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# Google Earth in the Middle School Geography Classroom: Its Impact on Spatial Literacy and Place Geography Understanding of Students

Kerri S.W. Westgard

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GOOGLE EARTH IN THE MIDDLE SCHOOL GEOGRAPHY CLASSROOM: ITS  
IMPACT ON SPATIAL LITERACY AND PLACE GEOGRAPHY  
UNDERSTANDING OF STUDENTS

by

Kerri S.W. Westgard  
Bachelor of Arts, Concordia College-Moorhead, MN, 1994  
Master of Science, Minnesota State University-Mankato, 2002

A Dissertation

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

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December

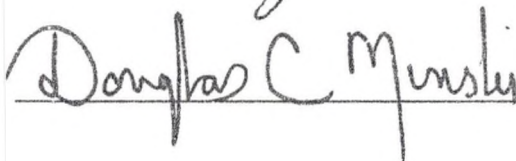
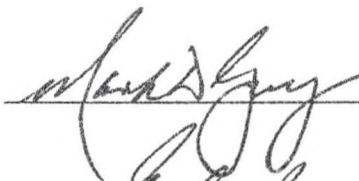
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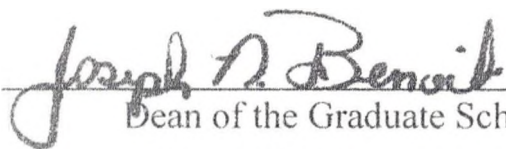
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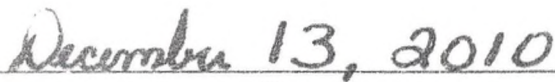
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This dissertation meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.



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To Maxine

At the age of 18, she became a mother upon my birth, forgoing her educational dream of studying library science after high school. She courageously endured unimaginable circumstances and made choices requiring great sacrifice to raise her three children as a single parent in a caring, enlightened environment. Throughout this part of her life's journey, she instilled in each of her children, all teachers today, the value of learning. Let this educational achievement serve as loving acknowledgement and remembrance of that academic dream she unselfishly sacrificed so many years ago to become my mother, the greatest teacher of all.

To Dave

Thanks for keeping me on my mental toes and joining our family so many years ago.

To Jeff

Husband, friend, and fellow explorer. I wish to express my deepest appreciation for your endless patience and all that you and your family do for me.

Jeff, I am, finally, at a loss for words.

## ABSTRACT

Success in today's globalized, multi-dimensional, and connected world requires individuals to have a variety of skill sets – i.e. oracy, numeracy, literacy, as well as the ability to think spatially. Student's spatial literacy, based on various national and international assessment results, indicates that even though there have been gains in U.S. scores over the past decade, overall performance, including those specific to spatial skills, are still below proficiency. Existing studies focused on the potential of virtual learning environment technology to reach students in a variety of academic areas, but a need still exists to study specifically the phenomenon of using Google Earth as a potentially more useful pedagogical tool to develop spatial literacy than the currently employed methods.

The purpose of this study was to determine the extent to which graphicacy achievement scores of students who were immersed in a Google Earth environment were different from students who were provided with only two-dimensional instruction for developing spatial skills. Situated learning theory and the work of Piaget and Inhelder's *Child's Conception of Space* provided the theoretical grounding from which this study evolved. The National Research Council's call to develop spatial literacy, as seen in *Learning to Think Spatially*, provided the impetus to begin research.

The target population ( $N = 84$ ) for this study consisted of eighth grade geography students at an upper Midwest Jr. High School during the 2009-2010 academic year. Students were assigned to the control or experimental group based on when they had

geography class. Control group students ( $n = 44$ ) used two-dimensional PowerPoint images to complete activities, while experimental group students ( $n = 40$ ) were immersed in the three-dimensional Google Earth world for activity completion. Research data was then compiled and statistically analyzed to answer five research questions developed for this study.

One-way ANOVAs were run on data collected and no statistically significant difference was found between the control and experimental group. However, two of the five research questions yielded practically significant data that indicates students who used Google Earth outperformed their counterparts who used PowerPoint on pattern prediction and spatial relationship understanding.

## CHAPTER I

### INTRODUCTION

#### Background

Success in today's globalized, multi-dimensional, and connected world requires individuals to have a variety of skill sets – i.e. oracy, numeracy, literacy, as well as the ability to think spatially. Some researchers suggested that in many careers (Association of American Geographers & Geospatial Information & Technology Association, 2006; Geospatial Industry Workforce Information System, 2006) one must be able to visualize a two-dimensional representation in the third dimension using spatial thinking. In other words, one needs to be spatially literate. Engineers, urban planners, Department of Defense employees, architects, pilots, neurologists, and air traffic controllers are examples of some careers that require the skill of being able to transform two-dimensional representations, such as blueprints, maps, location intelligence, magnetic resonance imaging (MRI), or radarscopes into three-dimensional thinking for job performance and problem solving. Furthermore, researchers have estimated that a probable 80% of all government information is spatially referenced (Al-Kodmany, 2002).

With advances in computing technologies and the increasing availability of geospatial data, “spatial thinking will play a significant role in the information-based economy of the 21st-century” (Blank & Crews, 2010, para 1). Without spatial thinking, it may be difficult for individuals to function in careers where such skill is a necessity.



Given the importance of visualization, it seems reasonable to assume, therefore, that the need to teach, learn, and develop spatial skills may become a necessary requirement for students in today's world.

In commenting on the importance of spatial literacy in today's world, the National Research Council (NRC) Committee on Support for Thinking Spatially has called, specifically, for the development of a systematic spatial literacy educational program. The purpose of such a program would be to "foster spatial literacy by enhancing levels of spatial thinking in K-12 students" (National Research Council, 2006, p. 3) and is described in NRC's document, *Learning to Think Spatially*. In heeding the NRC's call to foster spatial literacy, this empirical study looked at how using Google Earth in the middle school geography classroom affects spatial literacy and geography understanding of students. However, in order to understand the issues facing geography educators, it is essential that there is some clear understanding about what precisely is meant by the terms spatial literacy and spatial thinking.

### *Spatial Literacy and Spatial Thinking*

Spatial thinking involves analysis, problem solving, and pattern prediction involving objects and their three-dimensional relationships. Spatial thinking can involve geometry and geometric thinking, astronomy, mathematical transformation of information, engineering and architecture, geography, modeling, video gaming, and the arts. Essentially, spatial thinking is visualization and communication that may be important to all of the sciences. Without spatial thinking, the complex issues facing our world cannot be grappled with effectively and completely (Kerski, 2008a).

The National Research Council (2006) confines the definition of spatial thinking, termed often as geospatial thinking, specifically to the field of geography in the 2006 report, *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum*.

This particular type of spatial thinking, according to the NRC, is:

... based on a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning. It depends on understanding the meaning of space and using the properties of space as a vehicle for structuring problems, for finding answers, and for expressing solutions. By visualizing relationships within spatial structures, we can perceive, remember and analyze the static and, via transformations, the dynamic properties of objects and relationships between objects. We can use representations in a variety of modes and media (graphic [text, image, video], tactile, auditory, kinesthetic) to describe, explain, and communicate about the structure, operation, and function of those objects and their relationships. (p. 3)

Therefore, a spatially literate student has, by definition, developed “appropriate levels of spatial knowledge and skills in spatial ways of thinking and acting” (National Research Council, 2006, p. 20). Given the specific nature of geospatial thinking, how does one become spatially literate in today’s educational systems and what approaches can be utilized to teach spatial skills?

### *Spatial Thinking in Curriculum*

In the early 1990s, subject-specific educational councils developed a variety of national academic standards in the United States. These standards detail what every student should know about a particular subject in grades K-12. Based on these national

standards, a systematical set of assessment tools were developed to evaluate a student's knowledge of the subject matter. When one examines the nationally established educational standards, one notices many spatial thinking skills have been included in the standards and subsequently, students have been tested on spatial thinking skills. National educational standards that include spatial thinking skills are found in the disciplines of geometry, science, and geography (Geography Education National Implementation Project, 2005; National Committee on Science Education Standards and Assessment - National Research Council, 1996; National Council of Teachers of Mathematics, 2000; National Research Council, 2006).

Implementing national standards in geometry, science and the geography curriculum, however, has not provided a guarantee that all K-12 students will be spatially literate. Today, spatial thinking skill development, based on various national and international assessment results, indicates that even though there have been gains in U.S. scores over the past decade, overall performance, including those specific to spatial skills, are still below proficiency (Boakes, 2009; Grigg, Lauko, & Brockway, 2006). If there are national educational standards that address spatial thinking skills, why are scores achieved by K-12 students still below proficiency on the national assessments?

One possibility could be that schools do not focus as much attention on developing spatial thinking skills as they do reading and mathematics. This could be due to the issue that instructors lack training and/or knowledge on the development of spatial skills with appropriate pedagogy, or because of a commonly held assumption that people just develop a certain level of spatial literacy on their own (National Research Council, 2006). One must move beyond these reasons for lack of spatial literacy and seek

solutions because “without explicit attention to [spatial thinking], we cannot meet our responsibility for equipping the next generation of students for life and work in the 21<sup>st</sup> century” (Newcombe, 2006). One potential solution could be to focus attention on the teaching and learning of graphicacy in the geography curriculum.

### *Graphicacy*

The spatial skill graphicacy, formed on the model of literacy, is the ability to understand and generate information about spatial relationships that may not be successfully understood or communicated by words or numbers alone (Balchin & Coleman, 1966). Examples of graphicacy include the ability to use, interpret, and create items such as maps, photographs, diagrams, and/or graphs. Words and numbers are the primary method of communication in our society, yet “advances in information and communications technology and visualization techniques now mean that graphics are far more readily available and widely used than ever before” (Graphicacy, n.d., para 1). Because of these communication advances, advocates of spatial literacy and spatial thinking (Aldrich & Sheppard, 2000; Kerski, 2008a; National Research Council, 2006) have pointed out to educational institutions and instructors the importance of considering graphicacy as just as important a skill to learn as numeracy, literacy, and oracy in preparing children for today’s multi-dimensional graphic-filled world.

Nevertheless, as with many other spatial thinking skills, the teaching and learning of graphicacy has been historically overlooked. The challenge for educators, therefore, lies in how to bring graphicacy to the classroom given the lack of teacher preparation, awareness, potential costs, and convenience factors. One way to develop the spatial

thinking skill of graphicacy may be through geography lessons that incorporate spatial analysis, problem solving, and pattern prediction.

### *Graphicacy in Geographic Education*

Today in geographic education, two-dimensional materials – photographs, video, text, audio, and maps – are the tools most commonly used by students to develop spatial skills. Classroom lessons on the geographic theme of Place – the human and physical characteristics of a location – rely heavily on the use of these two-dimensional materials. This two-dimensional instructional method is used because it is more practical for most instructors as it is less costly and less time-consuming compared to an actual field study. For example, during a study of Himalayan culture, it may not be feasible for a class on the Great Plains in the United States to travel to the Himalayas in order to understand the fundamental nature of mountains and people living in the Himalayas. The challenge, therefore, lies in developing three-dimensional spatial skills in students with two-dimensional representations.

Most individuals acquire a more comprehensive sense of Place through three-dimensional world immersion. Being immersed in a location helps one to understand relationships and organize information, both hallmarks of graphicacy, in a more meaningful and efficient way. One can find examples of how being immersed in a location creates a “more meaningful understanding” in anthropology literature. Anthropologists who study culture immerse themselves in a site and situation, akin to what geographers would call Location and Place. In anthropology, individuals learn by participant observation to understand better the relationships between, and views of, the physical and human world in a more meaningful way, which in turn provides greater

detailed descriptions of unfamiliar places (What is Anthropology, 2010).

Anthropologists “realize that they cannot fully understand another culture by simply observing it; they must *experience* it as well” (Missouri History Museum, 2008, para. 1).

How, therefore, can geography educators provide a similar, valuable immersive experience in today’s geography classroom, considering the obstacles of time, place, and cost? What tools are available that can be used in unconventional ways to provide an immersive experience? Moreover, how would such tools affect student learning of spatial concepts?

Today, computer programs allow users to experience three-dimensional (3D) representations of what used to be available only in two-dimensional formats. These virtual 3D environments could have implications for the study of geography and the learning of spatial concepts and skills. But to what extent would students be able to perform differently on spatial concepts concerning graphicacy during the teaching of Place geography when instructed in a three-dimensional environment versus those students taught in the traditional two-dimensional environment?

Advancements in computer animation and computer processing power allow nearly seamless movement within a three-dimensional virtual environment in an application called Google Earth. Google Earth presents a real opportunity for geographic educators to determine the viability of using 3D mapping to strengthen spatial literacy skills, such as graphicacy, during lessons on Place geography. This study attempted to determine the extent to which the use of Google Earth in the middle school geography classroom could influence spatial literacy and Place geography knowledge of students through measurements of graphicacy proficiency.

## Need for the Study

Today, teachers are expected to incorporate more technology into their curriculum so students can be equipped with 21<sup>st</sup> century skills. While incorporating technology into a geography classroom, teachers may find that obtaining permission to download various academic software programs in geography, such as ArcGis and ArcView, troublesome. If the district's technology facilitator does not see the educational benefit of such software, they are often unwilling to download what, to them, may be deemed unnecessary as it uses server space and takes time to maintain. By using Google Earth, a web-based program that is well established and used extensively by various agencies, schools can access relevant software via an internet connection, and one can easily bypass software download issues. Studying the effects of using Google Earth in the classroom could also provide educators with some research-based justification to use internet-based technology in the classroom.

Van Leeuwen and Scholten (2009) hypothesized that education of spatial literacy with GIS programs, such as Google Earth, provided a benefit in addition to regular geography lectures and ordinary geography books. While studies (Baird & Fisher, 2006; Salaway, Borrenson-Caruso & Nelson, 2007) focus on the potential of virtual learning environment technology to reach students, a need existed to study specifically the phenomenon of Google Earth as a potentially more useful pedagogical tool to develop aspects of spatial literacy than current methods.

## Purpose and Significance of the Study

The purpose of this study was to determine the extent to which graphicacy achievement scores of students who use 3D Google Earth are different from students who

are provided with only two-dimensional instruction for developing spatial skills. The potential existed to reach deeper levels of spatial understanding in students immersed in the 3D Google Earth environment compared to traditional 2D approaches. Success of immersive learning was discussed briefly with the previous anthropology example, but is also based on the theory of situated cognition.

Brown, Collins, and Duguid (1989) are often credited with developing situated cognition or situated learning theory. Situated cognition suggests that when content is put into context and practiced under the guidance of a “master”, i.e. a teacher or expert in a field, deeper meaning is achieved (Lave & Wenger, 1991). By situating learning in a 3D environment, this approach not only had the potential to increase aspects of spatial literacy, but could have also reduced the time and monetary cost it would take to do such an experience in the real world. Google Earth was chosen for this investigation, as it is a free computer program, user friendly, rich with minable data, and can be easily accessed by schools via the internet. Researching the use of Google Earth in the classroom to develop spatial skills with situated cognition as a theoretical framework provided for a unique research-based experiment.

### Research Questions

The following questions were developed in an effort to understand the impact Google Earth may have on teaching spatial thinking when compared to traditional two-dimensional methodology.

1. To what extent will students be able to predict spatial patterns based on their observations?



2. How do students understand spatial relationships based on teaching methodology?
3. In what ways will students demonstrate their understanding of spatial relationships using Google Earth compared to traditional two-dimensional uses?
4. To what extent are students able to organize information based on what is observed?
5. In what way(s) will students' understanding of Place differ based on what is observed between the uses of two instructional methodologies?

#### Delimitation of the Study

The target population for this study consisted of eighth grade students in a geography course at an upper Midwest school. This study was restricted to four sections of geography, approximately 100 geography students, in one instructor's class at one school site.

#### Limitations of the Study

The literature and research regarding technology, such as Google Earth, evolves at a quick pace, therefore this study was limited to technology information available at the end of the year 2009. Additionally, results in this study should not be generalized to all settings since the findings are on a limited student sample based on convenience.

Another limitation is the assumption that all students had a general working understanding of elementary level spatial concepts, which includes, but is not limited to that of direction, space, and dimension.

## Terminology

**Affordances:** Psychologist James J. Gibson originally introduced the term affordances in his 1977 article "The Theory of Affordances" and explored it more fully in his book *The Ecological Approach to Visual Perception* in 1979. He defined affordances as all "action possibilities" latent in the environment, objectively measurable and independent of the individual's ability to recognize them, but always in relation to the actor and therefore dependent on their capabilities. For instance, a set of steps, which rises four feet high, does not afford the act of climbing if the actor is a crawling infant. Gibson's is the prevalent definition in cognitive psychology.

**Place:** When the term place is capitalized in this document, it indicates the geographical theme of Place, which is the study of the human and physical characteristics of a location.

**Practical significance:** Practical significance is defined as data that informs educational practice as opposed to statistical significance. McLean and Ernest (1998) support the use of practical significance testing in education because "statistical significance merely provides evidence that an event did not happen by chance....it provides no information about the meaningfulness of an event or if the result is replicable" (p.15).

**Spatial thinking:** Spatial thinking and spatial skills are based on the spatial structures we can perform on and in the structure of space, as stated by the National Research Council (2006):

The idea of spatial structure can be understood in terms of sets of primitives and the concepts that can be derived from them. The idea of spatial operations can be

understood in terms of the transformations that are possible within the space and the interpretations that can be generated from the spatial structures. (p. 36).

Such spatial operations, for purposes of this research, are referred as spatial skills.

## CHAPTER II

### REVIEW OF LITERATURE

Spatial literacy has recently gained more attention for a variety of reasons. Some suggest that this attention is due to the expansion of geotechnologies, such as handheld GPS devices and virtual globe software, i.e. Google Earth, or because globalization encourages one to have to think spatially (Kerski, 2008b; National Research Council, 2006; Spatial Intelligence and Learning Center, 2010). Solving complex issues such as urban sprawl, ecosystem loss, food and water supply could also be other reasons, all of which have spatial components (Kerski, 2008a). Perhaps, because of these reasons, many have, or are now questioning the extent to which spatial skills have been addressed in the K-12 school system.

The National Research Council (NRC) Committee on Support for Thinking Spatially has called upon K-12 schools to begin teaching spatial literacy, a sentiment echoed by many in a variety of academic fields such as math, science, and geography. Given this call to action, it was important to investigate what, if any, influence using Google Earth could have on developing spatial skills (graphicacy) and a student's sense of place. To support this investigation, it was essential to understand how researchers, theorists, and educators have approached the development of spatial concepts in geography students. To this end, literature was examined around three areas:

development of geography pedagogy, the role of graphicacy in spatial literacy, and supporting educational theories with attention to situated cognition.

Electronic searches were conducted using a variety of databases, including Academic Search Premier, EBSCO host, ERIC, Digital Dissertations, Google Scholar, and JSTOR. Criteria used for literature inclusion were publishing dates, empirical studies, journal articles, and reports relevant to geography pedagogy, graphicacy, spatial literacy, and situated cognition. An examination of available literature suggested that at the time of this study, there were no research or empirical studies that specifically addressed developing the spatial literacy skill of graphicacy using the three-dimensional environment of Google Earth in a middle school geography class to teach Place. Therefore, studying the effects of using Google Earth in the classroom could provide geography educators with some research-based justification to use internet-based technology in the classroom, as well as advancing our understanding of viable methods to teach Place geography.

This literature review begins with an overview of geography pedagogy and spatial literacy development. Situated learning theory was examined and integrated with teaching methods associated with Place geography and graphicacy to provide a theoretical framework from which this study has evolved.

### Geography Pedagogy

According to Dobson (2007), geography was founded some 2,500 years ago and was advanced as a subject by many scholars throughout the Classical Age. Geography would be recognized and respected up until the Middle Ages, when it lost its prominence as a field of study for nearly a thousand years. However, it was not until the Renaissance

that geography, as a discipline, would again find its place amongst scholars as a legitimate field of study. In the United States, geography was all but abandoned beginning in the late 1940s, as evidenced when many “esteemed” universities such as Columbia (De Bres, 1989) and Harvard (Smith, 1987) removed geography departments from their campuses.

