpose of this study is to fulfill the research paper requirements for a geography master's degree at Oregon State University for the researcher, Jillian. The research paper is about comparing Google Earth versus paper maps in 8th grade classrooms. This study will take place in all North Albany earth science classrooms and all students are invited to participate. Up to 175 students will be invited to take part in this study.

If the North Albany student chooses to participate, there will be a pre-test and a post-test about their background with maps and Google Earth. Then there will be a three day lesson about glaciers with Mrs. Kelly. At the end of the lesson, there will be a follow-up test like the pre-test.

Jillian will take notes recorded during the lesson and there will be no photos or video taken during the study. The risks in this study are minimal, though there is a risk that we could accidentally disclose the information that identifies you or our child. To avoid this, the information that you or your child provide during this study will be kept private to the extent permitted by law. Research records will be stored securely and only researchers will be able to see the records. Federal regulatory agencies and the Oregon State University Institutional Review Board (also known as "IRB", a group that reviews and approves research studies) may look at and copy records about this research. Some of these records could have information that describes the student participant but to help keep privacy, all data will be treated in a confidential manner.

There are potentially many potential benefits to this study, including whether students learn better with Google Earth or paper maps. It should be noted though that this study is not designed to directly benefit you or your child and that there will not be financial reimbursement for participating.

Oregon State University	IRB Study # 5616	Expiration Date 2/24/2014

OSU
Oregon State University

College of Oceanic & Atmospheric Sciences

North Albany earth science students do not have to participate in this study. If the student chooses not to participate, the same glacier lesson will be completed but the assignment will not be collected and there will be no pre-test or post-test. In the pre-test and post-test the student is encouraged to answer all of the questions.

If you have any questions the project or would like to view the final research paper, please feel free to call Jillian at or email her at If you have questions about your child's rights or welfare as a participant, please contact the Oregon State IRB Office, at or by email at

Your signature indicates that this study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Thank you!
Jillian Edstrom

Do not sign after the expiration date: 2/24/2014

____
Student Participant's Name (printed)

____
Signature of Student Participant Date

____
Guardian's Name (printed)

____
Signature of Guardian Date

Oregon State University	IRB Study # 5616	Expiration Date 2/24/2014

Appendix 3. Original Bering Glacier lesson plan, created by Peder Nelson and Joan Swafford.

BERING GLACIER WORKSHEET

Prior to receiving the worksheet, students should have a fair understanding of natural color and false color in satellite images. You will be looking at both in this data set.

1. Obtain a flash drive with the Bering Glacier data, and copy the files from the flash drive.
2. Double click the Bering Glacier KMZ file.
3. The file will automatically load the data into Google Earth for you.
4. When the "tip of the day" shows on the screen, push "close".
5. The computer will take a few minutes to load all the satellite images within the data set, *there will be some cool quick pictures*.
6. Notice in the bottom right corner of the screen, the eye altitude,

Record the eye altitude when you first opened the data?_________________

7. Now click on the "+" to make the image closer. Bring the image between 50-60 miles, eye altitude.
8. On the left of the screen you see the Bering glacier data.
9. Click on the box next to the words "Bering Glacier", this will close all the data.
10. Soon you will look at each year's image individually to mark the terminus of the glacier.
11. Click on the first data file - 2010 data 254 natcolor. This is the natural color image that the satellite took in 2010. *(Julian dates are used for most satellite images. This is the day of the year, out of 365).*

What is the date of the image, the month and day?_________________________

12. Click on the other 2010 data image, this is the false color. We used the program from OSU that takes the infrared information which we can not see with our eyes and gives the images false color.

What are the differences between the two 2010 images?

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13. Put a place mark where the glacier starts, the ice field. (Choose yellow and mark it as "Start") This point will be the start of each year's length measurement.
14. Draw a line the entire length of the glacier. (Choose yellow and mark it as 2010 length)
15. Record the length of the glacier in 2010 ____________________________
(As you go to other dates and draw lines, you will follow the 2010 line as best as you can.)
16. Draw a line at the terminus edge of the glacier. (Choose yellow)

NOW you will be looking at the data from a different year, data from 2006. You will be making comparisons between the years.

17. Click on the 2006 data 259 natcolor. This is the natural color image that the satellite took in 2006. (You will now proceed and collect the same data as you collected for the 2010 images.)

What is the date of the image?________________________

18. Click on the other 2006 data image, this is the false color.

What are the differences between the two 2006 images?

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19. Draw a line the entire length of the glacier, follow the 2010 line as best as you can. (Choose green and mark it as 2006 length)
20. Record the length of the glacier in 2006 ___________________________
21. Draw a line at the terminus edge of the glacier. (Choose green)

Explain how the lengths compare between the 2 years.

____
____
____

NOW you will be looking at the data from a different year, data from 1996. You will be making comparisons between the years.

22. Click on the 1996 data 248 natcolor. This is the natural color image that the satellite took in 1996

What is the date of the image?________________________

23. Click on the other 1996 data image, this is the false color.

What are the differences between the two 1996 images?

____
____
____

24. Draw a line the entire length of the glacier, follow the 2010 line as best as you can. (Choose violet and mark it as 1996 length)
25. Record the length of the glacier in 1996 ___________________________
26. Draw a line at the terminus edge of the glacier. (Choose violet)

NOW you will be looking at the data from a different year, data from 1986. You will be making comparisons between the years.

27. Click on the 1986 data 268 natcolor. This is the natural color image that the satellite took in 1986.

What is the date of the image?________________________

28. Click on the other 1986 data image, this is the false color.

What are the differences between the two 1986 images?

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29. Draw a line the entire length of the glacier; follow the 2010 line as best as you can. (Choose white and mark it as 1986 length)
30. Record the length of the glacier in 1986 __________________________
31. Draw a line at the terminus edge of the glacier. (Choose white)

ANALYSIS: You have looked at the data for the 4 years. Now you will compare and analyze the data. *(Teacher may choose additional questions adapedt to particular class focus.)*

Compare the lines. Which is the longest?

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During which year did the glacier appear to be the longest? *This is often called a glacial surge.*

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What could be some possible explanations for the glacial surge?

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____
____

Explore the area near the glacier. Can you find any other evidence of change between the years? *Look at the bodies of water. Look at any other habitat features in the area.*

____

IS the Bering Glacier growing or shrinking? Give evidence for your answer.

What climate conditions encourage glacier growth and glacier retreat?

What might account for glacier retreat today?

As glaciers get smaller, how might this affect the Earth?

Appendix 4. Google Earth Bering Glacier lesson, modified slightly from the original lesson provided.

Name: ___________________________
Period: ___________________________
Teacher: ___________________________

GOOGLE EARTH: BERING GLACIER WORKSHEET

Prior to receiving this worksheet, you should have a general understanding of natural color and false color in satellite images. At the beginning of the school year, you were introduced to Google Earth and Landsat satellite images. In this activity, you will use Google Earth and Landsat images to determine changes in the length of the Bering Glacier in Alaska and to draw inferences from these changes.

1. To begin this exercise, please obtain the Bering Glacier data from your teacher and make the files accessible on your computer.
2. Double click the Bering Glacier KMZ file.
3. The file will automatically load the data into Google Earth for you.
4. When the "tip of the day" shows on the screen, push "close."
5. The computer will take a few minutes to load all the satellite images within the data set. *Note: There will be some cool quick pictures.*
6. In the bottom right corner of the screen, please find the "eye altitude." This is the altitude at which the image appears to have been taken from space.

Record the eye altitude when you first opened the data:___________________________

7. Now click on the "+" to enlarge the image. Bring the image to between 50-60 miles, eye altitude.
8. On the left of the screen you see the Bering Glacier data.
9. Click on the box next to the words "Bering Glacier." This will close all the data. Next you will look at each year's image individually to mark the end of the glacier.
10. Click on the first data file: 2010 data 254 natcolor. This is the natural color image that the satellite took in 2010. This is the numbering system for most satellite images, meaning that this image was taken on the 254th day of the year. *(Hint: September 1st is the 244th day of the year)*

What is the date of the image, the month and day?________________________________

11. Click on the other 2010 data image; this is the false color. We used the program from OSU that takes the infrared information, which we cannot see with our eyes, and gives the image false color.