Starting in the late 1980s, the study of geography in the United States was reborn largely by people who focused on geographic education and geographic pedagogy (Grosvenor, 1995; Turner, 1989), with momentum provided by the growing national standards-based education movement (Kendall & Marzano, 1997). This rebirth was further helped in July 1992, when writers for the Geography Education Standards Project created the first draft of their geography standards, showing a growing commitment of professional collaboration to strengthening geography in the schools. In October of 1994, this draft would become the Geography Education Standards Project’s publication, *Geography for Life: National Geography Standards – 1994*, which today is by far the most encompassing and central document of geography standards to date.

*Geography for Life: National Geography Standards – 1994* made use of many other documents in setting geography standards, thereby giving a broad-based representation of what students of geography should know. *Geography for Life: National Geography Standards – 1994* outlines 18 standards for grades K-4, 5-8, and 9-12. The standards are ordered in six areas: The World in Spatial Terms, Places and Regions, Physical Systems, Human Systems, Environment and Society, and The Uses of Geography. At each grade level, a standard is defined by three to six activities, each of which is demonstrated by three accompanying learning opportunities, i.e. activities

described at a more enhanced level of detail than the standard. The National Geography Standards also detail Five Geographic Skills every student should master: to ask geographic questions; to acquire geographic information; to organize geographic information; to analyze geographic information; and to answer geographic questions (Geography Education Standards Project, 1994).

Soon after the publication of *Geography for Life: National Geography Standards*, literature pertaining to geographic pedagogy increased as many geography professionals, particularly educators, sought to streamline and conceptually reorganize the numerous standards as presented in the report. The result led to development of numerous teaching methods designed to incorporate the identified standards (see Appendix A for a geography pedagogy schemata). Of particular interest to this research is the organizing concept of Place, a theme of the Five Themes of Geography (see Table 1) that were originally developed in the 1980s, and later incorporated into National Geography Standards.

Table 1. Five Themes of Geography

Theme	Question Asked	Definition
Location	Where is it?	<p>Absolute: A location can be absolute (specific) as in coordinates of a map using longitude and latitude.</p> <p>Relative: A location can be relative - examples: next door, nearby, a short drive, down the road a ways. On the other hand, it can be in the same general location as another location - example: next to the post office.</p>

Table 1 cont.

Theme	Question Asked	Definition
Place	What is a location like?	A place is an area that is defined by everything in it. All places have human and physical features that give them personality and distinguish them from other places.
Movement	How do people, goods, and ideas move?	Movement refers to the way people, products, information and ideas are moved from one place to another.
Region	What are the shared characteristics of a location?	A region is an area that is defined by certain similar characteristics. Those unifying or similar characteristics can be physical, natural, human, or cultural.
Spatial Interaction	How do people depend on the environment? How do people adapt to the environment? How do people modify the environment?	Spatial interaction looks at the relationships between people and their environment; how people adapt to the environment and how they change it.

From "Five Themes of Geography" by D. Donn, no date, at <http://geography.mrdonn.org/5themes-definitions.html>. Copyright by Mr. Donn.

Additionally, the present research utilized Salter's (1990) OSAE (Observe, Speculate, Analyze and Evaluate) method, a four step geographic teaching method for skill development in inquiry and higher order level of thinking, which also fits well with the Five Geographic Skills described in the National Geography Standards (see Table 2).



Table 2. Five Geographic Skills and OSAE.

FIVE GEOGRAPHIC SKILLS <i>-National Geography Standards</i>	OSAE <i>-Salter</i>	TASK EXAMPLE
Asking Geographic Questions	Observe	Observe the scene in question by formulating questions, i.e. What are the evident landscape patterns?
Acquiring Geographic Information	Speculate	Make a hypothesis based on questions asked.
Organizing Geographic Information	-----	-----
Analyzing Geographic Information	Analyze	What are the landscape patterns based on?
Answering Geographic Questions	Evaluate	Create statement based on observations.

More recently, the National Research Council published a report that is quickly becoming a seminal document for geographic pedagogy called, *Learning to Think Spatially*. *Learning to Think Spatially* represents a collective belief that “spatial thinking merits the focused and systematic attention of scientists and educators alike” (National Research Council, 2006, p. x.). This report arose from a concern that spatial thinking skills are not systematically taught in a formal educational setting, even though they are valuable in today’s work force and everyday life, and that there are no valid or reliable assessments dedicated exclusively to spatial thinking. As a result, the National Research Council, in its report, has called for systemic educational change. The factors previously identified were the impetus for this dissertation and was based on the National Research Council’s Recommendation 1, which states:

The ultimate goal should be to foster a new generation of spatially literate students who have the habit of mind of thinking spatially, can practice spatial thinking in an informed way, and can adopt a critical stance to spatial thinking. Meeting this long-term goal will require careful articulation of the links between spatial thinking standards and existing disciplinary-based content standards. It will necessitate the development of innovative teaching methods and programs to train teachers, together in new ways to assess levels of spatial thinking and the performance of educational support systems. (National Research Council, 2006, p. 7)

Figure 1 is a concept map that shows how the present dissertation research aligns with aspects of Recommendation 1.

### Spatial Literacy Development

Based on the development of geography and geographic pedagogy from its beginnings to the most recent call to action in *Learning to Think Spatially*, it is clear that one goal of geography pedagogy is the development of a spatially literate student. What must a student demonstrate to be considered spatially literate and how can teachers instruct for spatial literacy mastery? To find out, the following areas of literature were explored: definitions of space, the spatial development of children, types of spatial skills to be addressed in curriculum, and pedagogy most appropriate to the development of spatial literacy.

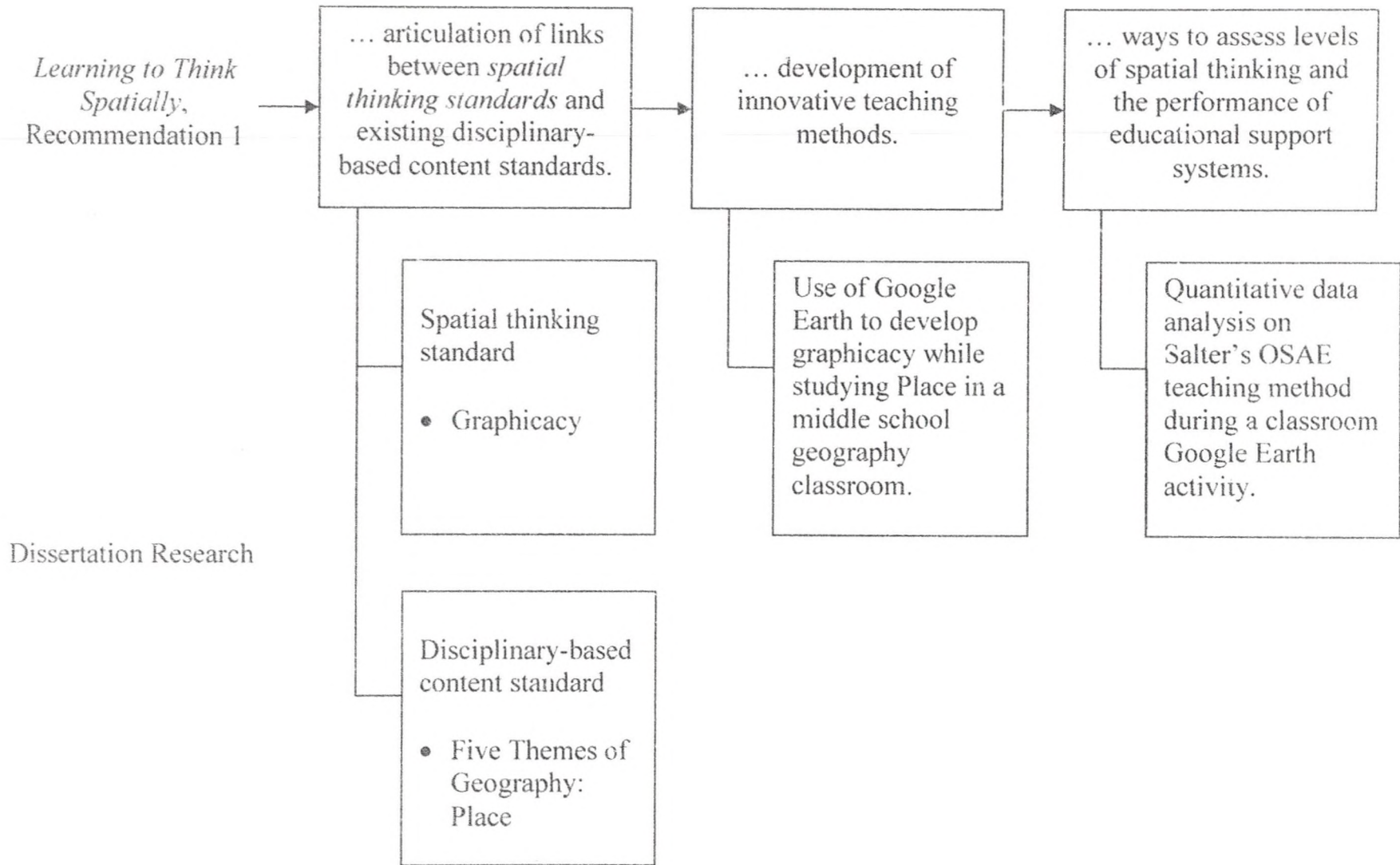


Figure 1. Aligning Recommendation 1 of *Learning to Think Spatially* to Dissertation Research

## *Defining Space*

Space is a central concept to many academic disciplines and there exists in the literature a variety of explanations as to what space is. Physically speaking, space is the infinite, three-dimensional extent in which objects and events occur and have relative position and direction (Space, n.d.). Philosophers, such as Leibniz, Kant, and Locke concerned themselves with the human perception of objects in space (Janiak, 2009), Newton saw space as an absolute — it can contain matter but exists apart from matter (Rynasiewicz, 2008), while physicist Einstein included the element of time with the concept of space to create the theory of relativity. Various mathematical theorems view space through a variety of lenses, such as geometric space or topological space. To geographers, space is a central concept used in the form of absolute, relative, and relational space (Holt-Jensen, 1999).

Geographers typically analyze space differently and use it to describe what is where and why it is there, in other words, why things, i.e. cities, exist in particular locations (Gersmehl & Brown, 1992; Holt-Jensen, 1999). Essentially, space is an idea about relationships and it can be subjective and relative “depending on the way it is structured by the mind on a particular occasion” (Boardman, 1983, p. 6). In addition to how geographers view space, of particular significance to the present research are the definitions of projective space and Euclidean space.

Projective space (also known as projective geometry) deals with perspective, more precisely, “to the way an eye or a camera projects a 3D scene to a 2D image” (Baker, 1998-2010). That is to say, projective space is the configuration of lines on a plane to make a two-dimensional image appear to be three-dimensional. Rendering or

reconstructing images in this way gives the viewer a three-dimensional perspective in computer applications such as Google Earth (for more technical descriptions of projective reconstruction or 3D visualization see Ma, Soatto, Kosecka, & Sastry, 2004; Seok, Hwang, & Hong, 2005). On the other hand, Euclidean space, another type of space, according to Boardman (1983), is “the spatial geometry of the mind in which relationships of objects in space are structured in terms of horizontal and vertical lines, squares, rectangles, triangles and circles” (p. 11). Figure 2 shows these three-dimensional perceptual differences between Euclidean and projective space, where projective space appears to have one additional dimension compared to the equivalent Euclidean space.

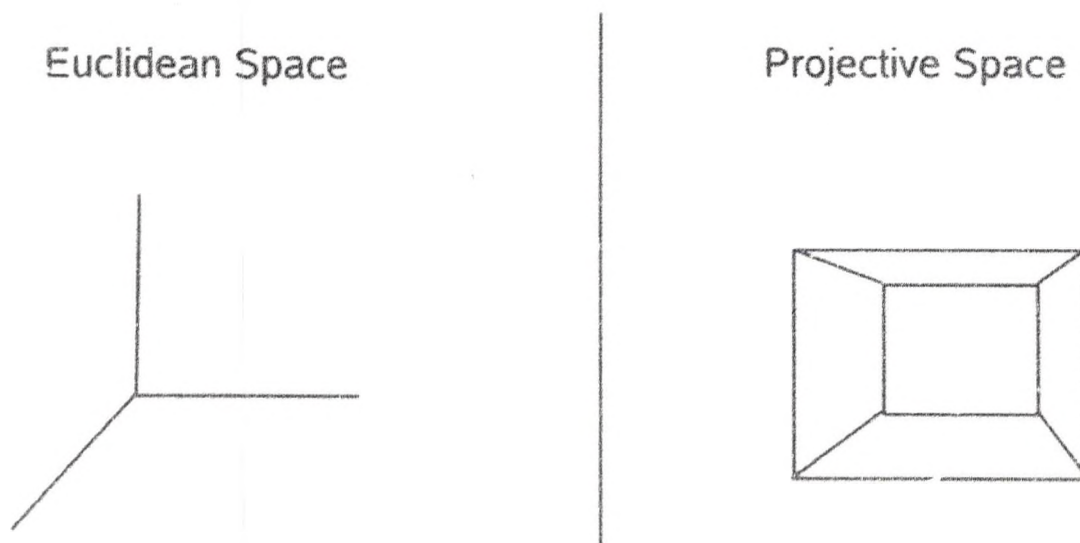


Figure 2. Euclidean and Projective Space. Adapted from “Maths – Projective Geometry,” by M. J. Baker. 1998-2010, euclideanspace website. Copyright 1998-2010 by Martin John Baker. Reprinted with permission.

## *Spatial Development in Children*

In the field of cognitive science, space is viewed as either perceptual or representational. Perceptual space is the knowledge of objects that results from direct contact with them, while representational space is when that object can be mentally generated in the absence of that object. The present research uses what Hart and Moore (1973) refer to as “the internalized cognitive representation of space, as opposed to the external representation such as children’s drawings” (p. 248).

The literature on spatial development suggests that there are various viewpoints regarding children’s cognitive spatial development. Piaget and Inhelder advocated that children are not developmentally able to conceptualize space until the latter part of the preoperational stage, the second Piagetian stage of cognitive development where the child learns to represent objects by words, images and drawings (Piaget & Inhelder, 1956). Other researchers stated the spatial abilities of young children have been underestimated (Gersmehl & Gersmehl, 2007; Newcombe & Huttenlocher, 2000) and regardless of one’s belief about when children develop spatially, many seem to agree that children’s spatial development occurs in progressive stages (Boardman, 1983; Downs, 1985; Piaget & Inhelder, 1956). Understanding what occurs at the different stages of spatial development in children is important in order to implement a developmentally appropriate teaching method because without such consideration, spatial concepts and materials may be introduced that are too advanced or too low-level for the student. One of the earliest and most widely referred to theories about children’s spatial development comes from Piaget and Inhelder (1956).

Piaget is most famous for his theory of cognitive development, which provides part of the foundation for constructivist thinking, the belief that knowledge is constructed. Piaget showed through clinical interview experiments that children move progressively through developmental stages and substages, each with a distinctive type of thinking (see Table 3).

Table 3. Piaget's Stages of Development.

Developmental Stage	Sub stage	Age in Years	Characteristics of Thinking
Sensori-motor		Birth to 2	-Egocentric -Based on physical interaction with environment -Failure to understand object permanence
Preoperational	Pre-conceptual	2 to 4	-Egocentric -Language develops -Object representation, imagination, memory
	Intuitive	4 to 7	-Formation of simple concepts -Continued language development -Egocentric, beginning of relationships/classification outside of oneself
Concrete Operational		7 to 12	-First true logical thought, i.e. conservation and reversibility, order of magnitude, symmetry, points of reference -Internalized and organized thinking -Egocentrism diminishes
Formal Operational		12 +	-Mental object manipulation -Judgment -Hypothetico-deductive -Propositional -Combinatorial

From "Graphicacy and Geography Teaching", by D. Boardman, 1983. Copyright 1983 by Croom Helm, London. Also from "Piaget's Theory of Cognitive Development," by W. Huitt, and J. Hummel, 2003, *Educational Psychology Interactive*. Copyright 2003 by Valdosta State University.

In addition to the theory of cognitive development, Piaget also wrote about other child development themes such as *Play, Dreams and Imitation in Childhood* (1951), *The Child's Conception of the World* (1929), and *The Child's Conception of Number* (1952). It is not surprising, therefore, that one is likely to find references concerning how Piaget influenced thought on the spatial development of children as well. In fact, much of today's work in the field of spatial cognition development was built upon *The Child's Conception of Space* (Piaget & Inhelder, 1956). In *The Child's Conception of Space* (CCS), Piaget and Inhelder concerned themselves with when and how children begin to visualize spatial relationships and spatial attributes of objects. It was concluded in their research that children experience space at two levels—first perceptual and then representational. Piaget and Inhelder admitted their work initially was to discover the child's development of representational space, and not perceptual space (also referred to as the internalized cognitive representation of space). Yet, Piaget and Inhelder realized that in order to understand the child's development of representational space, spatial perception prior to spatial representation needed to be explored.

It is from birth to the development of representational space that Piaget and Inhelder (1956) outlined the child's development of perceptual space, which occurs during the sensori-motor (birth to age two) stage of cognitive development. By outlining this stage, they refuted "the currently accepted explanations of the perceptual process" which at the time were centered on the mathematical "laws of spatial configuration" in the field of geometry (p. 5). Piaget and Inhelder stated that a child's development of spatial perception "involves a gradual construction and certainly does not exist



readymade at the outset of mental development” (p. 6). After exploring the development of perceptual space more closely, Piaget and Inhelder explained that this “gradual construction” of perceptual space is when children first recognize objects by touch, followed by a building up of a “spatial organization of sensori-motor behavior (that) results in new mental constructs, complete with their own laws” (p. 3). Additionally, the research Piaget and Inhelder conducted yielded results, which indicated that following a child’s initial perceptual space development (from birth to age two), spatial development occurs in three successive stages. The “first of these is topological, the second is metric and projective, and the third is on overall relationships bearing upon displacement of objects relative to one another” (Piaget and Inhelder, p. 44). These three stages of spatial development are often referred to as topological, projective, and Euclidean (see Table 4). In Table 4, each stage of spatial development presents its own unique set of abilities building upon the previous stage.

Table 4. Piaget and Inhelder’s Stages of Spatial Development

Spatial Development Stage	Approximate Age in Years	Description
Topological	4-7	Understanding and use of proximity and separation in describing connections.
Projective	7-12	Representing three-dimensional objects in two-dimensional form.
Euclidean	12 +	Distance, proportion and perspective being mastered. Draw maps and make conclusions about spatial relationships.

From “Graphicacy and Geography Teaching,” by D. Boardman, 1983. Copyright 1983 by Croom Helm in London.

A general conclusion drawn by Piaget and Inhelder (1956) during CCS supports the notion that spatial concepts are developed through actions, which will later be explored through the theory of situated cognition. Ultimately, Piaget and Inhelder concluded that spatial thinking occurs in sequential stages and:

The “intuition” of space is not a “reading” or apprehension of the properties of objects, but from the very beginning, an action performed on them. It is precise because it enriches and develops physical reality instead of merely extracting from it a set of readymade structures, that action is eventually able to transcend physical limitations and create operational schemata, which can be formalized and made to function in a purely abstract, deductive fashion. From the rudimentary sensori-motor activity right up to abstract operations, the development of a geometrical intuition is that of an activity, in the fullest sense, beginning with adaptive actions, which link it with object, and at the same time, assimilate the object to its own functional structure, transforming it in the process as completely as geometry has transformed physics. (p. 449)

Since the pioneering work of *The Child's Conception of Space*, other research has emerged on the topic. One study (Herman & Siegel, 1977) built upon the pioneering work found in *The Child's Conception of Space*, showed that children appear to develop accurate spatial representation of an environment, on many scales, by physically walking through that environment. It has also been shown that with practice, younger children show evidence of a working knowledge of Euclidean spatial relations (Boardman, 1983; Golledge, Gale, Pellegrino, & Doherty, 1992; Miller & Miller, 1970; National Research Council, 2006; Ornkloo & von Hofsten, 2007; Siegel & White, 1975), well before

Piaget's formal operational stage, when Piaget and Inhelder (1956) believed Euclidean spatial development begins. These particular research studies that show young children to use Euclidean spatial skills focused on the tasks asked of children in CCS. It was concluded that the questions were non-purposeful during the CCS study, as the children Piaget and Inhelder worked with did not understand what was being asked of them and were therefore unable to accomplish particular spatial tasks (Boardman, 1983)—it was a communication barrier on the child's part, not of spatial development. Regardless, Piaget and Inhelder were key theorists as they were among some of the first researchers to quantify spatial cognition development.

After *The Child's Conception of Space*, Downs (1985) stated a trend had emerged in spatial cognition development research that focused only on “basic concepts, models, techniques, and data sources” (p. 323); development of theoretically based pedagogy to grow spatial skills in students was lacking. It is only recently that efforts to systematize concepts of spatial thinking began in the domain of geographic education. As was previously stated, literature suggests that even though there are differing viewpoints as to what a child knows and can learn spatially and when they learn it, there is a consensus that children do experience spatial development in stages. It would therefore seem practical to have students develop spatial skills that were aligned to their present cognitive development stage (Downs, Liben, & Daggs, 1988), however, it will be necessary to first identify the spatial skills that students need to develop in order to be considered spatially literate.

## *Spatial Skills*

If one were to ask someone what he or she considers a spatial skill, the answer would probably depend on whom you were asking. Just as there are a variety of ideas and thoughts on space, there are just as many examples of spatial skills. Mathematicians may tell you someone would need to know the Pythagorean Theorem, Geographic Information System specialists may comment on the need to navigate, neuroscientists could say someone with dyslexia would need to decode spatially various pieces of information for brain processing. Although these and many more spatial skills are important to acquire, “students learn the meanings and uses of concepts relevant to spatial thinking in the context of specific disciplines or school subjects” (National Research Council, 2006, pp. 18-19). It is important to note here that the present research is concerned with spatial skills and concepts as they pertain to geography, rather than mathematics, which views space as something to understand the physical universe, a geometric abstraction. This is different from philosophers, who debate whether space is a substance or relation. These examples stress the point that there are many types of space and methods in which to study space. For geography, one spatial skill of interest to the present research study is graphicacy, which is the ability to understand and generate information about spatial relationships. An example of graphicacy found in geography would be the ability to use, interpret, and create maps, photographs, diagrams, and/or graphs.

Additionally, spatial skill development in the field of geography itself has changed over time. In the earlier part of the 20<sup>th</sup> century, Golledge (2002) states that for

the most part, “geographic knowledge has been declarative—i.e., it has focused on collecting and representing the human and physical facts of existence”. In the latter part of the century, geography has changed from this declarative data collection to knowledge generation through cognitive processes, “such as understanding ‘why’ and ‘how’ in addition to ‘what’ and ‘where’ ” (p. 1). In order to answer these hallmark questions of geographers, “What is where and why it is there?” (Kerski, 2008b), one must be competent in a variety of spatial thinking skills (see Table 5).

Table 5. Summary of Spatial Thinking Skills Related to Geography.

- 
- Detect spatial patterns and regularities.
  - Depict and interpret spatial information.
  - Use and create new representational modes to convey spatial data.
  - Combine multiple kinds of spatial and nonspatial information.
  - Hold large amounts of spatial information in mind at one time while browsing data.
  - See and describe connections between observable or inferred spatial patterns and distributions.
  - Evaluate and predict causes for the existence of spatial patterns.
  - Understand concepts dealing with the relationship between the three-dimensional Earth and two-dimensional maps, distance properties, orientation, direction, regions and location.
- 

From “Learning to Think Spatially”, by the National Research Council, 2006. Copyright 2006 by the National Academies Press. Also from “Spatial Thinkers Must Ask Questions,” by J. Kerski, 2008b, *Perspective*, 36(4), p. 17. Copyright 2008 by the National Council for Geographic Education.

### *Spatial Skill Pedagogy*

In regards to spatial skill development in geography curriculum, students can learn directly in formal educational settings, i.e. classrooms, and indirectly throughout one's lifetime, on the account that geography is a discipline where students must be able to contextualize vast amounts of geographic knowledge to real world situations and places. This is important to keep in mind because research suggests (Baker, Hope & Karandjeff, 2009; Cordova & Lepper, 1996) that contextualizing information produces increases in students' motivation and engagement in learning, which in turn can create meaningful learning experiences and allow students to practice applying knowledge to real world situations. When one considers that geography is a discipline where spatial knowledge needs to be contextualized and that children develop spatial skills in cognitive stages as per Piaget and Inhelder (1956), any pedagogical method for teaching spatial skills should address these points. It would then seem reasonable that geography teachers need to consider geographically relevant and developmentally appropriate pedagogy that fosters the development of spatial skills in their students. Based on the educational theories in existence, a teaching strategy grounded in constructivism theory can be appropriate for developing spatial literacy because the nature of constructivism lends itself to encompass the exploratory and idea-generating characteristics found in the field of geography.

#### Constructivism-Situated Cognition

Of the existing educational theories and theorists, the scope of this section of the literature review was limited to constructivist ideas. This is because research studies conducted indicate that social studies skills (which includes geography) and classroom

participation increase with various forms of constructivist inspired pedagogy (Akengin, 2008; McCray, 2007; Stears, 2009). To summarize, constructivism is a theory of knowledge that suggests comprehension and meaning comes from an individual's experiences. It should be noted here that within constructivism, there are different perspectives about how the individual learns. Cognitive constructivists place great value on knowledge construction by an individual, while social constructivists believe that knowledge construction is a shared, rather than an individual experience (Apedoe & Reeves, 2006).

For spatial skill development in geography, it would seem appropriate to then find a particular constructivist educational theory that addresses the exploratory nature of academic geography and the need for contextualization. One such constructivist theory is situated learning, sometimes referred to as situated cognition. Situated learning is grounded in Vygotsky's Zone of Proximal Development (ZPD) and Gibson's *Theory of Affordances* (Gibson, 1977), both of which call for students to contextualize learning. In other words, situated learning provides the opportunity for contextualization. Moreover, it would then be up to the instructor to implement student activities that matched up with the appropriate spatial development stage (perceptual, topical, projective or Euclidean). Therefore, using situated learning theory with developmentally appropriate activities in a geography curriculum could lead to increased spatial skills.

#### *Vygotsky's Zone of Proximal Development*

One educational theory that situated learning encompasses is Vygotsky's Zone of Proximal Development (Vygotsky, 1978). Vygotsky believed that education should provide students experiences that are in their ZPD, which is "the gap between what a

learner has already mastered and what he or she can achieve when provided with educational support” (Coffey, 2009, p. 1). In other words, ZPD is the distance between actual development and potential development. It is in the ZPD where instruction or guidance should be given by experts, those who already “know”, to allow a child to develop skills they will then use on their own (Cole & Wertsch, 2007).

In relation to situated learning, Cole and Wertsch (2007) help us understand the role of contextualization in ZPD theory; it is this point that helps one to connect ZPD and situated learning:

An important aspect of this (ZPD) is that less capable participants can participate in forms of interaction that are beyond their competence when acting alone...Of course, tutees operate within constraints provided in part by the more capable participants, but an essential aspect of this process is that they must be able to use words and other artifacts in ways that extend beyond their current understanding of them, thereby coordinating with possible future forms of action. If we ask what makes such intermental functioning possible, we must certainly speak about issues such as context. (p. 6-7)

### *Gibson's Theory of Affordances*

American psychologist, James Gibson, was “one of the most distinguished visual perceptionists of the twentieth century” who provided “an ecological approach to psychology” and “the basis for a new understanding of our place in the world” (pp. 1-6). One of Gibson’s notable works is the *Theory of Affordances*. According to Learning Theories Knowledgebase (2010):



Affordance theory states that the world is perceived not only in terms of object shapes and spatial relationships but also in terms of object possibilities for action (affordances) — perception drives action. According to Gibson's theory, perception of the environment inevitably leads to some course of action.

Affordances, or clues in the environment that indicate possibilities for action, are perceived in a direct, immediate way with no sensory processing. Examples include buttons for pushing, knobs for turning, handles for pulling, levers for sliding, etc. (para. 1).

### *Situated Cognition*

Situated cognition, because of its focus on contextualization and constructivism, is a theory to be considered for geographic education because of the potential for increased spatial skill development and student engagement. Brown et al. (1989) are often credited with developing situated cognition as a model of instruction. However, Oliver (1999) argues that the ideas of situated cognition are not new, as Dewey and Vygotsky both advocated similar approaches to instruction before Brown et al. in 1989. According to Oliver, Vygotsky thought learning tasks should be situated (contextualized) in a student's zone of proximal development (ZPD) and Dewey was a believer of situated approaches to learning, arguing that understanding is defined within a social entity. Regardless of who developed situated cognition, it is easily distinguished from the individualism of behaviorist, cognitive, and constructivist psychology, because it questions the argument that learning is only an internal or psychological activity characterized by individuals accumulating knowledge and skills (Niewolmy & Wilson, 2009). Grounded in Vygotsky's ZPD and Gibson's Theory of Affordance, situated

cognition, also referred to as situated learning, is a theory of instruction that suggests significant learning will “only take place if it is embedded in the social and physical context within which it will be used” (Herrington & Oliver, 1995). In other words, learning cannot be separated from the context in which it is learned (Lave & Wenger, 1991).

Additionally, many questions do arise in the literature about situated learning theory, particularly in a research meta-analysis by Hodkinson, Biesta and James (2007).

Hodkinson et al. point out five weaknesses with situated learning theory:

1. Tendency for individual differences and individual learning to disappear, with the focus on social interactions, activities and participation
2. Tendency to focus on the particular site where learning takes place (such as a specific workplace), thus bracketing off and largely ignoring wider social, cultural and structural influences.
3. Tendency to downplay issues of inequality and power relations within and beyond the site.
4. Tendency to separate out the agency of individual learners from the social structures that they are seen to inhabit, focusing on one or the other, not both.
5. Tendency for the majority of post-Vygotskian research and theorizing on learning to retain a concentration on cognition, rather than seeing learning as practical and embodied. (2007)

An additional criticism of situated learning theory found in the literature is its lack of evidence showing learning transfer, that is, the ability to use skills learned in one

environment (situation) in a different environment. Langer (2009) argues situated learning theory has shown no evidence of transfer and states "If 'situated' morphs into a particular kind of learning in which the issue of transfer is either not significant or a non-outcome, then it clearly has little or no value for schooling" (p. 190). Further substantiating the problem of knowledge transfer, Lave, a leader in situated learning theory, found that transfer did not occur between two mathematical activities where the problem solver is agent and on paper where the problem solver is the object of the exercise. That is, experience in real-life (what was the best purchase in a supermarket) did not transfer to schoolwork (Clancey, 1995). Perhaps these criticisms by Clancey (1995) and Hodkinson et al. (2007) came about because there appears to be a lack of empirical research on the topic of transfer in situated learning theory. It could be argued that transfer has not been a subject of empirical research (Langer, 2009) because the pioneers of situated learning theory (Lave & Wenger, 1991; Brown, Collins & Duguid, 1989) did not consider transfer as something that needed to be measured for the legitimacy of the theory.

Despite what critics of situated learning state, Collins (1988) notes there are four benefits of situated cognition as a theoretical basis for learning. First, students learn about the circumstances for applying knowledge. Second, students are more likely to engage in invention and problem solving when they learn in novel and diverse situations and settings. Third, students can see the implications of knowledge. Finally, students are supported in structuring knowledge in ways appropriate to later use by gaining and working with that knowledge in context (as cited in Brill, 2001). So, what are ways in which instructors can situate geographical topics in light of the benefits of situated

cognition while teaching graphicacy and Place understanding using Salter's OSAE method, a main goal of this research? One traditional pedagogical method in geography that fits these guidelines is field immersion, more commonly known as the field trip.

### *Field Immersion as Situated Learning*

Field immersion is a common practice in professional geography; it is the heart of study abroad programs, language camps, and anthropological ethnographies. In geography, field immersion provides an authentic situated learning environment where students can develop graphicacy skills and distinctive techniques for observation, analysis and display—all hallmarks of geography (National Research Council, 1997) and fundamental to understanding Place geography. However, providing field immersion experiences for students often costs more time and money than school districts are willing to afford, especially in times where high-stakes testing of a student's knowledge is the norm. Such a view is detrimental and supports what Kitchens (2009) calls a pedagogy of placelessness, the idea that students "are not often asked to consider or grasp the web of relations that affect the spaces in which they live" (p. 255)

Pedagogy of placelessness is a view held by some critical geographers and best described by Gruenwald (as cited in Kitchens, 2009) as the lack of a connection to or appreciation of places. This pedagogy of placelessness is due to today's school structure; a structure that inherently isolates students and teachers from places outside the school, therefore limiting student's experiences and perceptual development. In the case of geography, knowledge is often learned in abstraction, that is. students learn about the world from textbooks, not from real world immersion. In order to counter this lack of connection, Kitchens (2009) argues for a critical pedagogy of place where "educators

must act specifically to orient students in places by situating the curricular content in the everyday lives of students” (p.255). Such a place-based curriculum advocated by Kitchens can be possible, without the added expenses of time and money that comes from true field immersion experience, by utilizing existing classroom technology. One such technology is the three-dimensional world of Google Earth.

Google Earth, a free web-based technology, can take students to places near and far away, virtually, in order to explore and understand Place. Google Earth could virtually situate a student in an environment that would allow them to practice graphicacy skills, such as Salter’s OSAE method, which in turn provides one the opportunity to make connections and expand their perceptions of the world. However, no quantitative research exists to show Google Earth’s impact on students’ spatial literacy and Place understanding. This lack of quantitative data on Google Earth in the classroom provided momentum for the present research and the preceding literature review.

### Summary

This chapter summarized the literature related to the evolution of geography pedagogy, spatial literacy, and situated cognition, in order to develop a theoretically grounded quasi-experimental study to address the NRC’s call to action. As was shown, the field of geography and geography pedagogy has changed throughout time. From its beginnings some 2,500 years ago, geography as a discipline would gain and lose academic prominence in society. Today, geography is recognized as a required subject in United States schools, as seen in the Goals 2000: Educate America Act (1994). However, spatial literacy advocates such as the National Research Council (NRC) Committee on Support for Thinking Spatially are determined to bring attention to the

development (or lack thereof) of spatial skills in today's K-12 curriculum. The child's development of spatial skills has long been the subject of theorists such as Piaget and Inhelder and practitioners such as Boardman or Downs. It is only recently that spatial literacy has been defined and spatial skills identified (see Kerski 2008a, 2008b) to be incorporated into geography curriculum.

The present research proposes that a geography curriculum be based on a conceptual framework that takes into consideration Piaget and Inhelder's findings in *A Child's Conception of Space*, and that such a curriculum include spatial activities that are developmentally appropriate. It is also proposed that situated learning, a constructivist theory, be considered as the pedagogical method of spatial literacy development, as it appears to be best suited for the exploratory nature of geography.

The following chapter will discuss the methods and procedures for testing whether using Google Earth for its real-world immersion qualities as an instructional method is different than using two-dimensional world representations in teaching about Place geography. By using Google Earth for immersion, situated learning theory is incorporated into the geography curriculum to develop the spatial skill of graphicacy. The activities developed for this experiment were created to be developmentally appropriate for eighth graders, following Piaget and Inhelder's suggestion that children this age (12 to 14 years old) have mastered distance, proportion and perspective and are able to draw maps and make conclusions about spatial relationships.

## CHAPTER III

### METHODOLOGY

This chapter will describe the methodology and procedures used in this research project. The purpose of this study was to determine the extent to which Place geography and spatial literacy scores of students who use 3D Google Earth are different from students who are provided with only two-dimensional instruction for developing such skills. Studying the effects of using Google Earth with eighth grade geography students could provide educators with research-based justification to use 3D internet-based technology in the classroom and begin to answer the National Research Council's (NRC) (2006) call for the development of a systematic spatial literacy educational program. Researching the use of Google Earth in the classroom to develop spatial skills with situated cognition as a theoretical framework provided for a unique research-based experiment. This research is a quantitative, quasi-experimental study.

#### Survey Instrument

As previously stated, no quantitative research exists to show Google Earth's impact on students' spatial literacy and Place understanding. Literature reviewed prior to this research indicates that there are varieties of spatial comprehension tests, mainly those administered to predict job performance (PsyAsia International, 2010; Psychometric Success, 2009). Several of these types of spatial comprehension questions were incorporated into the survey. Additionally, elements of a spatial skills test geared

towards students (Spatial Skills Test Version 5. n.d.) were adapted for a portion of this research's survey instrument. The remaining questions were developed by the author to assess student performance in meeting geography standards and to address specific research questions.

For purposes of this research, the survey instrument was divided into three sections. The first section collected demographic information. The second section was comprised of questions selected to determine the extent of a student's ability to organize spatial information. The third section measured student's Place understanding and spatial literacy-graphicacy. In the second and third section of the instrument, two sets of directions were developed. These directions were geared towards whether the student was in the Google Earth or PowerPoint group; however, the questions remained the same for both groups. Each question of the instrument was coded for identification, the code can be found in italics immediately following the question in Appendix B.

#### *Section A – Demographic Information*

The demographic section of the survey instrument was intended to present a summary profile of the sample population. Questions were aimed at gathering details that could have an effect on student responses to survey items. The demographic portion of the survey instrument collected data about the respondents age, gender, use of technology (internet, cell phone, television, computer, video games), if they used Google Earth before, a personal assessment of their technology proficiency and a six-point Likert scale measuring their attitude on map reading, country locations, Google Earth and geography application.



### *Section B – Spatial Organization Ability*

Questions determining students' ability to organize spatial information measured mental rotation skills, way-finding and real world representations. These specific questions were chosen from the literature reviewed because students are asked to mentally manipulate two-dimensional shapes via mental rotation, follow spatial directions requiring way-finding skills using a two-dimensional map, and visualize real-world representations (3D) in order to classify the spatial data for map representation (2D). Spatial organizational ability was measured to provide further analysis and explanation to respondent's answers on the survey instrument.

### *Section C – Student's Place Understanding and Spatial Literacy-Graphicacy*

In the third section of the survey instrument, students were asked a variety of questions that measured their level of Place understanding and graphicacy. Students answered a series of questions using images of Manaus, Brazil to measure how they would predict and understand spatial patterns and spatial relationships. Using the Observe, Speculate, Analyze, Evaluate (OSAE) method (Salter, 1990), students answered questions which measured their understanding of Place and the demonstration level of their Place descriptions (see Appendix C for Place descriptions grading rubric).

### Target Population

The target population ( $N = 84$ ) for this study consisted of eighth grade students in a geography course at an upper Midwest Jr. High School. This study was restricted to four sections of geography, in one instructor's class at one school site. All students who participated in this study did so during the 2009-2010 academic year.

## Instrument Design

In an attempt to ensure age-appropriate survey questions, the author used the Flesch-Kincaid Grade Level Readability Test (My Byline Media, 2010) to edit the layout and wording of the questions in Microsoft Word, keeping readability level to grade 8 and under. Questions were constructed to make them unambiguous and easy to follow, taking into consideration the student's prior learning experiences. Length of the survey instrument was also considered, with one of the three instrument sections (Demographics, Spatial Organization Ability, Student's Place Understanding and Spatial Literacy-Graphicacy) being completed during one 50-minute class period. Each question in the instrument helped to answer one of the following research questions, as shown (also see Appendix D):

1. To what extent will students be able to predict spatial patterns based on their observations? *Questions M1, M2, M4, M5, M6, O4, O6, O8*
2. How do students understand spatial relationships based on teaching methodology? *Questions M7, O1b, O1c, O5, O10*
3. In what ways will students demonstrate their understanding of spatial relationships using Google Earth compared to traditional two-dimensional uses? *Questions M3, O3, O9, O11*
4. To what extent are students able to organize information based on what is observed? *Questions Q1 through Q13*
5. In what way(s) will students' understanding of Place differ based on what is observed between the uses of two instructional methodologies?  
*Questions O1d, O1e, O2, O7*

## Validity

To enhance validity, members of the Minnesota Alliance for Geographic Education (MAGE), a group of geography education professionals comprised of teachers and professors, were asked to evaluate the survey instrument and comment on question clarity, age-appropriateness of the questions, length, and content validity. The comments and suggestions from MAGE members helped ensure the questions were asking for the information sought. Several suggestions included rewording questions to better align with the targeted age group and provide clearer graphics. Overall, MAGE members felt this survey would elicit desperately needed data that would inform the development of spatial literacy curriculum

Additionally, to help ensure content validity, questions and their related activity were aligned not only to the research questions, but also to the National Geography Standards (see Appendix E).