What are the differences between the two 2010 images?

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12. You will now measure the length of the glacier. Put a place mark where the glacier ice starts. (Choose red and mark it as "Start") This point will be the start of each year's length measurement.
13. Find the furthest extent of the ice (also known as the "terminus edge") and measure the distance from the start point in the ice field across the entire length of the glacier. (Choose red and mark it as 2010 length)
14. Record the length of the glacier in 2010:_______________________________

    Note: Please record the length in meters. These are the units you will be using for the remainder of the exercise.

    (As you go to other dates and draw lines, you will follow the 2010 line as best as you can.)
15. Draw a line at the terminus edge of the glacier. (Choose red)

Now you will be looking at the data from 2006. You will be making comparisons between the years.

16. Click on the 2006 data 259 natcolor. This is the natural color image that the satellite took in 2006. You will now proceed to collect the same data as you collected for the 2010 images.

What is the date of the image?_______________________________________

17. Click on the other 2006 data image; this is false color.

What are the differences between the two 2006 images?

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18. Draw a line the entire length of the glacier; follow the 2010 line as closely as possible. (Choose yellow and mark it as 2006 length)
19. Record the length of the glacier in 2006: _______________________________
20. Draw a line at the terminus edge of the glacier. (Choose yellow)

Compare lengths of the glacier for the 2 years. How are they similar and how are they different from one another?

____

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Now you will be comparing the 2010 data with an image taken in 1996. You will be making comparisons between the years.

21. Click on the 1996 data 248 natcolor. This is the natural color image that the satellite took in 1996.
    What is the date of the image?________________________________

22. Click on the other 1996 data image; this is the false color.

What are the differences between the two 1996 images?

____
____
____
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23. Draw a line the entire length of the glacier; follow the 2010 line as closely as possible. (Choose green and mark it as 1996 length)
24. Record the length of the glacier in 1996: __________________________
25. Draw a line at the terminus edge of the glacier. (Choose green)

Now you will be looking at the data from a fourth year, data from 1986. You will be making comparisons between the years.

26. Click on the 1986 data 268 natcolor. This is the natural color image that the satellite took in 1986.

What is the date of the image?____________________________________

27. Click on the other 1986 data image; this is the false color.

What are the differences between the two 1986 images?

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28. Draw a line the entire length of the glacier; follow the 2010 line as closely as possible. (Choose blue and mark it as 1986 length)
29. Record the length of the glacier in 1986:__________________________
30. Draw a line at the terminus edge of the glacier. (Choose blue)

ANALYSIS: You have looked at the data for the 4 years. Now you will compare and analyze the data.

Compare the lines. Which is the longest?

During which year did the glacier appear to be the longest? *Note: This is often called a glacial surge.*

What could be some possible explanations for the glacial surge?

Explore the area near the glacier. Can you find any other evidence of change between the years? *Look at the bodies of water. Look at any other habitat features in the area.*

During the years covered by the images, is the Bering Glacier growing or shrinking? Give evidence for your answer.

What climate conditions encourage glacier growth and glacier retreat?

What might account for glacier retreat today?

As glaciers get smaller, how might this affect the rest of Earth?

Appendix 5. Paper maps Bering Glacier lesson, modified significantly from the original lesson provided.

Name: __________________________
Period: __________________________
Teacher: __________________________

PAPER MAP: BERING GLACIER WORKSHEET

Prior to receiving this worksheet, you should have a general understanding of natural color and false color in satellite images. At the beginning of the school year, you were introduced to Landsat satellite images. In this activity, you will use Landsat images to determine changes in the length of the Bering Glacier in Alaska and to draw inferences from these changes.

For this activity you will need four colored pencils (red, yellow, green, and blue), a ruler, and a packet titled "Bering Glacier Landsat Images."

1. Notice in the bottom left corner of the Bering Glacier image on page 1 the eye altitude of the image. This is the altitude at which the image appears to have been taken from space.

Record the eye altitude of this image:____

2. Now look at Landsat images of the Bering Glacier on pages 2-9. Here you will be able to see the terminus of the glacier.
3. Look at the image titled "2010 Data: 254 (Natural Color)" on page 2. This is the natural color image that the satellite took in 2010. This is the numbering system for most satellite images, meaning that this image was taken on the 254th day of the year. *(Hint: September 1st is the 244th day of the year)*

What is the date of the image, the month and day?________________________________

4. Look at the other 2010 data image on page 3; this is the false color. We used the program from OSU that takes the infrared information, which we cannot see with our eyes, and gives the image false color.

What are the differences between the two 2010 images?

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5. You will now measure the length of the glacier. Put a place mark where the glacier ice starts. (Choose red and mark it as "Start") This point will be the start of each year's length measurement.

6. Find the furthest extent of the ice (also known as the "terminus edge") and measure the distance from the start point in the ice field across the entire length of the glacier. (Choose red and mark it as 2010 length)
7. Record the length of the glacier in 2010:________________________________
   Note: Please record the length in centimeters. These are the units you will be using for the remainder of the exercise. 1 centimeter on the map equals 7,500 meters on the ground.
   (As you go to other dates and draw lines, you will follow the 2010 line as best as you can.)
8. Draw a line at the terminus edge of the glacier. (Choose red)

Now you will be looking at the data from 2006. You will be making comparisons between the years.

9. Look at the image titled "2006 Data: 259 (Natural Color)" on page 4. This is the natural color image that the satellite took in 2006. You will now proceed to collect the same data as you collected for the 2010 images.

What is the date of the image?____

10. Look at the other 2006 data image on page 5; this is false color.

What are the differences between the two 2006 images?

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11. Using a colored pencil, draw a line the entire length of the glacier; follow the 2010 line as closely as possible. (Choose yellow and mark it as 2006 length)
12. Record the length of the glacier in 2006: ________________________________
13. Draw a line at the terminus edge of the glacier. (Choose yellow)

Compare the lengths of the glacier for the 2 years. How are they similar and how are they different from one another?

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Now you will be comparing the data with an image from 1996. You will be making comparisons between the years.

14. Look at the image titled "1996 Data: 248 (Natural Color)" on page 6. This is the natural color image that the satellite took in 1996.
    What is the date of the image?____________________________________

15. Look at the other 1996 data image on page 7; this is the false color.

What are the differences between the two 1996 images?

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16. Draw a line the entire length of the glacier; follow the 2010 line as closely as possible. (Choose green and mark it as 1996 length)
17. Record the length of the glacier in 1996: ______________________________
18. Draw a line at the terminus edge of the glacier. (Choose green)

Now you will be looking at the data from a fourth year, data from 1986. You will be making comparisons between the years.

19. Look at the image titled "1986 Data: 268 (Natural Color" on page 8. This is the natural color image that the satellite took in 1986.

What is the date of the image?____

20. Look at the other 1986 data image on page 9; this is the false color.

What are the differences between the two 1986 images?

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21. Draw a line the entire length of the glacier; follow the 2010 line as closely as possible. (Choose blue and mark it as 1986 length)
22. Record the length of the glacier in 1986: ______________________________
23. Draw a line at the terminus edge of the glacier. (Choose blue)

ANALYSIS: You have looked at the data for the 4 years. Now you will compare and analyze the data.

Compare the lines. Which is the longest?

During which year did the glacier appear to be the longest? *Note: This is often called a glacial surge.*

What could be some possible explanations for the glacial surge?

Explore the area near the glacier. Can you find any other evidence of change between the years? *Look at the bodies of water. Look at any other habitat features in the area.*

During the years covered by the images, is the Bering Glacier growing or shrinking? Give evidence for your answer.

What climate conditions encourage glacier growth and glacier retreat?

What might account for glacier retreat today?