## Pilot Test

To further establish validity, a pilot study was conducted with two classes of eighth-graders ( $N = 35$ ), one science class and one social studies class at an upper Midwest Jr. High School. Students were asked to complete the survey questions and to comment on anything they found confusing—such as directions, question wording—and what they liked or disliked about the survey instrument activity and if they had used Google Earth before or not. Additional changes to the wording of questions and clarity of activity directions were implemented based on comments. Due to these survey instrument changes, pilot test responses were not included in the final data analysis. Additionally, Question 13 (Q13) was eliminated in the final item analysis, as it was

determined student's lacked prior geographical knowledge regarding birth rate and death rate, thus leading to student frustration and lack of effort on their part to answer Q13.

### Reliability

To show that the scores from the survey instrument were consistent, Cronbach's Alpha was used to test internal consistency and coefficient reliability. The statistical analysis provided a score on the 33-item instrument at .76. This score shows that the instrument is reliable, as .70 is considered acceptable in most social science research (UCLA Academic Technology Services, 2007).

### Ethics Approval

Appropriate Institutional Review Board (IRB) approval was obtained from the principal at the participating school after thorough review of the survey instrument. As the present research included normal educational practices, signed student consent forms were not mandatory; however, a letter was sent home to each student's parent/guardian explaining the procedure (see Appendix F). Additionally, approval was sought and granted by the University of North Dakota's IRB, where this dissertation has been submitted.

### Data Collection

In early January, 2010, parents/guardians of research participants were notified their child would be participating in a series of geography related activities that were part of the regular curriculum and the student responses would be collected and analyzed in a research study. Research participants were administered a different section of the instrument at three different times beginning in mid-January 2010. Between each section of the administered instrument, all students participated in lessons relevant to the

technical use of Google Earth and practicing the OSAE method of geographic observation. Before each section was completed, the instructor read aloud the directions and asked students if they needed clarification about the test directions. Students were reminded they could only ask help to read a question and the teacher would not be able to give them the answer to any question, and this was reiterated that their score on these tests would not affect their grade in geography class, but students must participate in the activity.

The first instrument section students completed was during one 50-minute class period. This part of the research was comprised of the Demographics and the Spatial Organization Ability (Q1 through Q13) section questions.

Next, students practiced OSAE skills with the teacher's assistance in the classroom during one class period (see Appendix G for activity) before completing the second section of the instrument. The second section of the instrument was completed in one 50-minute class period and asked students to answer questions (M1-M7) based on their observations and use of OSAE skills about Manaus, Brazil. It is at this point of the research study where two groups were formed for data collection. One group of students ( $n = 40$ ) used Google Earth, with its 3D capability and scenery manipulation, to answer their questions, while the other group ( $n = 44$ ) used 2D PowerPoint images to answer their questions. Each of these groups became two levels of the independent variable (instructional method) during the data analysis.

In addition to the teacher-led OSAE lesson, all students (not withholding potentially beneficial treatment) began instruction on how to use Google Earth (see Appendix H for activity) as a research tool over two 50-minute class periods. Google

Earth lessons were geared to make sure students could perform the basic functions of the program to minimize a potentially negative effect on student responses to the survey instrument if the student did not know how to control Google Earth. To ensure all students had a basic working knowledge of Google Earth, students were asked to demonstrate their understanding after the series of activities. All students must have passed their Google Earth demonstration (see Appendix I) before moving into the final section of research study.

The final section of the research questions (O1a through O11) collected data about the student's Place understanding and spatial literacy-graphicacy. Again, students were in two groups (those who used Google Earth ( $n = 40$ ) and those who used PowerPoint ( $n = 44$ )) to see if the instructional method had an effect on responses.

#### Data Preparation

Instruments for all students were evaluated for missing information and inconsistencies. Of the 87 respondents, 84 completed the entire survey. Three respondents had more than seven questions missing (due to absences) and those scores were dropped before the final data analysis. Students who failed to answer a question (Q1-Q13, M1-M7, and O1b-O11) were scored incorrect; as that would have been the procedure should the student have taken the test under other circumstances. Four students failed to answer the previous use of Google Earth question, and were scored with the mean response for that question ( $m = .70$ ; see Table 6).

## Data Analysis

All data were entered and coded by hand into SPSS, a statistical program. Every 10<sup>th</sup> survey was double-checked for data entry accuracy. Data was also saved as a Microsoft Excel program database, where missing values and inconsistencies were

Table 6. Mean Score for Missing Google Earth Response.

		SMEAN (Google Earth before)			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	24	28.6	28.6	28.6
	.70	4	4.8	4.8	33.3
	1.00	56	66.7	66.7	100.0
Total		84	100.0	100.0	

double-checked. A codebook was created to assign numerical values to multiple-choice questions where answers were either correct = 1 or incorrect = 0. For questions that required students to write out their response, a grading rubric was developed to assign a numerical value to the student's response (see Appendix C) in order that these responses could be added to the statistical program quantitatively. Separate spreadsheet files were created in order to gather a student's average score per research question.

All statistical calculations were performed using SPSS for Windows, version 18.0 on a personal computer. Statistical tables were created using SPSS and then copied into Microsoft Word.

## CHAPTER IV

### RESULTS

The purpose of the present study was to determine the extent to which graphicacy achievement scores of students who use 3D Google Earth (experimental) are different from students who were provided with traditional two-dimensional instruction (control) for developing such spatial skills. In this quasi-experimental independent group design, the target population ( $N = 84$ ) consisted of eighth grade students that were previously divided into four classes for one instructor's teaching assignment during the 2009-2010 school year. These students were then further divided into the control and experimental group based on the number of subjects in each individual class, in order to achieve a balanced number of subjects in each group (control  $n = 44$ , experimental  $n = 40$ ). Demographic data was collected in a one 50-minute class period for each student. Following the demographic data collection, the remainder of the instrument responses was collected on two separate occasions, each during a 50-minute class period.

It should also be noted that this instrument and resulting analyses are limited in that it can only speak to a population of eighth grade geography students in the upper Midwest.

#### Demographics

A total of 84 cases of eighth grade geography students were analyzed for this study. Of those, male students made up 48.8% ( $n = 41$ ) of the group and females made



up 51.2% ( $n = 43$ ) of the group. Of the eighth graders studied, 39.3% ( $n = 33$ ) were 13 years old, 57.1% ( $n = 48$ ) were 14 year olds, while 3.6% ( $n = 3$ ) were 15 years of age.

Students were asked to rate themselves on the amount of weekly technology use by five-hour increments in the following areas: internet, cell phone, television, computer (not including internet use), and video game (see Appendix J for results). This particular data was collected to show the amount of time students are engaged in certain types of technology, so that grounded generalizations could be made about the target population in the conclusion section of this study. Each hour of technology use was SPSS dummy coded (Cronk, 2006) as: zero = none; 1 = 0 to 5 hours; 2 = 6 -10 hours; 3 = 11 - 20 hours; 4 = 20 + hours.

Based on the mean of these coded hours it can be inferred that, overall, students used cell phones ( $M = 2.26$ ,  $SD = 1.45$ ) more frequently during a week, followed by television ( $M = 1.87$ ,  $SD = .95$ ), internet ( $M = 1.80$ ,  $SD = 1.11$ ), computer ( $M = 1.60$ ,  $SD = 1.01$ ) and video games ( $M = 1.06$ ,  $SD = .91$ ; see Table 7). Of interest to the present research is the student's use of the internet and computer, as those data could have an impact on a student's response to the survey instrument. This is because research has shown that cognitive overload occurs when students are trying to learn technology skills and another skill simultaneously, thus student learning is negatively affected (Chang & Ley, 2006; Wang, 2006). Based on the data collected, it will be important to keep in mind that internet and computer use in these particular eighth gradestudents were behind cell phone and television use, signaling a potential cognitive overload effect on instrument reponses.

Table 7. Demographic Information: Coded Hours of Self-Reported Student Use of Technology.

	<i>N</i>	Mean	Std. Deviation
Internet	84.00	1.80	1.11
Cell phone use	84.00	2.26	1.45
Television use	84.00	1.87	0.95
Computer use	84.00	1.60	1.01
Video game use	84.00	1.06	0.91
Experience with computer technology	84.00	2.43	0.83
Used Google Earth before	84.00	0.70	0.45
Valid <i>N</i> (listwise)	84.00		

However, to measure the possibility of cognitive overload affecting responses in a more direct way, students were asked to rate themselves on experience with computer technology (See Table 7). Each response for experience with computer technology was dummy coded for SPSS as follows: zero = none; 1 = novice: just starting to use computers (less than two years); 2 = intermediate: been using computers for at least two years; 3 = proficient: using computers for two or more years and can teach others about computers. The results indicate that 90.4 % ( $M = 2.43$ ,  $SD = .83$ ) of students ranked themselves as Intermediate or Proficient, possibly indicating that cognitive overload due to lack of experience with computer technology would not have an influence on student responses.

Next, students were asked to state whether they had used Google Earth before (See Table 7). Each response was coded for SPSS as follows: zero = no; 1 = yes. Four non-responses were coded with the mean of all responses ( $M = .70$ ). Over half ( $n = 56$ ,

66.7 %) of the students responded they had used Google Earth before. Again, this indicates there could be a possible affect on student responses due to cognitive overload (knowing how to use Google Earth in order to answer questions). In order to minimize this potential affect, all students participated in activities designed to teach them the basics of Google Earth and all had to pass a Google Earth test before continuing in the study (see Appendices H and I).

To conclude the demographic section of the survey, students were asked to rate their responses on a six-point Likert scale to four questions (See Table 8). Each of these questions was designed to gather information on the general attitude students held towards geographic skills and the application of those skills.

Table 8. Demographic Information: Likert Scale

Please rate each of the statements below by circling the appropriate option on the right.	Strongly Disagree	Disagree	Some What Disagree	Some What Agree	Agree	Strongly Agree
Knowing how to read a map is an important skill.	1	2	3	4	5	6
It is important to know where countries in the news are located.	1	2	3	4	5	6
It is important to know how to use Google Earth technology.	1	2	3	4	5	6
It is important to have an understanding of geography because people are better able to decide where to live and work.	1	2	3	4	5	6

Each point on the Likert scale was entered into SPSS and descriptive statistics were run. For the first question, “Knowing how to read a map is an important skill”,

most students (36.9%,  $n = 31$ ) responded with "somewhat agree," followed by "agree" (29.8%,  $n = 5$ ) and "strongly agree" (19%,  $n = 16$ ). For the sample of students, the mean score on this question is 4.4 and the standard deviation is 1.2. The distribution is normal, positively skewed. The next question, "It is important to know where countries in the news are located", was more evenly distributed, with most of the students ( $n = 29$ , 34.5 %) responding as "somewhat agree". For the sample of students, the mean score is 4.2 and the standard deviation is 1.1. The distribution is normal, positively skewed. Responses to the third question, "It is important to know how to use Google Earth technology", indicates students appear to split whether they agree or disagree. For the sample of students, the mean score on this question is 3.7 and the standard deviation is 1.1. The distribution is normal, negatively skewed. Finally, responses to the final question, "it is important to have an understanding of geography because people are better able to decide where to live and work" indicates most students fall into either the "somewhat agree" ( $n = 26$ , 31 %) or "agree" ( $n = 29$ , 34.5 %) category. For the sample of students, the mean score on this question is 4.4 and the standard deviation is 1.1. This distribution is normal, negatively skewed.

### Instrument Results

Results for each of the five research questions developed for the study were analyzed for statistical and practical significance. To analyze for statistical significance, ANOVAs were conducted on the data, while a comparison of means was used to determine practical significance. It should be noted here that practical significance is defined as data that informs educational practice as opposed to statistical significance. The independent variable for the present research was the instructional method used

(Google Earth-experimental or PowerPoint-control) during a geography unit on South America. Google Earth provided students the ability to maneuver virtually around the environment being studied in order to answer questions, allowing the student to view in projective space (three-dimensional), whereas PowerPoint remained a static, two-dimensional image. It was believed at the outset of this research study that the student use of Google Earth would produce different student responses from those students who used the traditional method of PowerPoint during the South American unit. The dependent variables are student answers to the instrument questions. When reading the tables, GE = Google Earth and PPT = PowerPoint.

#### *Research Question 1*

Research Question 1 was developed to determine the extent that the control and experimental group students would predict spatial patterns based on their observations. Responses to survey questions M1, M2, M4, M5, M6, O4, O6 and O8 were used as eight dependent variables to yield data for Research Question 1. These eight dependent variables (DV) are assumed to relate to each other, as they each ask students to predict spatial patterns. The responses to these questions were dummy coded for SPSS as follows: 0 = wrong, 1 = correct. Next, each student's response on the eight variables was computed to create a mean student score for Research Question 1. This mean score for each student then became the dependent variable.

The Research Question 1 means of students who answered questions using either Google Earth or PowerPoint (instructional methods) were compared using a one-way ANOVA. No significant difference was found ( $F(1, 82) = .00, p > .05$ ). The students from the two different groups did not differ significantly due to instructional method.

Perhaps more informative is the means comparison, as shown in Table 9, between groups on each question used to answer Research Question 1. On questions M1, M2, M5, M6 and O6 the experimental group had a higher mean, while the control group only scored higher on three questions, M4, O4 and O8. In other words based on mean results, of practical significance is that the experimental group scored a 63% on Research Question 1, while the control group scored 38% on Research Question 1.

Table 9. Research Question 1 Means Comparison by Question.

GE or PPT		M1	M2	M4	M5	M6	O4	O6	O8
PowerPoint	Mean	0.77	0.91	0.73	0.84	0.73	0.70	0.75	0.77
	Std. Deviation	0.42	0.29	0.45	0.37	0.45	0.46	0.44	0.42
Google Earth	Mean	0.80	0.97	0.63	0.85	0.85	0.65	0.85	0.60
	Std. Deviation	0.41	0.16	0.49	0.36	0.36	0.48	0.36	0.50

### *Research Question 2*

Research Question 2 was developed to analyze how students understand spatial relationships based on instructional method. Responses to survey questions M7, O1b, O1c, O5 and O10 were used as five dependent variables to yield data for Research Question 2. These five dependent variables are assumed to relate to each other, as they measure students understanding of spatial relationships. Again, each student's response on the five variables was computed to create a mean student score for Research Question 2. This mean score for each student then became the dependent variable.

A one-way ANOVA was calculated on Research Question 2 mean student scores to examine the effect of instructional method (Google Earth or PowerPoint) on questions

M7, O1b, O5 and O10 and O1c. No significant difference was found ( $F(1, 82) = .08, p > .05$ ). The students from the two different groups did not differ significantly due to instructional method.

In addition, as seen in Table 10, on questions M7, O1b, and O5 the experimental group had a higher mean, while the control group only scored a higher mean on two of the five questions, O1c and O10. Based on mean scores, of practical significance is that the experimental group scored a 60% on Research Question 2, while the control group scored 40%.

Table 10. Research Question 2 Means Comparison by Question.

GE or PPT		M7	O1b	O1c	O5	O10
PowerPoint	Mean	0.64	0.70	1.61	0.73	0.66
	Std. Deviation	0.49	0.46	0.69	0.45	0.48
Google Earth	Mean	0.65	0.87	1.50	0.77	0.63
	Std. Deviation	0.48	0.33	0.88	0.42	0.42

### *Research Question 3*

Research Question 3 was developed to analyze ways students understanding of Place depending on instructional method used. Responses to survey questions M3, O3, O9 and O11 were used as four dependent variables to yield data for Research Question 3. These four dependent variables are assumed to relate to each other, as they each ask students to demonstrate their understanding of spatial relationships. Each student's response on the four variables was computed to create a mean student score for Research Question 3. This mean score for each student then became the dependent variable.

A one-way ANOVA was calculated on Research Question 3 mean student scores to examine the effect of instructional method (Google Earth or PowerPoint) on questions M3, O3, O9 and O11. No significant difference was found ( $F(1, 82) = 1.0, p > .05$ ). Students from the two different groups did not differ significantly due to instructional method. In addition, as seen in Table 11, on questions O3 and O11, the experimental group had a higher mean, while the control group scored a higher mean on M3 and O9. In other words based on mean scores, of practical significance is that the experimental group scored a 50% on Research Question 3, while the control group scored 50%.

Table 11. Research Question 3 Means Comparison by Question.

GE or PPT		M3	O3	O9	O11
PowerPoint	Mean	0.55	0.41	1.55	1.41
	Std. Deviation	0.50	0.50	0.63	0.54
Google Earth	Mean	0.40	0.60	1.50	1.70
	Std. Deviation	0.50	0.50	0.75	0.65

#### *Research Question 4*

Following the demographic section of the instrument, students answered questions that tested elements of their pre-existing spatial skills. Questions on this section of the instrument asked students to perform mental rotation on two-dimensional images (Q1 – Q5); way-finding using mental rotation (Q6 – Q8); and real-world representations using two-dimensional figures (Q9 – Q12). The responses to these questions would provide a snapshot of student's spatial information organization. Additionally, statistics were run in SPSS to determine the mean on questions in each sub-



category of spatial organization ability (mental rotation, way-finding, representation) to provide a comprehensive overview of how students performed in each spatial sub-skill area. Each response given in this section (Q1 – Q12) was dummy coded for SPSS analysis as follows: zero = incorrect; 1 = correct.

With an  $N = 84$ , the mean of scores in the mental rotation ( $n = 5$ ) category was .54 with a standard deviation of .19; for the way-finding scores ( $n = 3$ ) the mean scores was .62 with a standard deviation of .1; and representation scores ( $n = 4$ ) had a mean of .43 with a standard deviation of .15. The purpose of obtaining the means for each sub-category of spatial organization ability was to see if any specific type of skill needed consideration —e.g. that a subset skill could possibly affect student response to instrument questions. Over the three areas tested, the mean score on mental rotation skills ( $M = .54$ ,  $SD = .19$ ) and way-finding skills ( $M = .64$ ,  $SD = .1$ ) was over .5, or 50%. It is worth noting though that students were below 50% in the representational skills questions ( $M = .43$ ,  $SD = .15$ ), indicating students could possibly have difficulty with this particular spatial concept (See Table 12). As shown in Table 13, the overall mean of spatial organization ability questions in this study was .52 with a standard deviation of .17 and the distribution is normal.

Table 12. Means of Mental Rotation, Way-Finding, and Representation Skills.

	Mental Rotation	Way-Finding	Representation
<i>N</i>	5	3	4
Range	.49	.19	.36
Minimum	.23	.52	.24
Maximum	.71	.71	.60
Standard Deviation	.19	.10	.15
Variance	.04	.00	.023
Mean	.54	.62	.42
Standard Error	.09	.06	.08
Skewness	-1.36	-0.37	-0.32
Standard Error	.91	1.2	1.0
Kurtosis	2.0	--	.12
Standard Error	2.00	--	2.61

*Note.* Only three mean scores were used for Way-Finding skills, thus explaining no Kurtosis report for that skill sub-set.

Table 13. Overall Means: Spatial Organization Ability Questions 1 through 12.

	Questions 1-12
<i>N</i>	12
Range	.49
Minimum	.23
Maximum	.71
Standard Deviation	.17
Variance	.03
Mean	.52
Standard Error	.05
Skewness	-0.77
Standard Error	.64
Kurtosis	-.28
Standard Error	1.23

As a result of students being divided into the control and experimental groups after the spatial organization ability questions were answered, different results are shown in Table 14 according those groupings. Pulling out the spatial organization ability data by the control and experimental group provided a clearer picture of how each of those groups did in each spatial organization skill sub-set (mental rotation, way-finding, and representation).

Table 14. Spatial Organization Ability Response Data by Group.

GE or PPT		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Power Point	Mean	0.6	0.2	0.4	0.7	0.6	0.6	0.5	0.6	0.5	0.4	0.5	0.3
	Std. Deviation	4	3	5	5	1	6	5	6	5	8	7	0
		0.4	0.4	0.5	0.4	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.4
Google Earth	Mean	9	2	0	4	9	8	0	8	0	1	0	6
	Std. Deviation	0.5	0.2	0.5	0.6	0.7	0.7	0.5	0.6	0.6	0.3	0.3	0.1
		0	3	8	7	0	7	0	0	5	0	8	8
	Std. Deviation	0.5	0.4	0.5	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.3
		1	2	0	7	6	2	1	0	8	6	9	8

For the mean on mental rotation skills questions, both groups were .54 with a control group standard deviation of .20 and experimental group standard deviation was .19. The way-finding mean results show the control group ( $n = 44$ ) mean as .62, standard deviation .06 and the experimental group ( $n = 40$ ) mean as .63, standard deviation .04. The representational skills question means for the control group ( $n = 44$ ) the mean was .48, standard deviation .12 while the experimental group ( $n = 40$ ) mean was .38, standard deviation .20.

### Research Question 5

Research Question 5 was developed to determine the ways students demonstrated their understanding of spatial relationships. Responses to survey questions O1d, O1e, O2 and O7 were used as four dependent variables to yield data for Research Question 5. These four dependent variables are assumed to relate to each other, as they measure students demonstration of spatial relationship understanding. Again, each student's response on the four variables was computed to create a mean student score for Research Question 5. This mean score for each student then became the dependent variable.

A one-way ANOVA was calculated on Research Question 5 mean student scores to examine the effect of instructional method (Google Earth or PowerPoint) on questions O1d, O1e, O2, and O7. No significant difference was found ( $F(1, 82) = .15, p > .05$ ). The students from the two different groups did not differ significantly due to instructional method. In addition, as seen in Table 15, on questions O1d and O1e, the experimental group had a higher mean, while the control group scored a higher mean on O2 and O7.

Table 15. Research Question 5 Means Comparison by Question.

GE or PPT		O1d	O1e	O2	O7
PowerPoint	Mean	0.80	1.41	1.73	1.75
	Std. Deviation	0.41	0.76	0.76	0.58
Google Earth	Mean	0.83	1.75	1.68	1.60
	Std. Deviation	0.38	0.87	1.14	0.87

## Correlations

Additional statistics were run to see if there was a correlation between student responses and their spatial organizational ability, as measured by Research Question 4, and if the Likert scale responses in the demographic section of the instrument had any correlation to student instrument responses.

A Spearman rho correlation coefficient was calculated for the relationship between subject's spatial organization ability and responses to Research Question 1. A moderate correlation was found ( $\rho(82) = .32, p < .01$ ), indicating a significant relationship between student's spatial organization ability and the extent students are able to predict spatial patterns. Higher spatial organization ability tended to result in better spatial pattern prediction.

Then a Spearman rho correlation coefficient was calculated for the relationship between subject's spatial organization ability and responses to Research Question 2. A moderate correlation was found ( $\rho(82) = .52, p < .01$ ), indicating a significant relationship between student's spatial organization ability and student understanding of spatial relationships. Higher spatial organization ability tended to result in better student understanding of spatial relationships.

A Spearman rho correlation coefficient was also calculated for the relationship between subject's spatial organization ability and responses to Research Question 3. An extremely weak correlation that was not significant was found ( $\rho(82) = .15, p > .01$ ). Spatial organization ability is not related to student's understanding of Place.

Finally, a Spearman rho correlation coefficient was calculated for the relationship between subject's spatial organization ability and responses to Research Question 5. A

moderate correlation was found ( $r_{ho}(82) = .36, p < .01$ ), indicating a significant relationship between student's spatial organization ability and student demonstration of spatial relationships. Higher spatial organization ability tended to result better student demonstration of spatial relationships.

In the next chapter, this data will be summarized and conclusions and recommendations will be discussed.

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine the extent to which Place geography and spatial literacy scores of students who use 3D Google Earth vary from students who were provided with only two-dimensional instruction for developing such skills. This was an important issue to study, as teachers are not only expected to incorporate more technology into their curriculum, but the importance of spatial literacy has come to the forefront of geographic education. To date, no empirical research has been completed that looks at Google Earth as a means of immersing students in a virtual environment for geographic skill development and Place understanding, both components of spatial literacy. This study was designed to provide information as to the effect that a virtual environment could have on student responses during an eighth grade geography unit on South America. The remainder of this chapter will provide a summary and discussion of the research findings. Furthermore, limitations, recommendations for future studies and conclusions will also be made.

#### Summary of Findings

Results from this study are summarized based on the data analysis of student responses to the research instrument. Findings to include discussions will now be presented consistent to demographic information and research questions guiding the present study.

### *Demographics*

Students were asked to provide demographic data and to rate themselves on various aspects of technology use and geography understanding via the research instrument as seen in Appendix B. Based on student responses regarding current technology use, students reported that they used cell phones, watched television more frequently during the week, and spent less time on the internet, using a computer for non-internet use, and playing video games. Additionally, not all the students had experience using Google Earth. With that in mind, students completed a series of activities introducing them to the mechanics of how the hardware (computer) and software (Google Earth) used in the study worked in order to minimize any effect on responses due to cognitive overload. Before continuing with the research activity, students needed to show proficiency at using Google Earth as indicated by passing a series of tasks.

Moreover, students were asked to rate themselves on their technology proficiency. Analysis of technology proficiency data indicated that cognitive overload due to inexperience associated with using computers would have little effect on a student's response to questions. Most students (90.4 %) identified themselves as either "Intermediate" or "Proficient" in technology use.

Students also completed a Likert-scale section to indicate their attitudes towards geography and applying geography to everyday situations. To determine if any Likert scale responses provided by the students correlated with Research Questions 1, 2, 3 and 5, a Spearman *rho* correlation coefficient was calculated. It is important to note here that according to Cronk (2006), correlations greater than 0.7 are considered strong, correlations less than 0.3 are considered weak and those correlations between 0.3 and 0.7



are considered moderate. An interesting finding is that a moderate correlation was found between the mean of Research Question 3 and D4 ( $\rho(82) = .40, p < .01$ ), indicating a significant relationship between the two variables. Understanding Place tended to rely on a student's attitude towards the application of geography.

### *Research Questions*

Research questions were developed to investigate what, if any, effect using Google Earth in an 8<sup>th</sup> grade geography classroom could have on developing a student's Place understanding and graphicacy compared to using PowerPoint images. Survey instrument questions were then assigned to one of the research questions, thus yielding data to answer that research question. To review, the following are the research questions developed for the instrument:

1. To what extent will students be able to predict spatial patterns based on their observations?
2. How do students understand spatial relationships based on teaching methodology?
3. In what ways will students demonstrate their understanding of spatial relationships using Google Earth compared to traditional two-dimensional uses?
4. To what extent are students able to organize information based on what is observed?
5. In what way(s) will students' understanding of Place differ based on what is observed between the uses of two instructional methodologies?

### *Research Question 1 Summary*

A one-way ANOVA was conducted on the data gathered for Research Question 1 to determine if there was a statistically significant difference between the control and experimental group due to instructional method used. After analyzing the ANOVA results, no statistically significant difference between the control and experimental groups was found. Implementing Google Earth or PowerPoint as an instructional method did not affect students' ability to predict patterns based on their observations. A means analysis was also conducted on the entire samples' ( $n = 84$ ) responses to questions related to Research Question 1, which showed students scored 6.2 out of a potential 8.0 (76%) for the questions related to Research Question 1. Additionally, when the same means score data are used, but divided according to the control ( $n = 44$ ) and experimental ( $n = 40$ ) group responses, each group's total mean was 6.2 out of a potential 8.0 (76%) on questions related to Research Question 1. The extent to which students predict spatial patterns based on their observations appear to be equal between the groups.

It is interesting to note that when the mean of each individual question that makes up Research Question 1 (M1, M2, M4, M5, M6, O4, O6 and O8) was compared between the control and experimental groupings, a practically significant difference was found. On questions M1, M2, M5, M6 and O6 the experimental group had a higher mean, while the control group only scored higher on three questions: M4, O4 and O8. Looking at the data in this way shows that the experimental group did better on five of the eight questions (.625, rounded = 63%) that made up Research Question 1, while the control group only scored better on three (.375, rounded = 38%) of the eight questions.

Additionally, it was determined through a correlation of the mean results between Research Question 4, which measured spatial organizational ability, and Research Question 1 that a significant relationship existed between the two. Higher spatial organization ability tended to result in better spatial pattern prediction. What is interesting to note is when data for Research Question 4 was compared between the control and experimental groups, one sees that the mean of responses for the spatial representation skill questions in the experimental group was lower ( $n = 40, m = .38$ ) than the control group ( $n = 44, m = .48$ ). This possibly indicates a student's ability to represent data spatially has no effect on their pattern prediction ability.

#### *Research Question 2 Summary*

A one-way ANOVA was conducted on the data gathered for Research Question 2 to determine if there was a statistically significant difference between the control and experimental group. After analyzing the ANOVA results, no statistically significant difference between the control and experimental groups was found. Teaching methodology did not significantly affect students' understanding of spatial relationships. A mean analysis was also conducted on the entire samples' ( $n = 84$ ) responses to questions related to Research Question 2, which showed students scored 4.38 out of a potential 7.0 (63%). Additionally, when the same mean score data are used, but divided according to the control ( $n = 44$ ) and experimental ( $n = 40$ ) group responses, the experimental group student mean was 4.43 out of a potential 7.0 (63%) and the control group student mean was 4.34 out of a potential 7.0 (62%). Students appear to understand spatial relationships fairly equally between the groups.

It is interesting to note that when the mean of each individual question that makes up Research Question 2 (M7, O1b, O1c, O5 and O10) was compared between the control and experimental groupings, a practically significant difference was found. On questions M7, O1b, and O5 the experimental group had a higher mean, while the control group scored a higher mean on two of the five questions, O1c and O10. Looking at the data in this way shows that the experimental group did better on three of the five questions (60%) that made up Research Question 2, while the control group only scored better on two of the five questions (40%) that made up Research Question 2.

Also, a student's spatial organizational ability was considered during the analysis of Research Question 2. It was determined through a correlation of the mean results between Research Question 4, which measured spatial organizational ability, and Research Question 2 that a significant relationship existed between the two. Higher spatial organization ability tended to result in better student understanding of spatial relationships. Again, of note is when data for Research Question 4 was compared between the control and experimental groups, one sees that the mean of responses for the spatial representation skill questions in the experimental group was lower ( $n = 40, m = .38$ ) than the control group ( $n = 44, m = .48$ ). This possibly indicates a student's ability to represent data spatially has no effect on their understanding of spatial relationships.

### *Research Question 3 Summary*

A one-way ANOVA was conducted on the data gathered for Research Question 3 to determine if there was a statistically significant difference between the control and experimental group. After analyzing the ANOVA results, no statistically significant difference was found between the control and experimental groups. Students did not

statistically differ between the groups while demonstrating an understanding of spatial relationships due to instructional method. A means analysis was also conducted on the entire samples' (n = 84) responses to questions related to Research Question 3, which showed students scored 4.05 out of a potential 8.0 (51%) on all questions related to Research Question 3. Additionally, when the same mean score data are used, but divided according to the control (n = 44) and experimental (n = 40) group responses, the experimental group student mean was 4.20 out of a potential 8.0 (.525, rounded = 53%) and the control group student mean was 3.91 out of a potential 8.0 (.488, rounded = 49%). While there was some difference in the way students demonstrated their understanding of spatial relationships between the control and experimental group, the researcher is not comfortable stating the difference that exists is of practical significance because both groups fell below the 60% grading mark.

When the mean of each individual question that makes up Research Question 3 (O3, O11, M3 and O9) was compared between the control and experimental groupings, no practically significance difference was found between the groups. The experimental group had a higher mean on two of the four questions, while the control group scored a higher mean on the other two. In other words, based on mean results per question that made up Research Question 3, both groups scored a 50%.

#### *Research Question 4 Summary*

Research Question 4 was developed to investigate a student's spatial organizational ability. The mean of a student's responses to Q1 – Q12 used to answer Research Question 4 was computed for a correlational analysis between a student's spatial organizational ability and their responses to Research Questions 1, 2, 3 and 5.

Using Spearman *rho*, moderate correlations were found between students' spatial organization ability and Research Questions 1, 2 and 5, with an extremely weak correlation on Research Question 3. In summary, the level of a student's spatial organization ability appeared to be a factor in how students responded to the questions found in Research Question 1, 2, 3, and 5.

Additionally, when responses to Q1 - Q12 were categorized according to the control group and experimental group, the mean results of the two were comparable on the mental rotation and way-finding skills (Q1 – Q12). However, on the representation skills questions (Q9 – Q12), the experimental group of students had a lower mean than the control group. Having a lower mean on the representation skills section of the spatial organization ability assessment indicates there could have been a potential affect on how students in the experimental group answered questions (M1, M2, M3, O3, and O8) that relied on spatial representation ability.

#### *Research Question 5 Summary*

A one-way ANOVA was conducted on the data gathered for Research Question 5 to determine if there was a statistically significant difference between the control and experimental group. After analyzing the data, no statistically significant difference in students' understanding of Place was evidenced between the control and experimental groups. A mean analysis was also conducted on the entire samples' ( $n = 84$ ) responses to questions related to Research Question 5, which showed students scored a 5.76 out of a potential 10.0 (58%) on all questions related to Research Question 5. Additionally, when the same means score data are used, but divided according to the control ( $n = 44$ ) and experimental ( $n = 40$ ) group responses, the experimental group studied

out of a potential 10.0 (.585, rounded = 59%) and the control group student mean was 5.68 out of a potential 10.0 (.568, rounded = 57%). While there was some difference in the way students understood Place between the control and experimental group, the researcher is not comfortable stating the difference that exists is of practical significance.

When the mean of each individual question that makes up Research Question 5 (O1d, O1e, O2 and O7) is compared between the control and experimental groupings, no practically significance difference was found to exist between the groups. On questions O1d and O1e, the experimental group had a higher mean, while the control group scored a higher mean on O2 and O7. In other words, despite the fact that mean results for each question that made up Research Question 5 may have been different, practically speaking, both groups scored a 50%.

### Discussion

The majority of the present research focused on the use of a free, three-dimensional technology that was readily available to use in the classroom—Google Earth. Google Earth was used as a way to immerse the experimental group of students in a virtual world to see if it had an effect on the outcomes during a geography unit compared to using the static, two-dimensional images of PowerPoint. Though there was existing research on how students develop spatially, little research existed on teaching methodologies used to develop spatially literate students with currently available technology. The present study set out to discover if using an immersive virtual environment to develop spatial skills would be a viable teaching methodology, as situated learning theory would suggest it to be. It appears from the resulting data analysis that immersing students in a virtual world, such as Google Earth, leads to significant

development with a potential for improvement in some spatial skill areas. This is important because as the National Research Council (2006) states, spatial thinking skills are not systematically taught in schools. Based on the present study's results, there are now opportunities to explore Google Earth as a curricular tool to aid in systematically teaching spatial skills to students. Google Earth activities such as those found in the present study, can permeate geographic pedagogy with spatial thinking skills in a ways that meet a teacher's need (Google Earth is free, readily available), incorporates technology into the curriculum (we live in a technological world), and meets the demands of preparing spatially literate students for today's interactive, global world. To further understand the importance of the present study's results, this discussion will now focus on the overall findings and the practical significance of Research Question 1 and Research Question 2 results.

As evidenced by the aforementioned summary of results, no statistically significant differences between the control and experimental groups were found for Research Questions 1, 2, 3 and 5. Instructional method had no statistically significant effect on student responses. However, correlations found from results obtained for Research Question 4 suggest that a student's existing spatial organizational ability could have had an unforeseen effect on the instrument responses. Additionally, a means was calculated for the responses given to Research Questions 1, 2, 3 and 5 to determine if any practically (rather than statistically) significant differences existed between the control and experimental groups. In other words, did one group score better overall on any particular research question than the other due to instructional method? In writing about practical versus statistical significance testing, authors McLean and Ernest (1998) support



the use of practical significance testing in education because “statistical significance merely provides evidence that an event did not happen by chance....it provides no information about the meaningfulness of an event or if the result is replicable” (p.15). In educational practice, items such as an exam score or grading of a performance skill provide meaningful assessment data spoken of by McLean and Ernest. In turn, this data informs educational practice, helping instructors seek improved ways of teaching a skill or delivering a concept to ensure a student’s development in that particular academic area.

Practical significance in the present study was based on students’ mean score achieved on each research question. In formal educational settings, instructors provide letter grades for coursework, typically based on the mean of scores achieved by a student from a variety of assignments, i.e. papers, exams, projects, performances. It is this notion of averaging scores that influenced the choice of additional data analysis for practical significance—a means comparison of scores for Research Questions 1, 2, 3 and 5 between the experimental group and the control group. It should be noted here that data was determined as practically significant in the present study if it met the criteria based on the instructor’s grading scale - scores could not be lower than 60% to indicate passing the concept/course. The data indicate that students who completed activities using Google Earth overall outperformed students who used PowerPoint to complete the same activities for Research Question 1, outperformance scores are italicized in Table 16, and Research Question 2, outperformance scores are italicized in Table 17, based on the mean scores of the experimental group being controlled to the extent

possible, does appear to affect student's ability to predict spatial patterns and understanding of spatial relationships.

Table 16. Question Means Comparison for Research Question 1

GE or PPT (Survey Question)	M1	M2	M4	M5	M6	O4	O6	O8
PowerPoint Mean	0.77	0.91	0.73	0.84	0.73	0.70	0.75	0.77
Google Earth Mean	0.80	0.97	0.63	0.85	0.85	0.65	0.85	0.60

Table 17. Question Means Comparison for Research Question 2

GE or PPT (Survey Question)	M7	O1b	O1c	O5	O10
PowerPoint Mean	0.64	0.70	1.61	0.73	0.66
Google Earth Mean	0.65	0.87	1.50	0.77	0.63

It is also interesting to note that between the control and experimental group, students' demonstration of spatial relationships and understanding of Place per question were precisely equal—each group scoring at 50% on the items making up Research Question 3 and 5. However, on Research Question 3, the entire sample scored below passing (51%) on Research Question 3 (demonstrating a lack of understanding spatial relationships). Could the questions related to Research Question 3 have been too difficult and out of a student's Zone of Proximal Development or that students were not in Piaget's spatial stage as previously assumed? These are questions that future research could address, as the discovery was made post hoc. After analyzing the data, how do practically significant findings from Research Question 1 and Research Question 2 fit

with available literature and existing research and what are the implications of these findings?

### *Addressing Significant Findings*

Professionals and experts in spatial thinking (Aldrich & Sheppard, 2000; Blachin & Coleman, 1965; Boardman, 1983; Downs, 1985; Gersmehl, P.J. & Gersmehl, C. A., 2007; Golledge, Gale, Pellegrino & Doherty, 1992; Kerski, 2008; National Research Council, 2006; Newcombe, 2006; Salter, 1990) agree that spatial thinking involves analysis, problem solving and pattern prediction of objects and their three-dimensional relationships. Pattern prediction of objects and their three-dimensional relationships was the topic of investigation for Research Question 1 and understanding spatial relationships through analysis was the focus of Research Question 2.

The findings from Research Question 1 reaffirm claims made about situated learning theory efficacy (Brill, 2001; Brown, Collins & Duguid, 1989; Herrington & Oliver, 1995; Kitchens, 2009; Oliver, 1999; Lave & Wenger, 1991). Situated learning theory states that the closer to the reality of an object under study, for the present study, as situating the student in a three-dimensional landscape, to practice the skills of an expert (pattern prediction via OSAE), deeper meaning is achieved. By looking at situated learning theory to inform the development of different, and potentially better, spatial skill instructional methods, it was hoped that a discovery would be made that could allow educators to break away from the restrictive two-dimensional world.

In the present study, it was discovered that Google Earth allowed students to look around the landscape of South America from one vantage point and then travel to another point in order to see a completely different view, thereby helping to find numerous

patterns in the landscape. Google Earth allowed students to observe, speculate, analyze and evaluate (OSAE) the landscape in 360 degrees. Two-dimensional images, in this case via PowerPoint, did not provide such interactive immersion for the control group, it restricted what students were able to view and subsequently how they answered instrument questions for Research Question 1 and Research Question 2. Such maneuverability provided by Google Earth clearly benefitted students in the experimental group, as suggested by the practical significance of Research Question 1 and Research Question 2.