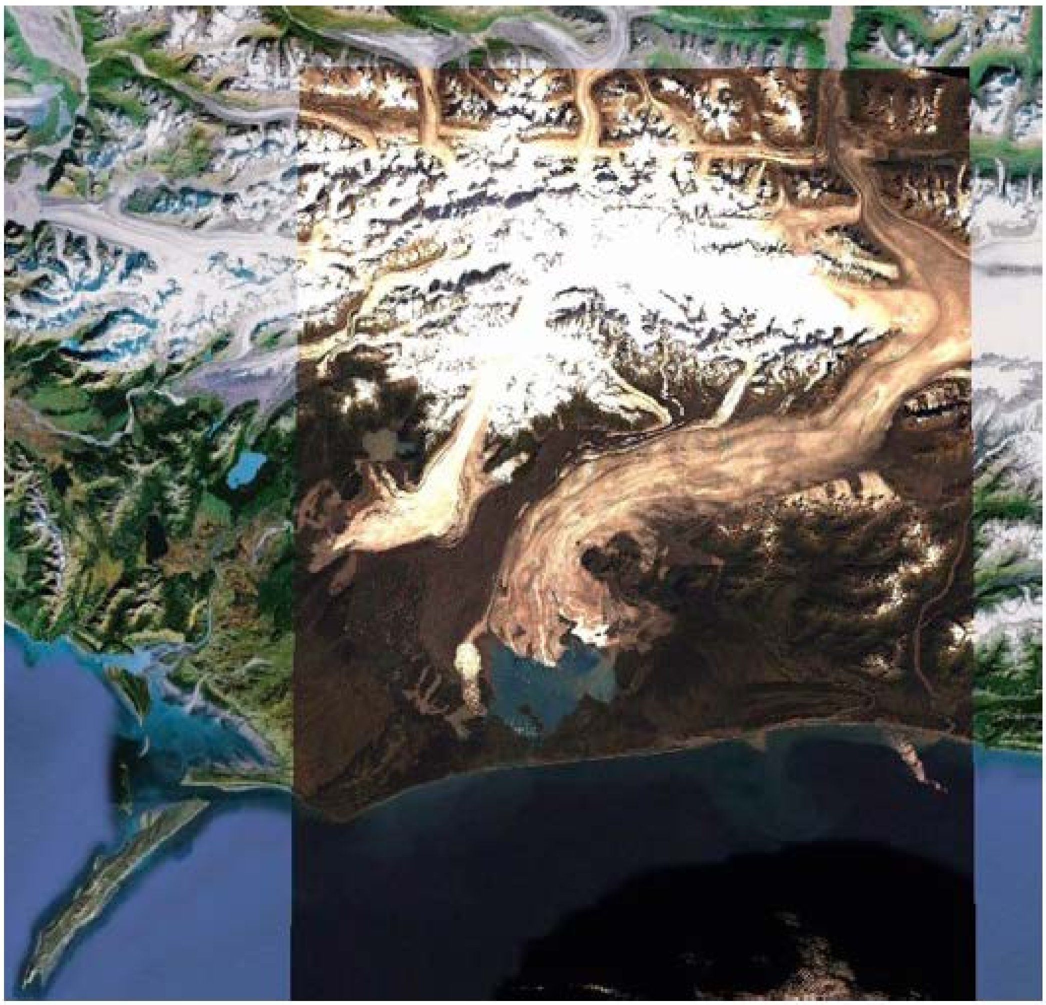
As glaciers get smaller, how might this affect the rest of Earth?

Appendix 6. Images created for the Paper maps Bering Glacier lesson.