Furthermore, a spatially literate person understands spatial relationships (the focus of Research Question 2), which in turn provides connections to and appreciation for Places. As Kitchens (2009) points out, a lack of such understanding results in what is termed a pedagogy of placelessness. Without this understanding of space and the relationships of objects in space, students lack the skills necessary to compete and thrive in today's multi-dimensional world. The findings from Research Question 2 suggest that Google Earth could be used to develop spatial understanding in students, as it upholds the general conclusion made by Piaget and Inhelder (1956) during their study *The Child's Conception of Space*, as well as Herman & Siegel's (1977) findings. Research Question 2 results show that spatial concepts are developed through actions, such as walking around and observing the landscape. Even though the world students walked through in Google Earth was a simulated one, Research Question 2 results reaffirm which suggest that children appear to develop accurate spatial accounts of an environment by physically walking through that environment. In other words, Research Question 2 results indicated that there is the potential that if one walks through a virtual, three-dimensional

environment it could result in accurate spatial accounts demonstrating an understanding of spatial relationships.

To conclude, based on the results of this research, and the accessibility of Google Earth, an instructor can simulate a landscape under study with ease. Doing so provides students an immersive and situated, albeit simulated, environment (as opposed to traditional two-dimensional images often used) from which they could better practice as an apprentice, those skills expert geographers would ask of the landscape: what is where and why is it there? (Kerski, 2008a).

### *Implications*

The findings suggests that using Google Earth as tool to provide a situated learning experience for spatial skill development is worth considering. Instructors now have a research-based justification to use Google Earth, a readily available, free and three-dimensional immersive environment in the classroom. Instructors can lead their students on a virtual field experience that, at the very least, can be used to develop pattern prediction and spatial relationship understanding skills. Time, cost and transportation to real-world locations do not need to be considered when exploring distant locations in Google Earth. Ideally, when one has the opportunity, the field experience is the preferred teaching method as it situates learning to help students answer questions, such as what is where and why is it there, and also to practice OSAE (observe, speculate, analyze and evaluate) skills in a relevant situation while developing graphicacy. Reason would suggest that if the field experience is not possible due to constraints (time, cost, transportation), an instructor should find the next best thing for student immersion, typically this has been provided to students via a two-dimensional world, i.e. photographs

and readings. Today, however, technology offers instructors the opportunity to simulate those three-dimensional places, using tools such as Google Earth.

### Limitations

Results in this study should not be generalized to all settings since the findings are based on a sample of convenience. Another limitation in this study was the assumption that all students have a general working understanding of elementary level spatial concepts, which includes, but is not limited to that of direction, space, and dimension. Generalizations based from this study about spatial skill development apply only to skills of pattern prediction and understanding spatial relationships. The premise of this study has also assumed the ease in which instructors can access Google Earth when considering the constraining factors experienced when using the field experience as a teaching method.

### Recommendations for Future Study

The following are recommendations based on an analysis of data in the current study:

1. Researchers should consider replicating this study with samples from different geographical areas of the United States and different age grouping. Doing so would provide greater demographic variety and a sample with different previous exposure to spatial skills and concepts, allowing for broader generalizations and comparisons.
2. Future studies should consider the ease with which Google Earth can be accessed in the classroom to provide immersive field experiences, as well as the same instructor's ability to take students to real-world locations.

3. Future researchers may wish to explore a comparative study that examines one group of students who use Google Earth for a particular set of activities, followed by the use of two-dimensional images for the same or similar activities, subsequently measuring if there is a difference ( i.e. student scored better using one methodology over another while developing aspects spatial skills).
4. Students in the present study's experimental group had a lower mean on the representation skills section of the spatial organization ability assessment. It would be reasonable to assume that responses to questions which relied, at least in part, on a student's representational skill ability would also be lower (M1, M2, M3, O3, O8). Yet students in the experimental group scored better than the control group on questions M1, M2 and O3. This discrepancy could be the topic of further investigations.

### Conclusions

There is an ever-increasing amount of spatial data available to society, and it is apparent there will continue to be an increasing need for people that can analyze and interpret such data. The National Research Council pointed out the inadequacy of research based teaching methods focused on spatial skill development and emphasized the need to reconsider spatial literacy as part of the school curriculum in the seminal document *Learning to Think Spatially* (2006).

Statistically speaking, the data analysis from the present research suggests that no difference exists between the two groups of students based on the results of Research Questions 1, 2, 3 and 5. However, teachers need and can use research data that is of practical significance. Therefore, when findings from Research Question 1 and 2 are

viewed from the vantage point of practical significance, a teacher can use the methodology presented in this research to assist and possibly improve a student's spatial literacy, particularly in the areas of pattern prediction and spatial relationship understanding. The ability to predict patterns and understand spatial relationships provide students with tools to observe, speculate, analyze and evaluate the physical and human characteristics of a location (Place). These practically significant results and their implications are important to keep in mind as one looks to answer the National Research Council's call to find ways in which instructors can develop spatial literacy in schools.



## APPENDICES

## APPENDIX A

### GEOGRAPHY PEDAGOGY SCHEMATA

#### Overview of Geography Pedagogy

##### What is Geography?

- A physical science - Geographers study, measure and map the elemental forces that shape our planet.
- A social science - Geographers study families, tribes and nations and how they grow and change through time.
- The study of spatial relationships - Geographers study & map relationships between people, places & environments.
- A bridge among disciplines - Geographers work with individuals and organizations with many interests.

##### Geography consists of three interrelated and inseparable components:

- Subject matter - the foundation for national geography standards
- Skills - utilizes the Five Sets of Geographic Skills
- Perspectives - spatial (pattern and Earth processes) and ecological (complex web of relationships between living and nonliving elements on the Earth's surface)

##### Four Geographic Traditions:

- Geography is a spatial science
- Geography involves area studies

- Geography studies human - environmental relationships
- Geography is a physical science

#### Five Geographic Themes:

- Location - Absolute and Relative
- Place - Physical and Human
- Human - Environment Interaction
- Movement - Earth's processes, people, products, ideas
- Region - Physical and Human

#### Six Essential Elements:

- The World in Spatial Terms - Geographers study the relationships between people, places and environments.
- Places and Regions - Geographers study individuals & groups of people in physical places & human regions.
- Physical Systems - Geographers study physical processes, ecosystems & their relationships with plants & animals.
- Human Systems - Geographers study human activities, settlements, structures and human competition.
- Environment and Society - Geographers study the relationships between the natural world and human activity.
- The uses of Geography - Geographers learn from the relationship between people, places & environments over time.

Eighteen geography standards the geographically informed person knows and understands:

1. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.
2. How to use mental maps to organize information about people, places, and environments in a spatial context.
3. How to analyze the spatial organization of people, places, and environments on Earth's surface.
4. The physical and human characteristics of places.
5. That people create regions to interpret Earth's complexity.
6. How culture and experience influence people's perceptions of places and regions.
7. The physical processes that shape the patterns of Earth's surface.
8. The characteristics and spatial distribution of ecosystems on Earth's surface.
9. The characteristics, distribution, and migration of human populations on Earth's surface.
10. The characteristics, distribution, and complexity of Earth's cultural mosaics.
11. The patterns and networks of economic interdependence on the Earth's surface.
12. The process, patterns, and functions of human settlement.
13. How the forces of cooperation and conflict among people influence the division and control of Earth's surface.
14. How human actions modify the physical environment.
15. How physical systems affect human systems.

16. The changes that occur in the meaning, use, distribution, and importance of resources.

17. How to apply geography to interpret the past.

18. How to apply geography to interpret the present and plan for the future.

#### Geographic Skills:

- Asking and answering geographic questions
- Acquiring geographic information
- Organizing and presenting geographic information
- Analyzing geographic information
- Developing and testing geographic generalizations

#### O.S.A.E. Skills:

- Observe - note precisely the physical and human characteristics of the landscape.  
Peel away the layers.
- Speculate - ask questions about the physical and human processes, patterns, perceptions and artifacts.
- Analyze - seek answers from various sources to your questions. Talk with people; get online.
- Evaluate - reach conclusions; make judgments about the landscape, its functions and values to society.

#### National Geographic Society (NGS) Geography Education Program Strategic Areas:

- Grass-Roots Organization - academic geographers, teachers, decision-makers and citizens promote geography.

- Teacher Education - NGS and state Alliances conduct summer geography and leadership institutes & workshops.
- Materials Development - Lesson plans, resource guides, Teacher Consultant In-Service kits, computer & multimedia products.
- Public Awareness - Geography Awareness Week involves students while NGS Geography Education Program
- Outreach to Decision Makers - local and national politicians, curriculum consultants, Geography Awareness Week proclamations.

APPENDIX B

SURVEY INSTRUMENT: GOOGLE EARTH AND POWER POINT

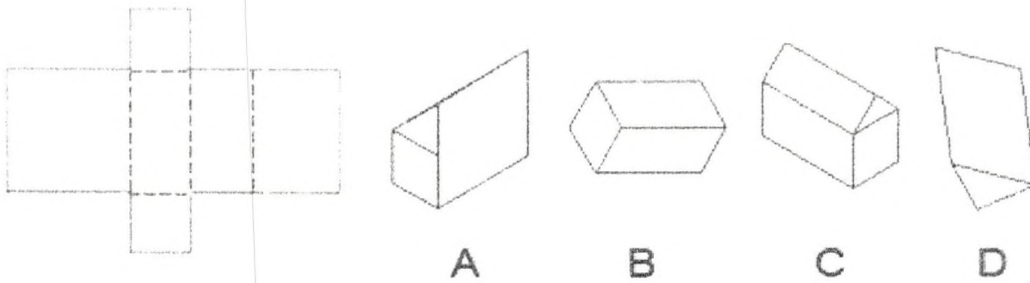
Google Earth in the Geography Classroom-Section A

Gender	Age		Use of Technology <i>check all that apply</i>				
			Item used	Hours/week used			
<input type="checkbox"/> Male	<input type="checkbox"/> 11	<input type="checkbox"/> 13	<input type="checkbox"/> Internet	<input type="checkbox"/> 0-5	<input type="checkbox"/> 6-10	<input type="checkbox"/> 11-20	<input type="checkbox"/> 20+
<input type="checkbox"/> Female	<input type="checkbox"/> 12	<input type="checkbox"/> 14	<input type="checkbox"/> Cell phone	<input type="checkbox"/> 0-5	<input type="checkbox"/> 6-10	<input type="checkbox"/> 11-20	<input type="checkbox"/> 20+
<b>Have you used Google Earth before?</b>			<input type="checkbox"/> Television	<input type="checkbox"/> 0-5	<input type="checkbox"/> 6-10	<input type="checkbox"/> 11-20	<input type="checkbox"/> 20+
<input type="checkbox"/> Yes <input type="checkbox"/> No			<input type="checkbox"/> Computer	<input type="checkbox"/> 0-5	<input type="checkbox"/> 6-10	<input type="checkbox"/> 11-20	<input type="checkbox"/> 20+
			<input type="checkbox"/> Video games	<input type="checkbox"/> 0-5	<input type="checkbox"/> 6-10	<input type="checkbox"/> 11-20	<input type="checkbox"/> 20+
<b>Experience with computer technology <i>check 1</i></b>							
<input type="checkbox"/> None							
<input type="checkbox"/> Novice – just starting to use computers (less than 2 years).							
<input type="checkbox"/> Intermediate – been using computers for at least 2 years.							
<input type="checkbox"/> Proficient - using computers for a 2+ years and can teach others about computers.							

Please rate each of the statements below by circling the appropriate option on the right.	Strongly Disagree	Disagree	Some What Disagree	Some What Agree	Agree	Strongly Agree
Knowing how to read a map is an important skill. <i>D1</i>	1	2	3	4	5	6
It is important to know where countries in the news are located. <i>D2</i>	1	2	3	4	5	6
It is important to know how to use Google Earth technology. <i>D3</i>	1	2	3	4	5	6
It is important to have an understanding of geography because people are better able to decide where to live and work. <i>D4</i>	1	2	3	4	5	6

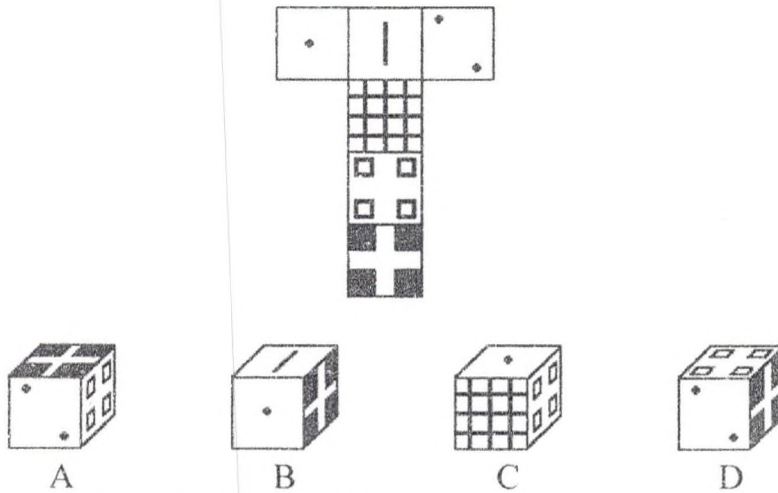
Directions: Choose the best answer.

1. Which diagram results from folding the diagram (on the left) on the dotted lines? Q1



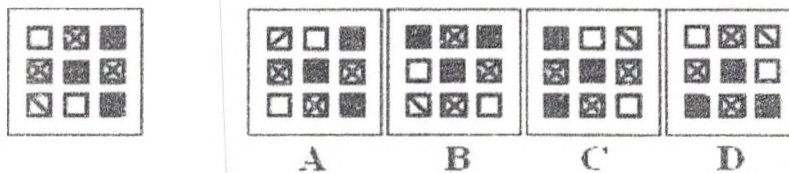
<http://www.intellicetest.com/questions/spatial.htm>

2. Which of the cubes is the same as the unfolded cube below? Q2



<http://www.intellicetest.com/report/spatial.htm>

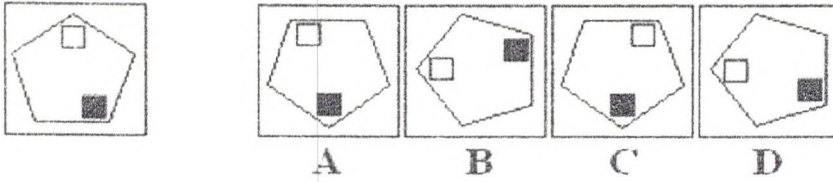
3. In the figures shown below, one of the shapes (A-D) is identical to the first figure but has been rotated. Which figure is identical to the first? Q3



<http://psychometric-success.com/practice-papers/Psychometric%20Success%20Spatial%20Ability%20-%20Practice%20Test%201.pdf>

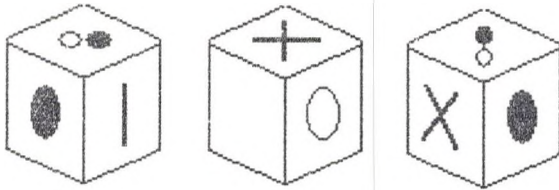


4. In the figures shown below, one of the shapes (A-D) is identical to the first figure but has been rotated. Which figure is identical to the first? Q4

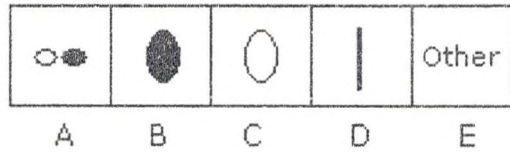


<http://psychometric-success.com/practice-papers/Psychometric%20Success%20Spatial%20Ability%20-%20Practice%20Test%201.pdf>

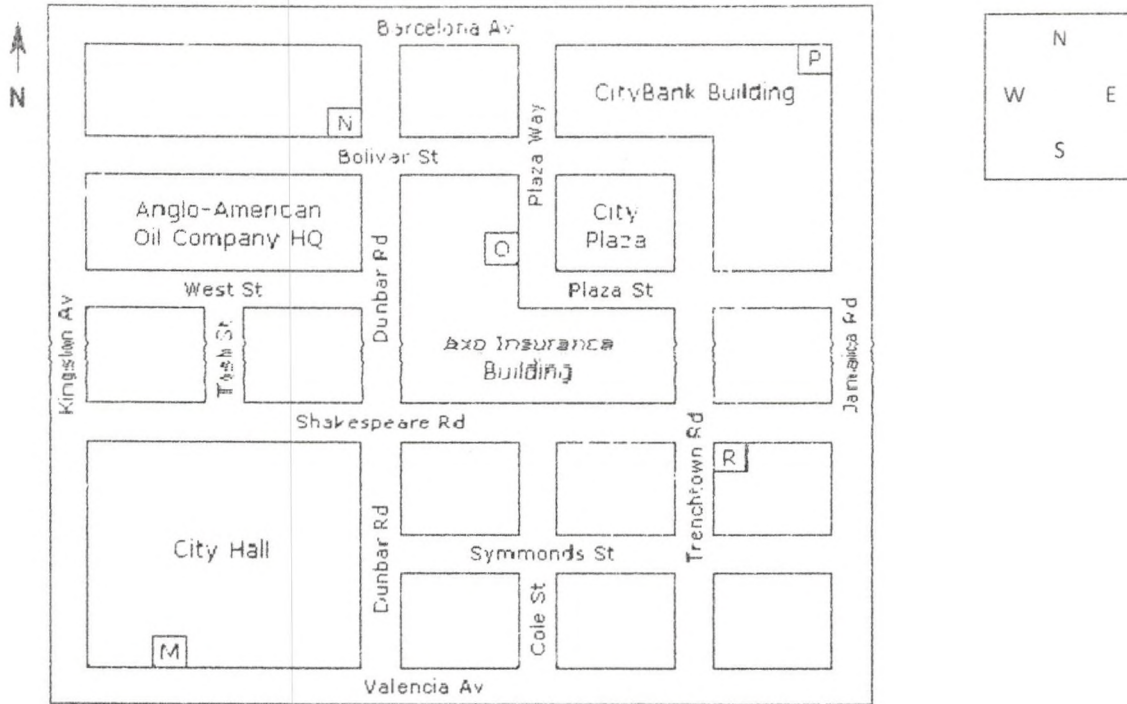
5. Three views of the same cube are shown below. Which symbol is opposite the X? Q5



Answers



<http://www.psychometric-success.com/aptitude-tests/spatial-ability-tests-cubes.htm>



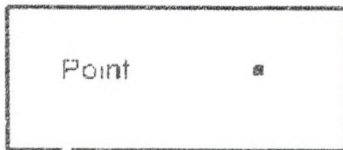
<http://www.psychometric-success.com/aptitude-tests/spatial-ability-tests-maps-plans.htm>

Use the map to answer the following questions.

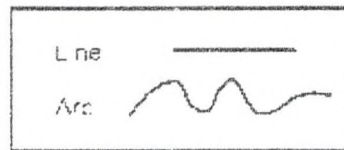
6. If you are on Tosh St with City Hall to your right, what direction are you facing? *Q6*
  - A. North
  - B. South
  - C. East
  - D. West
  
7. You turn and walk to the junction with West St. You then turn right and walk to the next junction before turning left. Where is location "O" in relation to your position? *Q7*
  - A. North
  - B. South
  - C. East
  - D. West
  
8. Now you start from location "M" and proceed as follows: left onto Valencia Av – heading east, second left – heading north, second right – heading east, second left – heading north. You then proceed north for two blocks. What is your location? *Q8*
  - A. Letter N
  - B. Letter O
  - C. Letter R
  - D. Letter P

*DIRECTIONS: Points, lines, and areas can represent real world objects. Based on the examples below, classify the spatial data in each question by choosing the best representation for that data. In other words, what would be the best way to show these items on something like a map?*

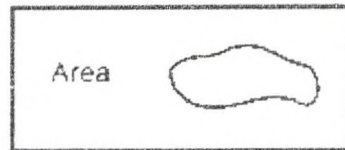
[http://genip.tamu.edu/spatial\\_skills\\_test.pdf](http://genip.tamu.edu/spatial_skills_test.pdf)



ex) trees, road intersections, poles in distribution networks



ex) roads, rivers



ex) the areal extent of a city, an area of a continent

9. What is the best way(s) to show locations of weather stations in a state? *Q9*
  - A. Points
  - B. Lines
  - C. Points and Lines
  - D. Points and Area
  - E. Lines and Area
  
10. What is the best way(s) to show Mississippi river channels? *Q10*
  - A. Points
  - B. Lines
  - C. Points and Lines
  - D. Points and Area
  - E. Lines and Area
  
11. What is the best way(s) to show the shuttle bus route of an elementary school? *Q11*
  - A. Points
  - B. Lines
  - C. Points and Lines
  - D. Points and Area
  - E. Lines and Area
  
12. What is the best way(s) to show the places that can be reached by fire engines in 5 minutes or less? *Q12*
  - A. Points
  - B. Lines
  - C. Points and Lines
  - D. Points and Area
  - E. Lines and Area

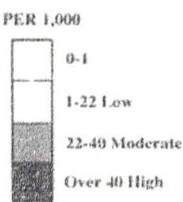
13. The United Nations is concerned about the relationship between the birth rate and the death rate in various countries and regions in the world. As a geographer, you have studied the world maps below that show the spatial distribution of birth and death rates. Where is there a strong positive relationship (similar patterns) between World Birth Rates and World Death Rates? Q13

[http://genip.tamu.edu/spatial\\_skills\\_test.pdf](http://genip.tamu.edu/spatial_skills_test.pdf)

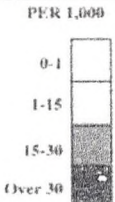
- A. Africa
- B. North America
- C. Europe
- D. South America



WORLD BIRTH RATE



WORLD DEATH RATE



**CAUTION - PLEASE** do not zoom in or out of the current Google Earth viewing window. *If that "accidentally" happens, you can always go back to the correct view by double-clicking on the yellow pushpin called "Start here for Manaus, Brazil" found in the Places panel.*

Using the information in the current Google Earth viewer window and the OSAE method (Observe, Speculate, Analyze, Evaluate), please answer the following seven (7) questions by circling your answer. Remember that you must work on this activity by yourself and read all the options before choosing your answer.

1. In July 1987, Manaus, Brazil appears to be \_\_\_\_\_ *M1*
  - A. a city surrounded by deserts.
  - B. a city surrounded by lakes.
  - C. a city surrounded by rivers.
  - D. a city surrounded by mountains.
  
2. In July 1987, to the northeast of Manaus, Brazil, what do you observe? *M2*
  - A. I observe a dense, forested area (green space).
  - B. I observe many (more than 10) roads going into or out of the city.
  - C. I observe many (more than 10) lakes.
  - D. I observe a mountain range.
  
3. *Before answering this question, make sure you have the correct view by double-clicking on the yellow pushpin called "Start here for Manaus, Brazil" found in the Places panel.*

Using the Google Earth ruler, how many rivers (do not include tributaries) are in your current viewing screen to the northwest of Manaus, Brazil that are greater than 8 miles long? *M3*

  - A. 1 to 2 rivers
  - B. 3 to 4 rivers
  - C. 8 to 9 rivers
  - D. 10 to 11

*Please turn over to continue*

4. Based on the July 1987 Manaus, Brazil overlay, which of the following is a logical speculation. Double-click on yellow pushpin in the Places panel called "Start here for Manaus, Brazil" to center your view if necessary. *M4*
- A. The people of Manaus, Brazil may rely only on ground transportation (example: cars, trucks) to move within and outside of the city.
  - B. The people of Manaus, Brazil may rely only on water transportation (example: boats, canoes) to move within and outside of the city.
  - C. The people of Manaus, Brazil may rely only on ground and water transportation to move within and outside of the city.
  - D. The people of Manaus, Brazil may rely only on animal and ground transportation (example: horse, donkey) to move within and outside of the city.

**Now uncheck the 12 July 1987 overlay and check the 10 July 2001 overlay. A and B place marks should still be checked. You can change between (by checking and un-checking) the two overlays (1987 and 2001) if needed to answer the following questions.**

5. Based on the 10 July 2001 overlay, using place marks A and B (red pushpin) as reference points, what appears to have happened to Manaus, Brazil between 1987 and 2001? *M5*
- A. The city of Manaus, Brazil appears to have grown in size.
  - B. The city of Manaus, Brazil appears to have decreased in size.
  - C. The city of Manaus, Brazil appears to have not changed in size.
  - D. The city of Manaus, Brazil appears to have decreased in elevation.
6. Based on your observation of BOTH the 10 July 2001 overlay and the 12 July 1987 overlay, which of the following is a logical prediction for the future landscape pattern surrounding Manaus, Brazil? *M6*
- A. The landscape pattern will show more urban (city) area and less green space.
  - B. The landscape pattern will not change from the 2001 image.
  - C. The landscape pattern will show more green space and less urban (city) area.
  - D. The landscape pattern will not change from the 1987 image.

7. In the 10 July 2001 overlay, to the northeast of Manaus, Brazil, locate the rectangular area of mature forest (look for green space in the shape of a square/rectangle-do not ask your fellow classmates for help). What is the most logical reason this rectangular green space is here? *M7*
- A. People decided not to build in that area because roads cannot get there.
  - B. People decided landscapes viewed from the sky should be symmetrical.
  - C. People decided that particular area of land should be a preserved ecosystem.
  - D. People have not yet decided what to do with the land within a 50-mile radius of Manaus, Brazil.

8.0

Using the OSAE method (Observe, Speculate, Analyze, Evaluate) answer the following questions using the Manaus, Brazil PowerPoint slides. Remember that you must work on this activity by yourself.

1. In July 1987, Manaus, Brazil appears to be \_\_\_\_\_ *M1*
  - A. a city surrounded by deserts.
  - B. a city surrounded by lakes.
  - C. a city surrounded by rivers.
  - D. a city surrounded by mountains.
  
2. In July 1987, to the northeast of Manaus, Brazil, what do you observe? *M2*
  - A. I observe a dense, forested area (green space).
  - B. I observe many (more than 10) roads going into or out of the city.
  - C. I observe many (more than 10) lakes.
  - D. I observe a mountain range.
  
3. How many rivers (do not include tributaries) are in your photo to the northwest of Manaus, Brazil that are greater than 8 miles long? The scale appears at the bottom left corner of the photo. *M3*
  - A. 1 to 2 rivers
  - B. 3 to 4 rivers
  - C. 8 to 9 rivers
  - D. 10 to 11
  
4. Based on the July 1987 Manaus, Brazil photo, which of the following is a logical speculation. *M4*
  - A. The people of Manaus, Brazil may rely only on ground transportation (example: cars, trucks) to move within and outside of the city.
  - B. The people of Manaus, Brazil may rely only on water transportation (example: boats, canoes) to move within and outside of the city.
  - C. The people of Manaus, Brazil may rely only on ground and water transportation to move within and outside of the city.
  - D. The people of Manaus, Brazil may rely only on animal and ground transportation (example: horse, donkey) to move within and outside of the city.



5. Based on the 10 July 2001 photo, what appears to have happened to Manaus, Brazil between 1987 and 2001? *M5*
- A. The city of Manaus, Brazil appears to have grown in size.
  - B. The city of Manaus, Brazil appears to have decreased in size.
  - C. The city of Manaus, Brazil appears to have not changed in size.
  - D. The city of Manaus, Brazil appears to have decreased in elevation.
6. Based on your observation of BOTH the 10 July 2001 photo and the 12 July 1987 photo, which of the following is a logical prediction for the future landscape pattern surrounding Manaus, Brazil? *M6*
- A. The landscape pattern will show more urban (city) area and less green space.
  - B. The landscape pattern will not change from the 2001 image.
  - C. The landscape pattern will show more green space and less urban (city) area.
  - D. The landscape pattern will not change from the 1987 image.
7. In the 10 July 2001 photo, to the northeast of Manaus, Brazil, locate the rectangular area of mature forest (look for green space in the shape of a square/rectangle-do not ask your fellow classmates for help). What is the most logical reason this rectangular green space is here? *M7*
- A. People decided not to build in that area because roads cannot get there.
  - B. People decided landscapes viewed from the sky should be symmetrical.
  - C. People decided that particular area of land should be a preserved ecosystem.
  - D. People have not yet decided what to do with the land within a 50-mile radius of Manaus, Brazil.

With a sense of physical and human place, we can read the landscape around us and make observations about what we see.

Using the OSAE (Observe, Speculate, Analyze and Evaluate) method learned in class, answer the following questions based on the locations found in the Places panel of Google Earth. Once you get to the location, use all the skills you learned in class to get the best view possible.

**Image 1: Yungus Road, Bolivia.**

What do you see that would make people call this road “Death Road”?

1. Fill in the OSAE chart *O1b through 6*

What is it? (a) <i>Observation</i>	Where is it on the landscape? (b) <i>Speculation</i>	Why is it there? (c) <i>Analysis</i>	Should it be there? (d) <i>Evaluation</i>	What is the result of it being there? (e) <i>Evaluation</i>
<b>Yungus Road</b>  (red arrow pointing to it)				

2. Based on your completed chart above, why is this road nicknamed by the local people as “Death Road”? Answer in the space provided. *O2*  
 It is called Death Road because

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### **Image 2: Perito Moreno Glacier, Argentina**

3. Based on the image, which of the following features would you most likely find if you were to walk along the Perito Moreno Glacier? *O3*
  - a. Smooth ice sheets.
  - b. Densely forested regions.
  - c. Numerous farming communities.
  - d. Steep faced cliffs.
  
4. Based on your observation, which of the following is a logical prediction for this landscape pattern in the next 10-20 years? *O4*
  - a. More urban centers (cities) will appear near the glacier.
  - b. The glacier will continue to move in a southwest direction.
  - c. There will be more evidence of vegetation (plants, trees)
  - d. The southeast rock field will have completely disappeared.

### **Image 3: Atacama Desert mine, Chile**

5. Based on your observation, what is the most logical reason this mine is located in a desert? *O5*
  - a. The mine is located at a place near a large labor force.
  - b. The mine is located near pre-existing transportation networks.
  - c. The mine is located near the resources (e.x. copper) being mined.
  - d. The mine is located near a natural water source.
  
6. Which of the following is a logical prediction for this landscape pattern in the next 10-20 years? *O6*
  - a. The southwest sand dunes will have completely disappeared.
  - b. More urban centers (cities) will appear near the mine.
  - c. If there are more resources (e.x. copper) found here, the mine may get larger (deep and wide).
  - d. There will be more evidence of vegetation (plants, trees)

**Image 4: Machu Picchu, Peru**

7. Does Machu Picchu seem to be at a low or a high altitude? Explain your reasoning. *O7*

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8. Machu Picchu follows a pattern associated with which of the following? *O8*

- a. City
- b. Country
- c. Continent
- d. State

**Image 5: Copacabana Beach, Rio de Janeiro, Brazil**

9. Use your OSAE skills and answer: What is going on in this picture? Identify and describe the human and physical characteristics. Look around and take me there through your description. *O9*

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**Image 6: Christ the Redeemer statute, Rio de Janeiro, Brazil**

10. Based on your observation of the current image: What is the geographical explanation as to why the city of Rio de Janeiro is located at this exact spot? *O10*
- a. The bay makes for profitable shipping and protection.
  - b. There are numerous agricultural fields visible.
  - c. It is where there are no mountains.
  - d. There is less chance of getting malaria.

11. In as many statements as possible, describe what you see here at Rio de Janeiro:  
*O11*

- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
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- \_\_\_\_\_
- \_\_\_\_\_

With a sense of physical and human place, we can read the landscape around us and make observations about what we see.

Using the OSAE (Observe, Speculate, Analyze and Evaluate) method learned in class, answer the following questions based on the Power Point images presented to you from the location indicated.

**Image 1: Yungus Road, Bolivia.**

What do you see that would make people call this road “Death Road”?

1. Fill in the OSAE chart *O1b through e*

What is it? (a) <i>Observation</i>	Where is it on the landscape? (b) <i>Speculation</i>	Why is it there? (c) <i>Analysis</i>	Should it be there? (d) <i>Evaluation</i>	What is the result of it being there? (e) <i>Evaluation</i>
<b>Yungus Road</b>  (red arrow pointing to it)				

2. Based on your completed chart above, why is this road nicknamed by the local people as “Death Road”? Answer in the space provided. *O2*  
It is called Death Road because

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### **Image 2: Perito Moreno Glacier, Argentina**

3. Based on the image, which of the following features would you most likely find if you were to walk along the Perito Moreno Glacier? *O3*
  - a. Smooth ice sheets.
  - b. Densely forested regions.
  - c. Numerous farming communities.
  - d. Steep faced cliffs.
  
4. Based on your observation, which of the following is a logical prediction for this landscape pattern in the next 10-20 years? *O4*
  - a. More urban centers (cities) will appear near the glacier.
  - b. The glacier will continue to move in a southwest direction.
  - c. There will be more evidence of vegetation (plants, trees)
  - d. The southeast rock field will have completely disappeared.

### **Image 3: Atacama Desert mine, Chile**

5. Based on your observation, what is the most logical reason this mine is located in a desert? *O5*
  - a. The mine is located at a place near a large labor force.
  - b. The mine is located near pre-existing transportation networks.
  - c. The mine is located near the resources (e.x. copper) being mined.
  - d. The mine is located near a natural water source.
  
6. Which of the following is a logical prediction for this landscape pattern in the next 10-20 years? *O6*
  - a. The southwest sand dunes will have completely disappeared.
  - b. More urban centers (cities) will appear near the mine.
  - c. If there are more resources (e.x. copper) found here, the mine may get larger (deep and wide).
  - d. There will be more evidence of vegetation (plants, trees)

**Image 4: Machu Picchu, Peru**

7. Does Machu Picchu seem to be at a low or a high altitude? Explain your reasoning. *O7*

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8. Machu Picchu follows a pattern associated with which of the following? *O8*

- a. City
- b. Country
- c. Continent
- d. State

**Image 5: Copacabana Beach, Rio de Janeiro, Brazil**

9. Use your OSAE skills and answer: What is going on in this picture? Identify and describe the human and physical characteristics. Look around and take me there through your description. *O9*

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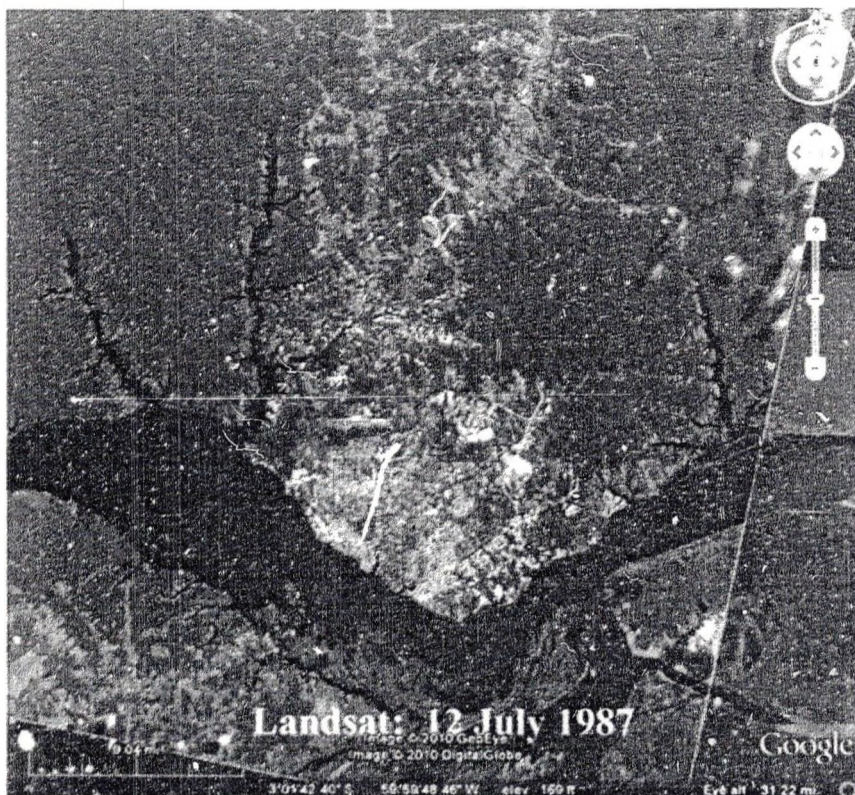
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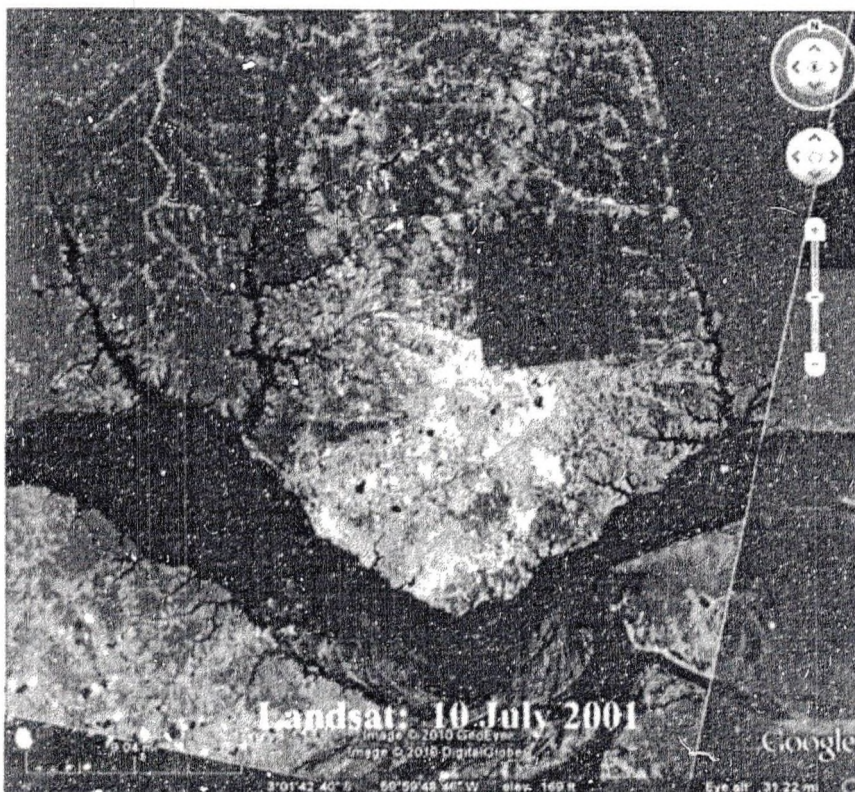




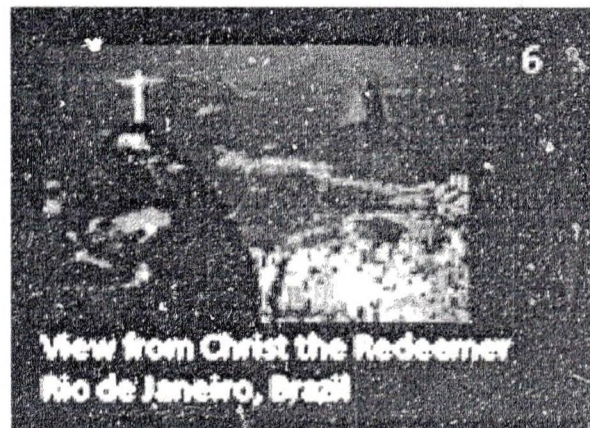
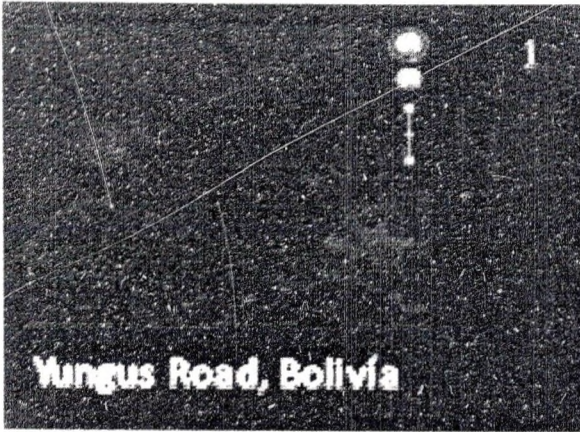
Screen Shots for Classroom Activity #3