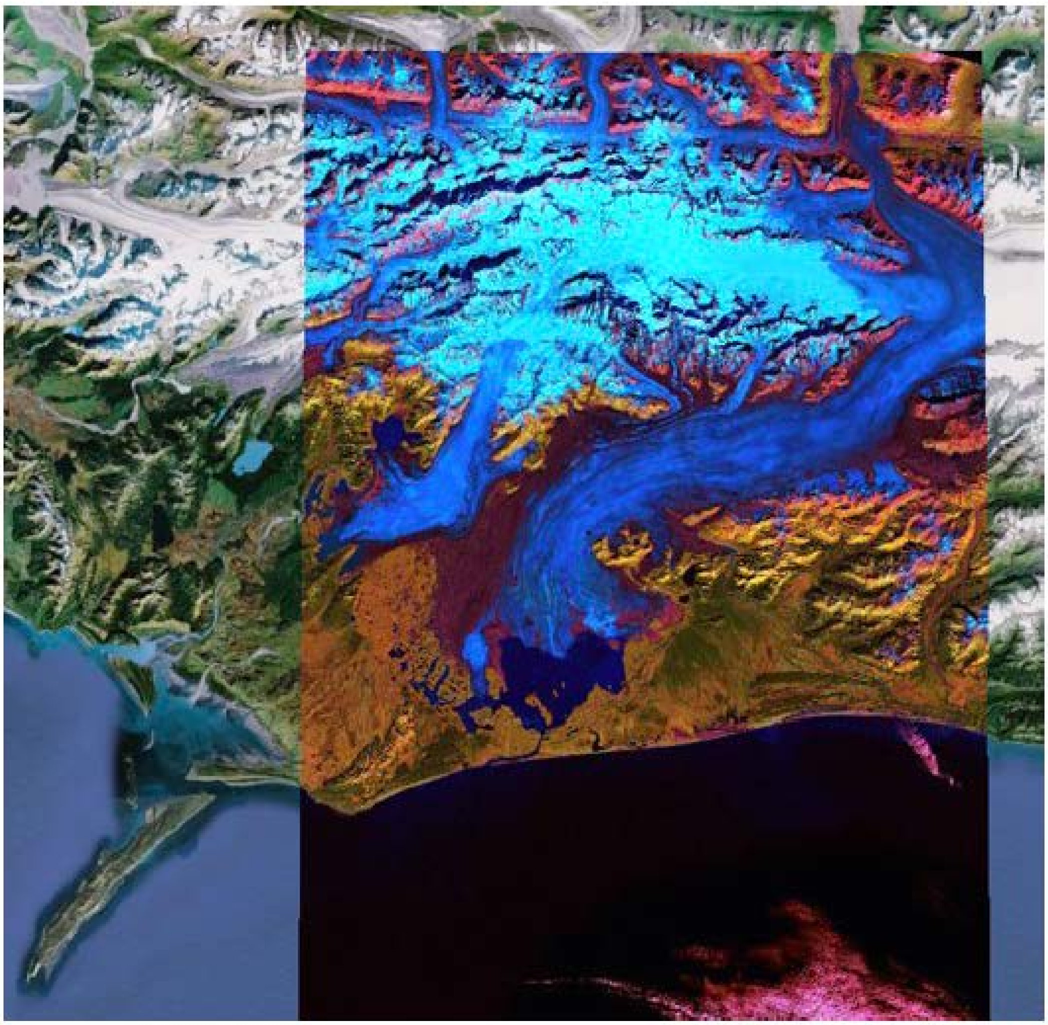
Bering Glacier Landsat Images

Bering Glacier

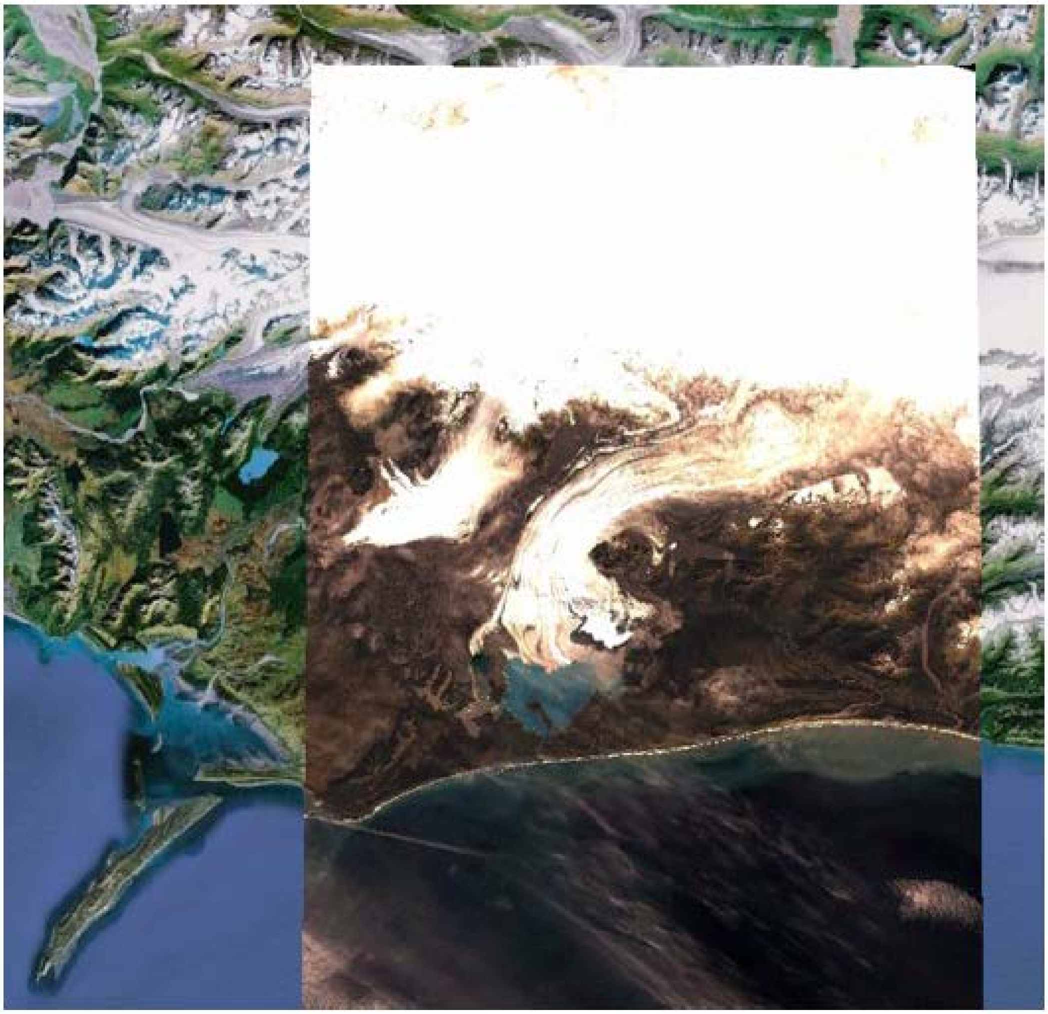
2010 Data: 254 (Natural Color)



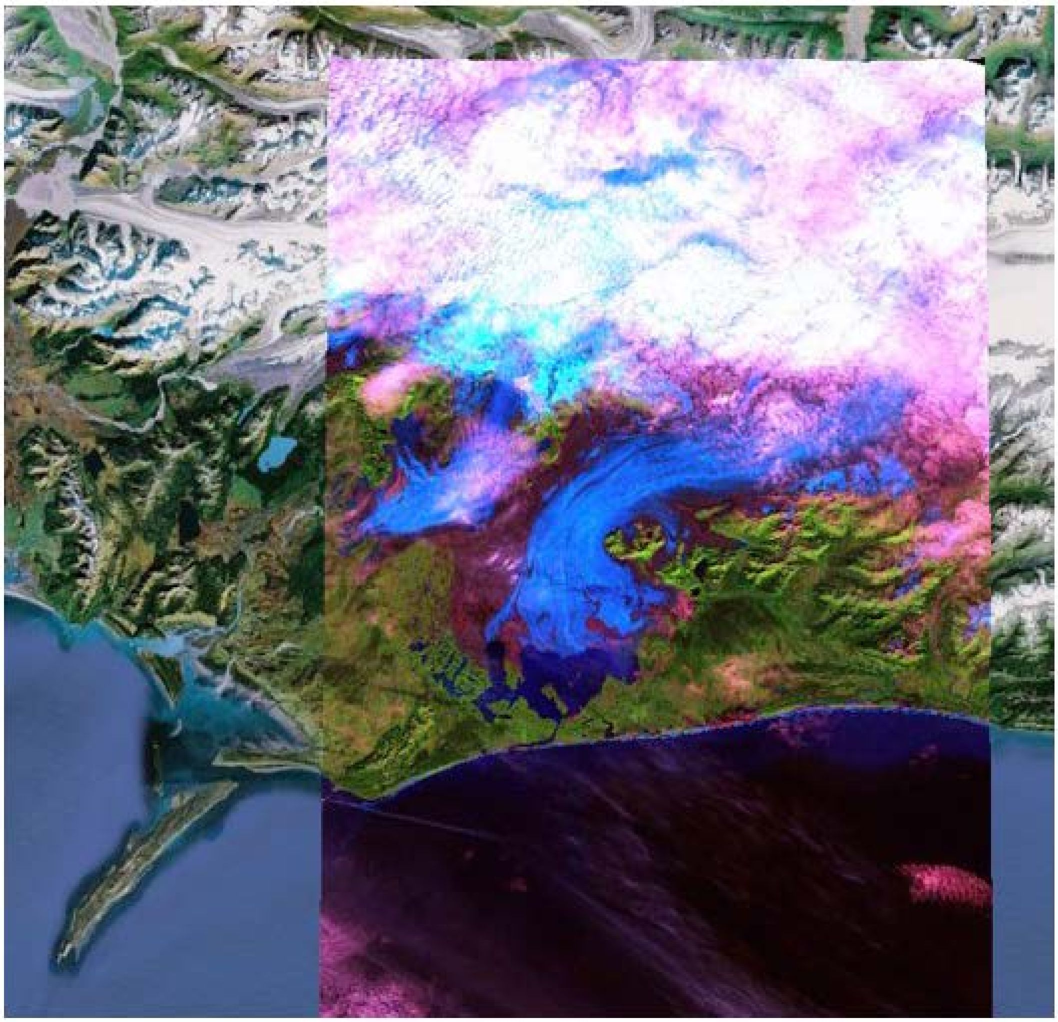
2010 Data: 254 (False Color)



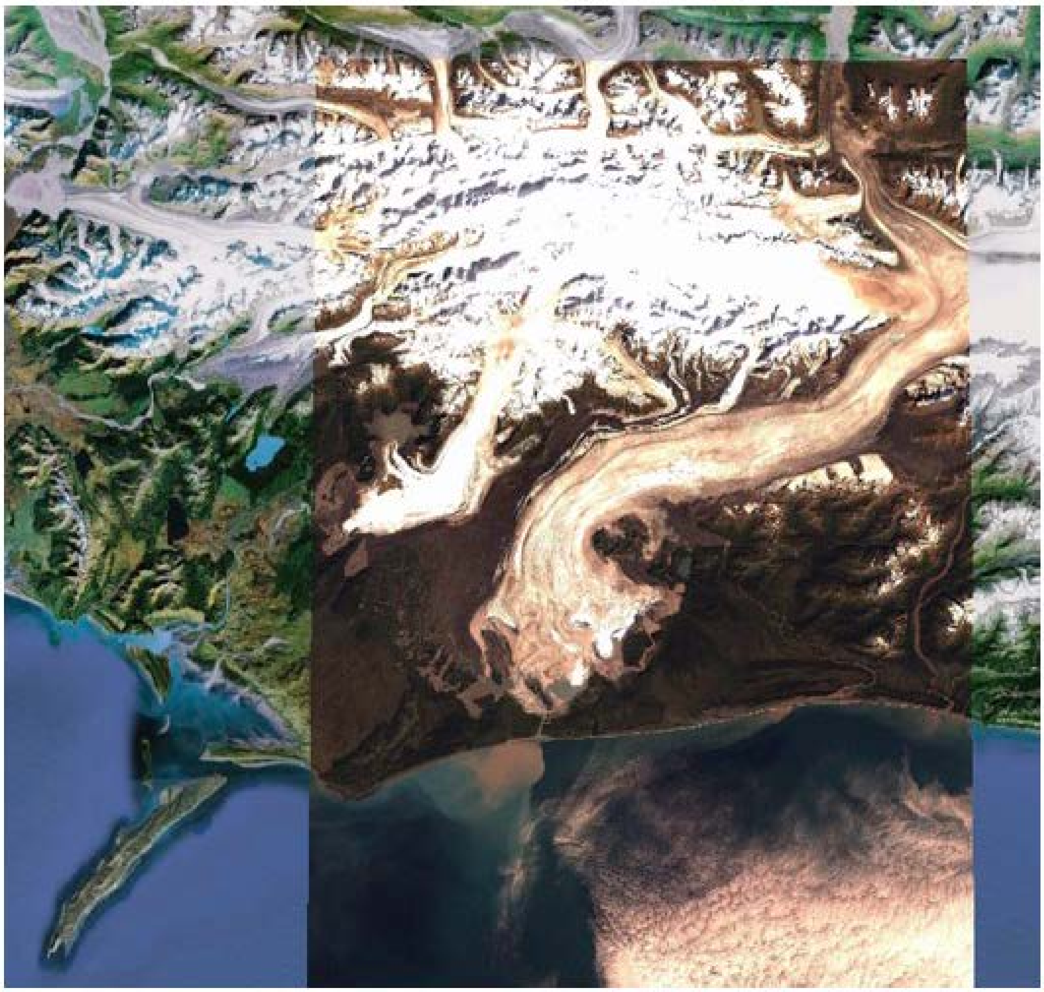
2006 Data: 259 (Natural Color)



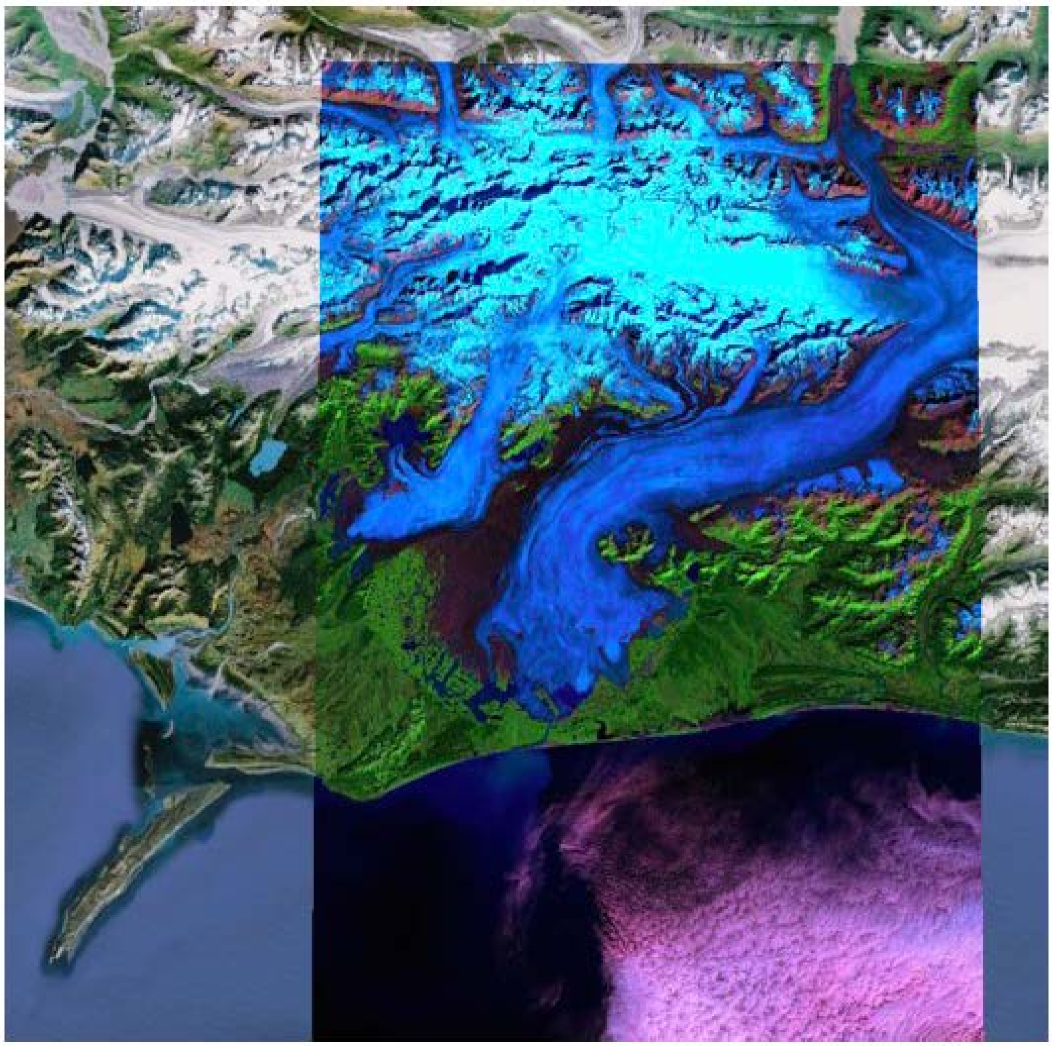
2006 Data: 259 (False Color)



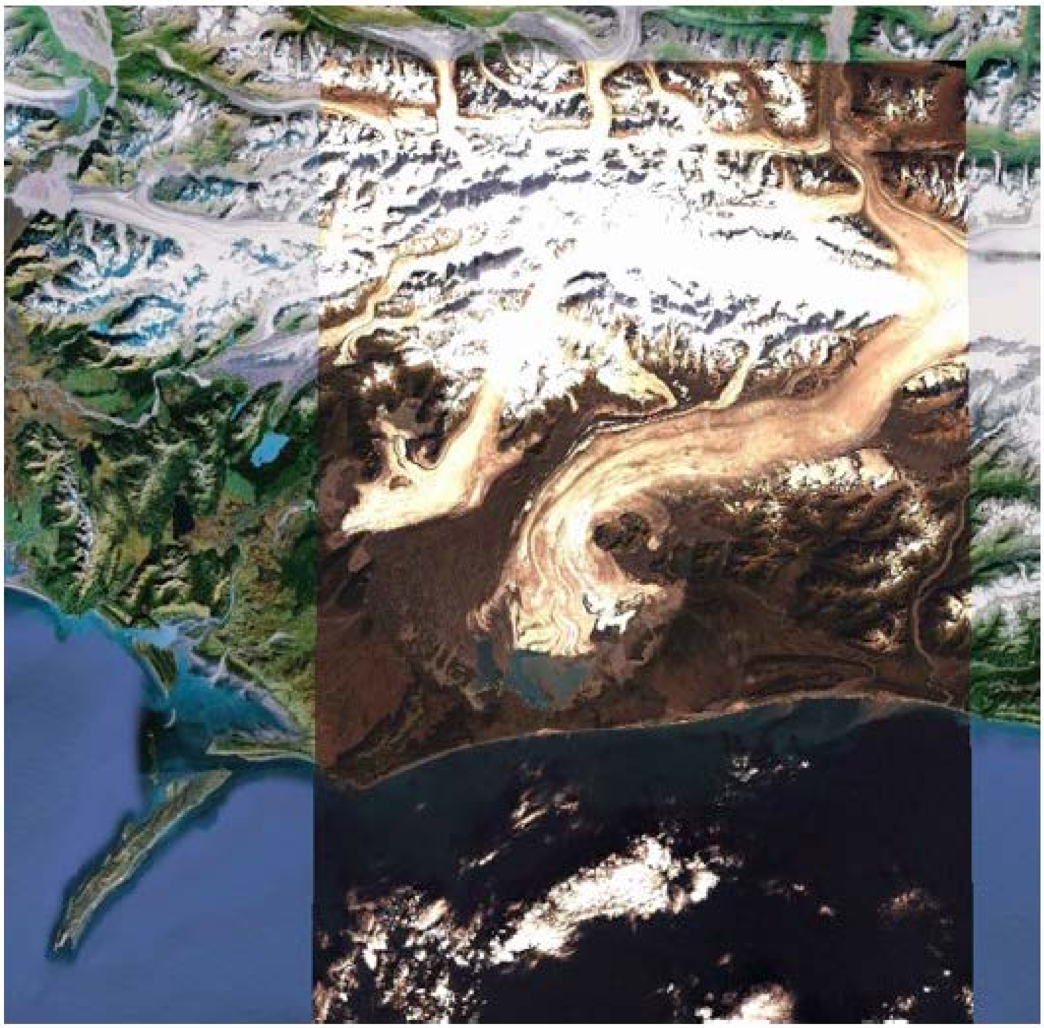
1996 Data: 248 (Natural Color)



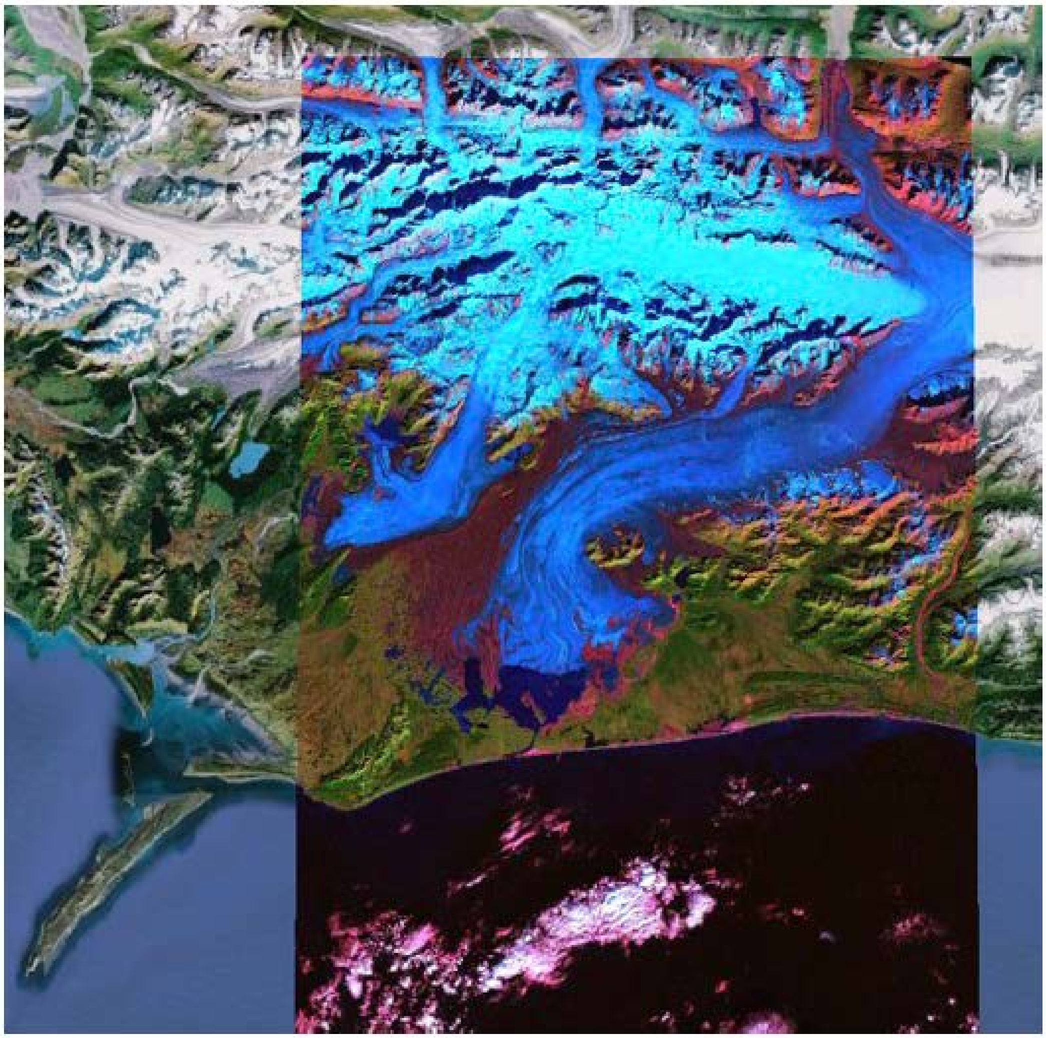
1996 Data: 248 (False Color)



1986 Data: 268 (Natural Color)



1986 Data: 268 (False Color)



Appendix 7. A copy of the pre-test/post-test distributed to all classes.

Bering Glacier Pre and Post-Test

1. Age: ___________

2. Gender?
a) Male b) Female

3. In the past five years, have you traveled outside Oregon?
a) Yes b) No

4. In the past five years, approximately how many times have you traveled outside of the United States?

a) None	c) Two
b) One	d) Three or more

5. How many languages can you speak fluently other than English?

a) None	c) Two
b) One	d) Three or more

6. How many hours a week do you use the Internet?

a) 1 - 4	d) More than 12
b) 5 - 8	e) Never
c) 9 – 12	

7. How frequently do you look up information on the Internet as part of class or research assignments?

a) Daily, or almost daily	d) Once a month
b) 2-3 times a week	e) Never
c) Once a week	

8. How often do you use maps? (Paper or electronic – such as phone, tablet, or computer)

a) Daily, or almost daily	d) Once a month
b) 2-3 times a week	e) Never
c) Once a week	

9. Have you ever used Geographic Information System (GIS) software before?

a) Yes	b) No
c) Unsure	

10. Have you ever used Google Earth before?

a) Yes	b) No

11. Why have you used Google Earth before? (Mark all that apply)

a) For a class assignment
b) To look up where something is
c) For personal use
d) I don't use Google Earth

12. How often do you use Google Earth?
a) Daily, or almost daily
b) 2-3 times a week
c) Once a week
d) Once a month
e) Never

13. How many hours a week do you play videogames?
a) 1 - 4
b) 5 - 8
c) 9 – 12
d) More than 12
e) Never

14. Compared to other students, how would you rate your ability to make the computer to do what you want it to do?
a) Much lower than average
b) Lower than average
c) Average
d) Better than average
e) Much better than average

15. Describe a glacier. (This might include characteristics, features, or where they could be found).

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16. Glaciers are important because…

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Appendix 8. Results from all student participants.

Number	School	Teacher	Lesson	Period	1-PRE	2-PRE	3-PRE	4-PRE	5-PRE	6-PRE	7-PRE	8-PRE	9-PRE	10-PRE	11-PRE	12-PRE	13-PRE	14-PRE	15-PRE	16-PRE	Score	15-POST	16-POST
1	LPMS	Rumage	Paper Maps	3	13	A	A	A	A	D	A	C	A	A	A,B,C	D	D	E	2	1	25	-	-
2	LPMS	Rumage	Paper Maps	3	14	B	A	D	B	B	B	D	C	A	A,B,C	D	E	C	3	2	23	3	3
3	LPMS	Rumage	Paper Maps	3	13	A	A	D	A	B	C	D	C	A	A,B,C	D	B	E	3	2	23	3	2
4	LPMS	Rumage	Paper Maps	3	14	B	A	D	A	B	B	C	C	A	B,C	C	A	B	3	2	28	3	3
5	LPMS	Rumage	Paper Maps	3	13	B	A	C	B	C	A	C	C	A	A,B,C	D	B	D	3	1	27	3	3
6	LPMS	Rumage	Paper Maps	3	13	B	A	A	B	C	A	D	C	A	A	D	E	C	2	1	23	2	2
7	LPMS	Rumage	Paper Maps	3	13	A	A	C	B	B	B	C	B	A	B,C	D	B	D	2	1	27	2	3
8	LPMS	Rumage	Paper Maps	3	13	B	A	C	B	B	D	D	B	A	C	C	E	C	2	0	-	2	1
9	LPMS	Rumage	Paper Maps	3	13	B	A	A	A	B	A	C	C	A	A,B,C	D	E	B	2	2	27	-	-
10	LPMS	Rumage	Paper Maps	3	14	B	A	A	A	B	C	B	C	A	A,B,C	D	E	C	2	1	29	2	2
11	LPMS	Rumage	Paper Maps	3	13	B	A	D	B	B	A	E	A	A	A,B	D	A	D	3	1	26	3	2
12	LPMS	Rumage	Paper Maps	3	14	A	A	A	A	C	D	C	A	A	C	D	B	C	2	1	29	2	2
13	LPMS	Rumage	Paper Maps	3	13	B	A	A	B	B	B	D	B	A	B,C	D	E	C	3	2	24	3	3
14	LPMS	Rumage	Paper Maps	3	14	B	A	A	A	A	C	A	C	A	A	D	A	C	2	1	-	2	2
15	LPMS	Rumage	Paper Maps	3	13	A	A	B	B	B	D	E	A	A	A,C	D	A	D	2	2	23	2	2
16	LPMS	Rumage	Paper Maps	4	14	B	A	D	B	A	C	A	B	A	A,B	D	E	C	2	1	26	2	1
17	LPMS	Rumage	Paper Maps	4	13	A	A	A	A	C	A	C	A	A	B,C	D	B	E	2	3	27	2	2
18	LPMS	Rumage	Paper Maps	4	14	B	A	A	A	B	B	C	B	A	B,C	D	A	C	2	1	28	-	-
19	LPMS	Rumage	Paper Maps	4	13	B	A	B	A	C	-	B	B	A	C	D	E	D	3	1	28	2	3
20	LPMS	Rumage	Paper Maps	4	14	B	A	D	A	C	D	E	C	A	A,B,C	D	E	B	2	1	-	2	3
21	LPMS	Rumage	Paper Maps	4	13	B	A	B	B	A	D	D	C	A	B	C	E	D	2	1	24	2	1
22	LPMS	Rumage	Paper Maps	4	13	B	A	D	A	C	C	E	A	A	A	D	E	C	1	2	23	1	2
23	LPMS	Rumage	Paper Maps	4	13	A	A	D	B	B	C	B	C	A	A,B	D	E	C	2	2	24	2	2
24	LPMS	Rumage	Paper Maps	4	14	B	A	A	A	C	D	D	C	A	B,C	D	B	B	2	1	24	1	2
25	LPMS	Rumage	Paper Maps	4	13	B	A	D	A		-	B	C	A	A,B,C	D	A	C	3	3	28	3	3
26	LPMS	Rumage	Paper Maps	4	14	B	A	A	A	A	B	E	B	A	A	E	B	C	2	1	29	2	3
27	LPMS	Rumage	Paper Maps	4	13	B	A	C	A	D	C	D	B	A	A,B,C	D	E	C	2	1	26	1	2
28	LPMS	Rumage	Paper Maps	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	3	1
29	LPMS	Rumage	Paper Maps	4	14	A	A	D	A	A	C	C	C	A	A,B,C	D	B	C	2	1	23	2	2
30	LPMS	Rumage	Paper Maps	5	14	A	A	B	A	A	C	D	B	A	A,B,C	D	B	D	1	0	-	1	1
31	LPMS	Rumage	Paper Maps	5	14	B	A	A	A	B	B	D	B	A	A,B,C	D	A	C	3	2	25	3	3
32	LPMS	Rumage	Paper Maps	5	13	B	A	D	C	B	A	A	C	A	A,B	B	B	C	2	0	23	2	1
33	LPMS	Rumage	Paper Maps	5	14	A	A	A	A	D	B	D	C	A	A,B,C	D	D	C	1	1	-	-	-
34	LPMS	Rumage	Paper Maps	5	14	B	B	A	D	C	B	D	B	B	D	E	E	C	1	1	-	2	1
35	LPMS	Rumage	Paper Maps	5	13	A	A	D	C	A	A	D	A	A	A,B	B	C	D	2	0	24	1	1
36	LPMS	Rumage	Paper Maps	5	14	A	A	A	A	A	C	E	C	A	A,B,C	E	A	C	0	0	23	1	0
37	LPMS	Rumage	Paper Maps	5	14	A	A	D	A	B	B	D	C	A	A,B	D	D	C	1	1	29	1	3
38	LPMS	Rumage	Paper Maps	5	13	A	A	A	A	A	B	D	C	A	B	D	E	D	1	2	23	2	2
39	LPMS	Rumage	Paper Maps	5	14	B	B	B	A	B	B	C	B	A	A,B	D	A	C	3	1	27	2	2
40	LPMS	Rumage	Paper Maps	5	13	A	A	D	A	B	C	D	C	A	A,B,C	C	C	E	2	2	27	1	2
41	LPMS	Rumage	Paper Maps	6	14	A	A	A	A	A	C	C	C	A	A,B,C	B	B	D	1	1	-	1	1
42	LPMS	Rumage	Paper Maps	6	14	B	A	D	A	C	B	B	C	A	A,B	D	A	C	2	1	-	2	1
43	LPMS	Rumage	Paper Maps	6	13	B	A	A	A	B	C	D	C	A	A,B,C	D	A	C	3	0	-	2	1
44	LPMS	Rumage	Paper Maps	6	14	B	A	A	A	B	A	B	C	A	C	D	B	C	2	0	-	2	1
45	LPMS	Rumage	Paper Maps	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
46	LPMS	Rumage	Paper Maps	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
47	LPMS	Rumage	Paper Maps	6	13	B	A	C	A	B	A	C	C	A	A,B	D	E	C	3	2	-	-	-
48	LPMS	Rumage	Paper Maps	6	13	A	A	D	B	A	C	D	A	A	A,B,C	D	A	C	2	1	-	-	-
49	LPMS	Rumage	Paper Maps	6	13	B	A	A	A	A	A	B	C	A	B,C	E	E	C	2	0	-	2	1
50	LPMS	Rumage	Paper Maps	6	13	A	A	D	B	C	B	C	C	A	A,B,C	D	B	E	2	0	-	2	2
51	LPMS	Rumage	Paper Maps	6	13	B	A	D	C	A	C	D	C	A	A,B	D	A	D	2	1	-	1	1
52	LPMS	Rumage	Paper Maps	6	14	A	A	B	A	A	D	D	C	A	B,C	D	A	B	3	1	-	2	2
53	LPMS	Rumage	Paper Maps	6	13	A	A	A	B	C	A	A	A	A	A,B,C	D	B	A	2	1	-	3	1
54	LPMS	Rumage	Paper Maps	7	13	B	A	A	A	C	B	D	C	A	A,C	D	A	C	1	1	-	-	-
55	LPMS	Rumage	Paper Maps	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
56	LPMS	Rumage	Paper Maps	7	14	A	A	B	C	A	B	A	C	A	A	D	D	C	1	1	-	1	1
57	LPMS	Rumage	Paper Maps	7	13	B	A	A	A	D	A	C	C	A	A,B,C	D	E	D	2	0	-	1	1
58	LPMS	Rumage	Paper Maps	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59	LPMS	Rumage	Paper Maps	7	13	B	A	D	B	C	B	C	B	A	A,C	D	A	C	3	0	-	2	2
60	LPMS	Rumage	Paper Maps	7	13	A	A	D	B	B	D	A	C	A	A,B,C	C	C	E	1	2	-	1	2
61	LPMS	Rumage	Paper Maps	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
62	LPMS	Rumage	Paper Maps	7	13	A	A	D	B	B	A	D	C	A	B	D	B	C	1	0	-	2	1
63	LPMS	Rumage	Paper Maps	7	13	B	A	A	A	D	A	D	C	A	A,B,C	D	A	D	2	0	-	2	1
64	LPMS	Rumage	Paper Maps	7	13	A	A	C	B	D	B	D	C	A	B,C	D	D	D	2	2	-	1	2
65	LPMS	Rumage	Paper Maps	7	13	B	A	C	A	B	B	D	B	A	A,B,C	D	A	D	2	2	-	3	3
66	LPMS	Rumage	Paper Maps	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	LPMS	Rumage	Paper Maps	7	14	B	A	B	A	B	C	C	C	A	A,B,C	D	A	C	2	2	-	2	2
68	LPMS	Rumage	Paper Maps	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69	LPMS	Rumage	Paper Maps	7	14	B	A	B	C	A	B	C	B	A	B,C	D	E	C	2	1	-	3	2
70	LPMS	Rumage	Paper Maps	7	13	B	A	D	A	B	C	D	C	A	C	D	E	C	2	1	-	1	2
71	LPMS	Rumage	Paper Maps	7	13	A	A	D	A	D	C	D	C	A	C	D	B	A	1	0	-	2	1

- denotes data not submitted

Number	School	Teacher	Lesson	Period	1-PRE	2-PRE	3-PRE	4-PRE	5-PRE	6-PRE	7-PRE	8-PRE	9-PRE	10-PRE	11-PRE	12-PRE	13-PRE	14-PRE	15-PRE	16-PRE	Score	15-POST	16-POST
72	NAMS	Kelly	Paper Map	1	13	B	Y	B	A	D	B	D	B	Y	C	E	E	C	1	0	-	3	1
73	NAMS	Kelly	Paper Map	1	13	B	Y	A	A	C	B	B	B	Y	C	D	A	D	2	2	25	3	2
74	NAMS	Kelly	Paper Map	1	15	B	Y	D	B	A	A	C	A	Y	B	D	E	E	3	1	25	3	1
75	NAMS	Kelly	Paper Map	1	14	A	Y	C	B	D	A	E	C	Y	A	D	D	C	1	1	0	1	0
76	NAMS	Kelly	Paper Map	1	13	B	Y	D	A	B	B	C	C	Y	C	D	E	C	1	0	31	3	3
77	NAMS	Kelly	Paper Map	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	3	1
78	NAMS	Kelly	Paper Map	1	14	B	Y	B	A	B	C	E	B	Y	B	D	E	C	0	0	-	3	1
79	NAMS	Kelly	Paper Map	1	13	B	Y	D	A	B	B	C	C	Y	C	D	E	C	1	0	28	2	2
80	NAMS	Kelly	Google Earth	2	14	A	Y	A	A	A	B	E	B	Y	B	D	A	C	2	1	-	2	1
81	NAMS	Kelly	Google Earth	2	14	B	Y	B	B	A	C	A	B	Y	C	D	E	C	2	1	-	2	2
82	NAMS	Kelly	Google Earth	2	14	A	Y	A	A	D	D	C	C	N	C	E	D	D	-	-	-	2	2
83	NAMS	Kelly	Google Earth	2	13	B	Y	D	A	C	C	D	C	Y	C	D	A	C	2	2	-	2	2
84	NAMS	Kelly	Google Earth	2	14	B	Y	C	A	B	A	D	B	Y	C	D	B	D	3	1	-	2	2
85	NAMS	Kelly	Google Earth	2	13	B	Y	D	A	B	D	E	B	Y	C	E	E	D	-	-	-	-	-
86	NAMS	Kelly	Google Earth	2	14	A	Y	D	D	D	A	C	A	Y	D	B	D	D	1	0	-	-	-
87	NAMS	Kelly	Google Earth	2	13	B	Y	A	B	A	C	E	B	Y	A	D	A	B	2	3	16	2	3
88	NAMS	Kelly	Google Earth	2	-	A	Y	B	A	B	A	B	C	Y	C	D	B	-	-	-	-	-	-
89	NAMS	Kelly	Paper Map	3	13	B	N	A	A	B	B	D	C	Y	B	D	E	C	2	1	-	2	1
90	NAMS	Kelly	Paper Map	3	14	B	Y	A	A	A	B	C	C	Y	C	D	E	C	3	3	-	-	-
91	NAMS	Kelly	Paper Map	3	14	B	Y	A	A	A	A	C	C	Y	C	E	A	D	2	3	20	2	3
92	NAMS	Kelly	Paper Map	3	14	A	Y	A	A	D	D	D	B	Y	C	D	C	D	2	2	27	2	2
93	NAMS	Kelly	Paper Map	3	14	A	Y		B	B	C	D	B	Y	C	E	D	C	2	1	22	2	2
94	NAMS	Kelly	Paper Map	3	14	B	Y	B	A	A	B	D	C	Y	C	D	E	D	3	1	24	3	2
95	NAMS	Kelly	Paper Map	3	14	B	Y	B	A	B	C	E	C	Y	C	D	B	D	2	1	25	2	2
96	NAMS	Kelly	Paper Map	3	14	A	Y	A	A	A	C	A	C	Y	B	C	A	D	2	1	24	-	-
97	NAMS	Kelly	Paper Map	3	13	A	Y	A	A	A	C	C	C	Y	B	E	E	A	1	0	-	-	-
98	NAMS	Kelly	Google Earth	6	14	B	Y	A	A	D	C	B	B	Y	C	D	A	D	-	-	-	-	-
99	NAMS	Kelly	Google Earth	6	14	A	Y	A	A	A	E	E	B	Y	C	E	A	B	-	-	-	-	-
100	NAMS	Kelly	Google Earth	6	14	A	Y	D	A	C	C	D	B	Y	C	D	C	-	2	1	-	2	1
101	NAMS	Kelly	Google Earth	6	14	B	Y	B	A	A	C	C	B	Y	C	D	A	A	2	1	23	3	2
102	NAMS	Kelly	Google Earth	6	13	A	Y	A	A	B	A	D	C	Y	C	E	A	D	-	-	23	2	2
103	NAMS	Kelly	Google Earth	6	14	A	Y	C	A	A	A	A	B	Y	A	A	C	C	2	1	-	-	-
104	NAMS	Kelly	Google Earth	6	13	B	Y	C	C	A	D	C	B	Y	A	C	A	C	1	0	-	-	-
105	NAMS	Kelly	Google Earth	6	13	B	Y	D	A	B	B	C	B	Y	C	D	A	C	2	1	25	2	2
106	NAMS	Kelly	Google Earth	6	14	A	Y	A	A	A	B	C	C	Y	B	C	A	C	2	1	-	2	2
107	NAMS	Kelly	Google Earth	6	13	B	Y	D	A	A	B	A	B	N	D	E	E	C	2	2	-	2	1
108	NAMS	Kelly	Google Earth	6	13	B	Y	A	A	A	B	D	C	N	C	D	A	C	2	1	23	2	1
109	NAMS	Kelly	Google Earth	7	13	B	-	A	A	A	C	B	C	Y	B	E	E	C	2	1	-	3	1
110	NAMS	Kelly	Google Earth	7	13	B	Y	D	A	C	C	D	C	Y	C	E	A	E	1	1	27	2	2
111	NAMS	Kelly	Google Earth	7	14	B	N	A	B	C	D	B	B	Y	C	C	B	D	1	2	28	1	3
112	NAMS	Kelly	Google Earth	7	14	B	N	A	D	C	C	C	B	Y	C	D	A	E	1	0	-	1	1
113	NAMS	Kelly	Google Earth	7	13	B	Y	C	A	A	C	C	C	Y	B	C	A	D	2	0	-	2	2
114	NAMS	Kelly	Google Earth	7	14	B	Y	D	A	B	A	D	C	Y	B	D	E	D	1	2	25	2	2
115	NAMS	Kelly	Google Earth	7	13	B	Y	A	A	A	A	D	C	Y	B	D	E	D	1	0	-	2	2
116	NAMS	Kelly	Google Earth	7	13	A	N	D	A	A	B	D	A	Y	C	E	A	D	2	1	-	2	2
117	NAMS	Kelly	Google Earth	7	14	A	Y	A	A	D	B	B	B	Y	B	D	D	D	2	1	-	2	2
118	NAMS	Kelly	Google Earth	7	13	B	Y	A	A	D	D	E	A	Y	C	E	E	C	2	1	-	2	2
119	NAMS	Kelly	Google Earth	7	13	A	Y	D	A	C	A	D	C	Y	B	D	B	E	1	1	22	1	2
120	NAMS	Kelly	Google Earth	7	14	B	Y	A	A	A	D	C	A	N	C	E	E	B	1	0	24	-	-
121	NAMS	Kelly	Google Earth	7	14	A	Y	D	A	B	B	D	C	Y	B	D	C	D	1	0	18	-	-
122	NAMS	Kelly	Google Earth	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	2	2
123	NAMS	Kelly	Google Earth	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	3	2

- denotes data not submitted