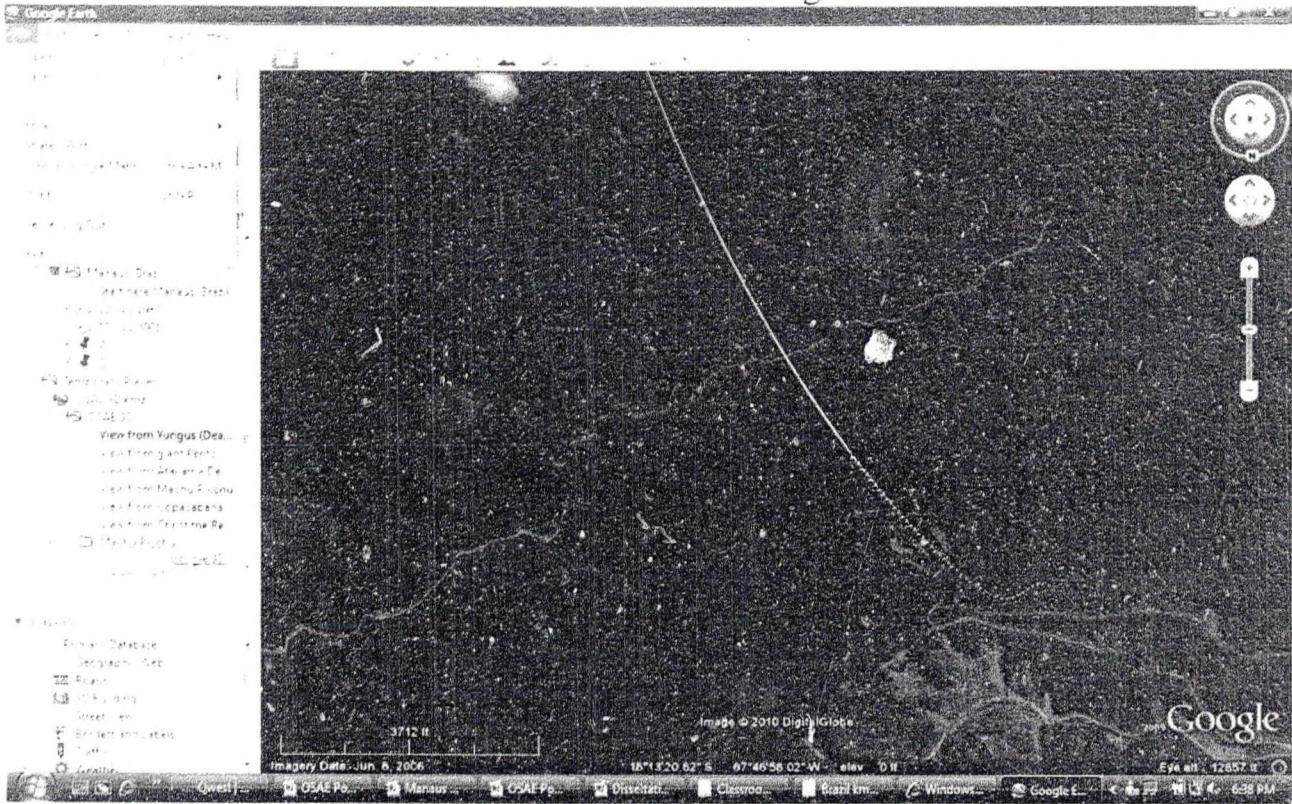
Screen Shot of Manaus, Brazil July 12, 1987



Screen Shot of Manaus, Brazil July 10, 2001



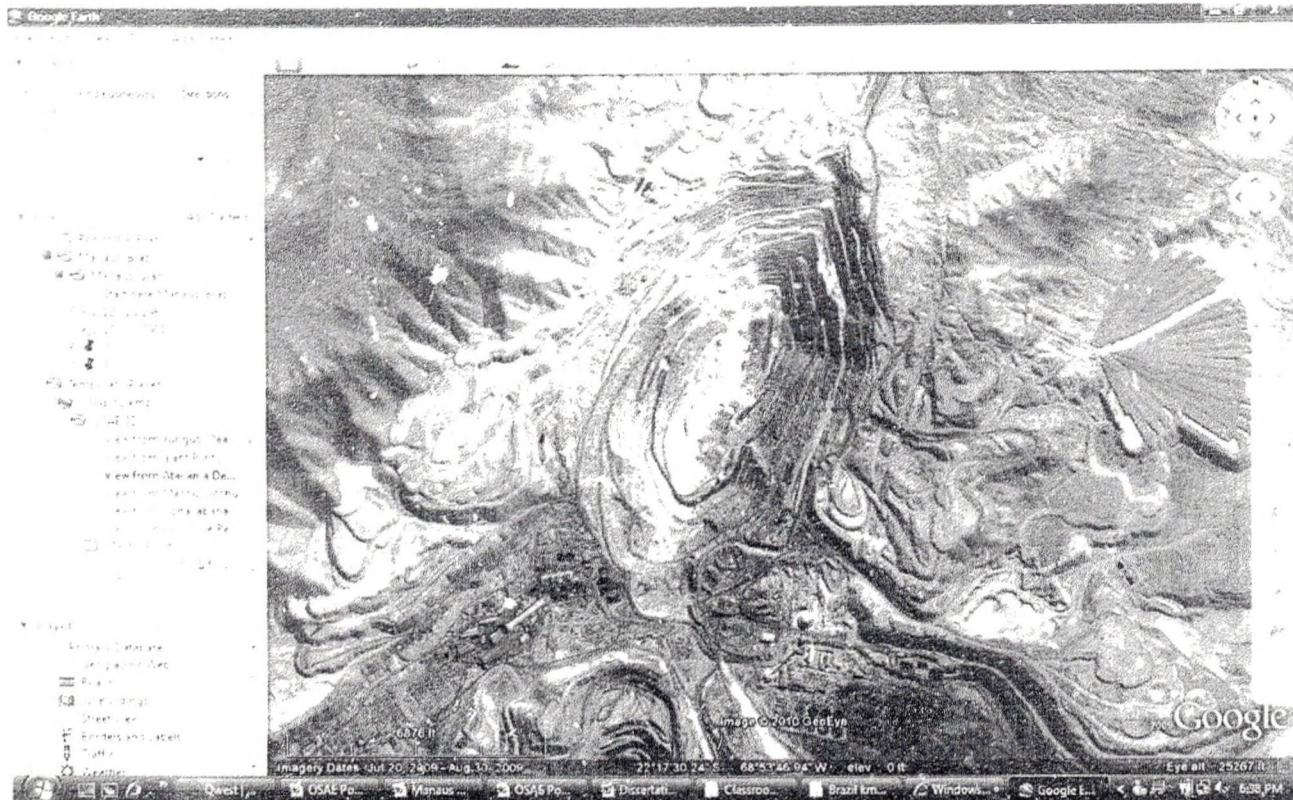
# OSAE Test: PowerPoint Image 1 - 6



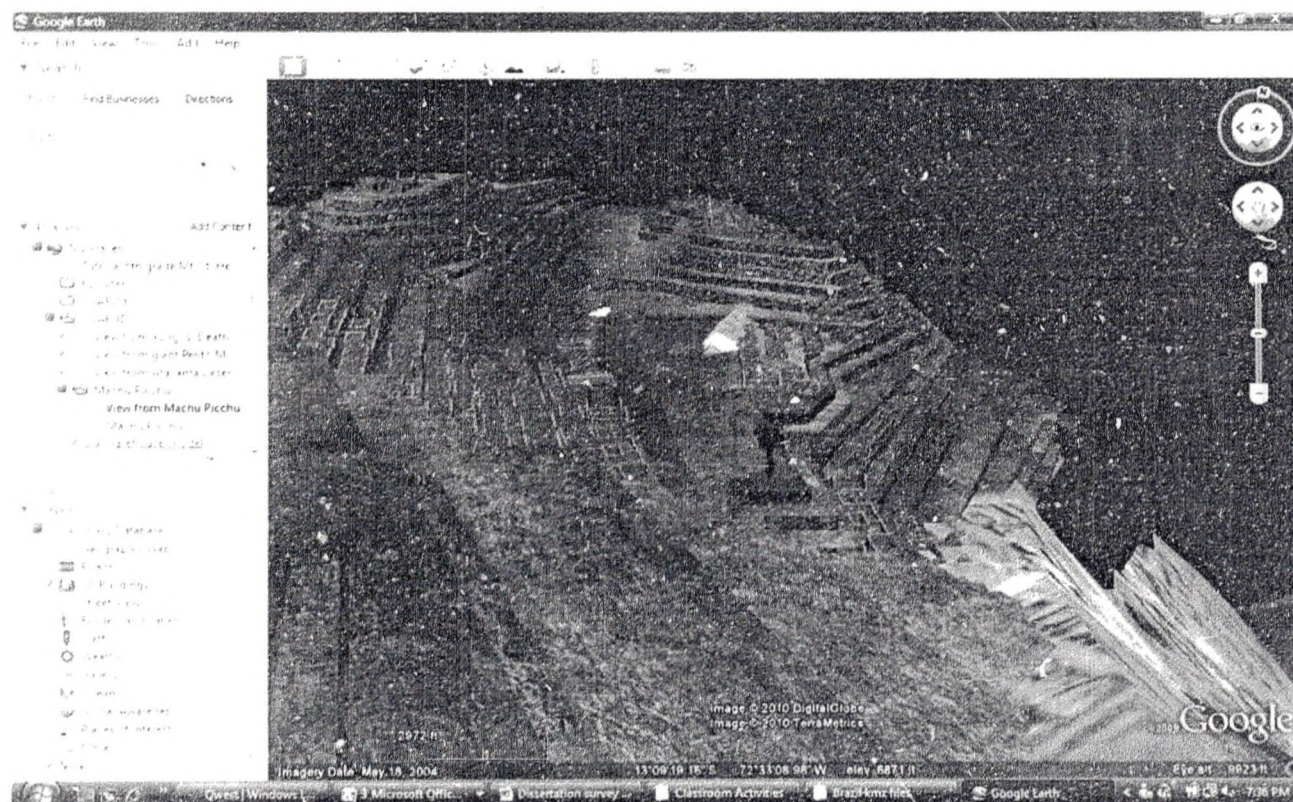
Screen Shot OSAE Test: Google Earth Image 1



Screen Shot OSAE Test: Google Earth Image 2



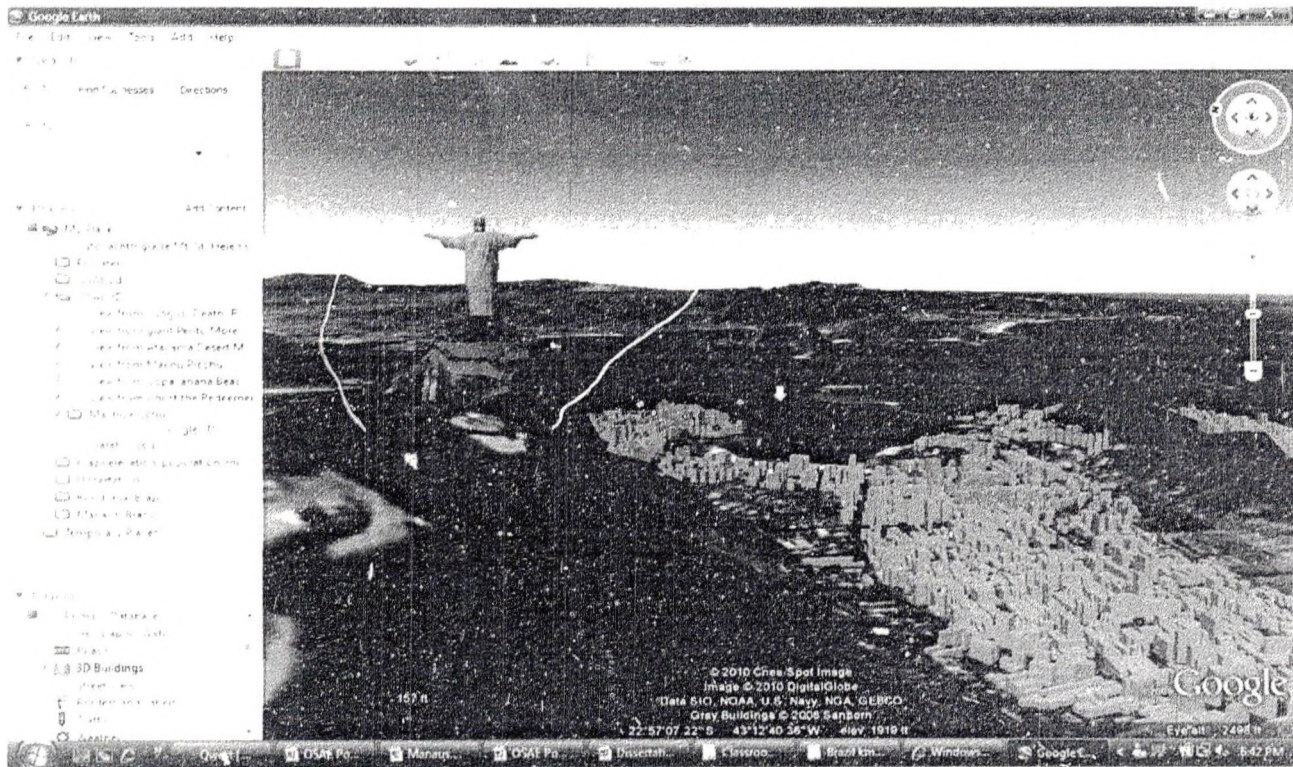
Screen Shot OSAE Test: Google Earth Image 3



Screen Shot OSAE Test: Google Earth Image 4



Screen Shot OSAE Test: Google Earth Image 5



Screen Shot OSAE Test: Google Earth Image 6

## APPENDIX C

### PLACE DESCRIPTIONS GRADING RUBRIC

A 4-point response provides evidence of extensive interpretation and thoroughly addresses the points relevant to the item. It is well-organized, elaborate, and thorough. It is relevant, comprehensive, detailed, and demonstrates a thorough understanding of the concept or item. It contains logical reasoning and communicates effectively and clearly. It thoroughly addresses the important elements of the item.

A 3-point response provides evidence that an essential interpretation has been made. It is thoughtful and reasonably accurate. It indicates an understanding of the concept or item, communicates adequately, and generally reaches reasonable conclusions. It contains some combination of the following flaws: minor flaws in reasoning, neglects to address some aspect of the concept or item, or some details might be missing.

A 2-point response is mostly accurate and relevant. It contains some combination of the following flaws: incomplete evidence of interpretation, unsubstantiated statements made about the text, an incomplete understanding of the concept or item, lacks comprehensiveness, faulty reasoning, or unclear communication.

A 1-point response demonstrates a partial understanding of the concept or item but is sketchy and unclear. It indicates some effort beyond restating the item. It contains some combination of the following flaws: little evidence of interpretation, unorganized and incomplete, failure to address most aspects of the concept or item, major flaws in

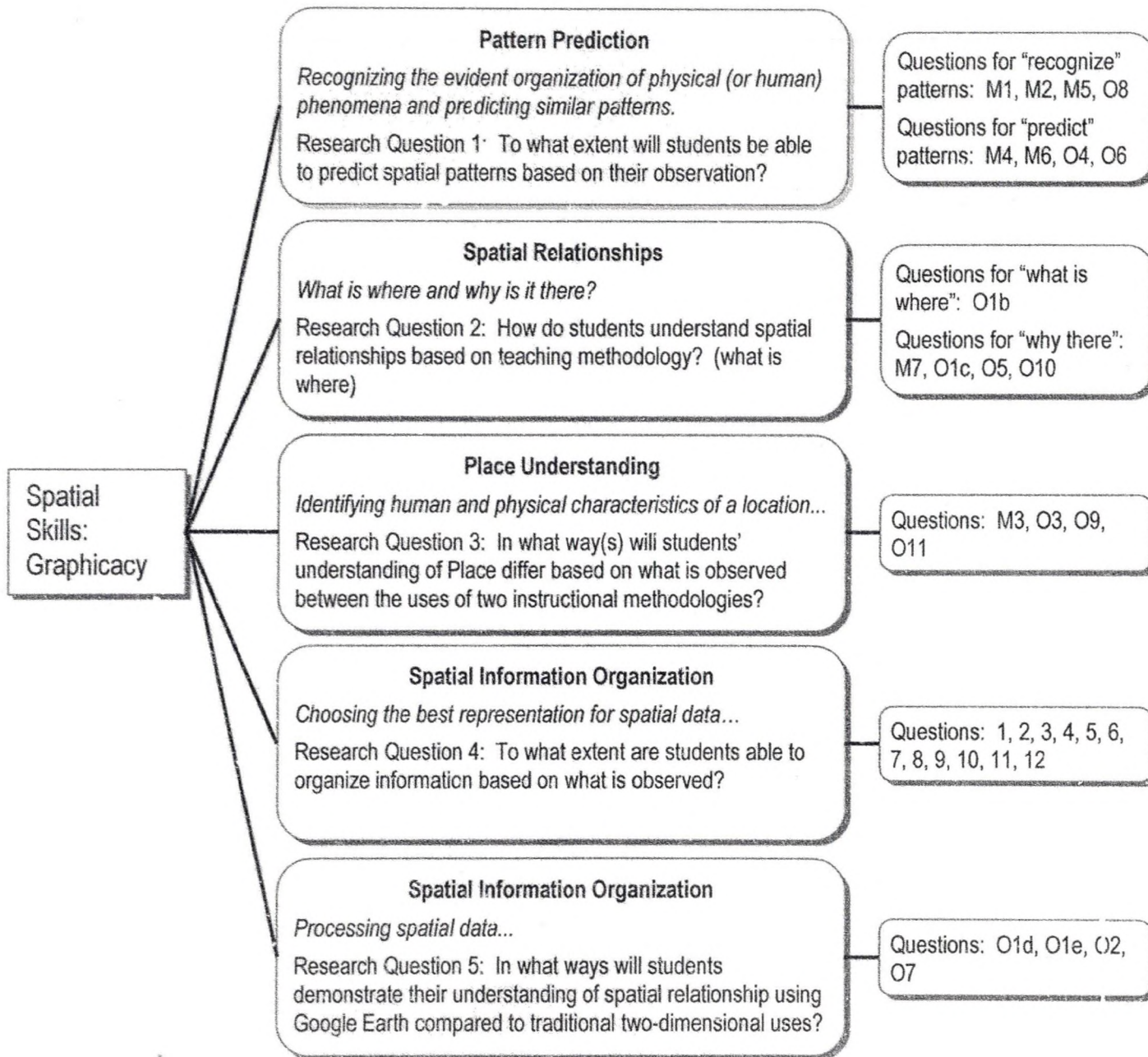
reasoning that led to invalid conclusions, a definite lack of understanding of the concept or item, or demonstrates no coherent meaning from text.

A 0 is assigned if there is no response or if the response indicates no understanding of the concept or item.

Reference:

Ohlweiler, K. (2005). Proficiency Test Scoring Rubrics Extended Response and Short Answer. Retrieved September 24, 2010, from Winton Woods High School Web site: <http://www.waycross.org/wintonwoods/scoringrubric.html#CER>





## APPENDIX E

### SURVEY INSTRUMENT QUESTIONS ALIGNED TO NATIONAL GEOGRAPHY STANDARDS

Survey Question Number	National Geography Standard
Q6, Q7, Q8	1
Q9, Q10, Q11, Q12	2
Q13	12
M1	1, 3, 4, 12
M2	1, 3, 4, 8
M3	1, 3, 4
M4	1, 3, 4, 15
M5	1, 3, 4, 9
M6	1, 3, 4, 18
M7	1, 3, 4, 14
O1b	1, 3, 4,
O1c	1, 3, 4, 6, 14
O1d	1, 3, 4, 6
O1e	1, 3, 4, 14
O2	1, 3, 4, 6, 15
O3	1, 3, 4, 7
O4	1, 3, 4, 18
O5	1, 3, 4, 16
O6	1, 3, 4, 18
O7	1, 3, 4, 7
O8	1, 3, 4, 12
O9	1, 3, 4, 12
O10	1, 3, 4, 12, 14, 15
O11	1, 3, 4, 12, 14, 15

*Note.* Questions aligned to National Geography Standards also take into consideration the question's corresponding activity.

APPENDIX F

LETTER INFORMING PARENT/GUARDIAN OF INTENT



Department of Teaching and Learning  
Education Building Room 5  
231 Centennial Dr. Stop 7189  
Grand Forks, ND 58202  
701-777-3239

kwestgard@dgf.k12.mn.us

January 4, 2010

Dear Parent/Guardian & Student,

In order to improve geographic education, we will be participating in a series of activities using Google Earth in geography class. These activities are already a part of our everyday educational practices planned in January and February 2010 and your student's responses will be used in my doctoral dissertation.

I am conducting this project to evaluate spatial literacy. Your student's anonymous responses during these activities will be kept secure by the researcher (Mrs. Westgard). These responses, in essence, are your student's answer to questions on spatial subject matter. Additionally, since your student will answer questions anonymously, regardless of the answer submitted, student answers on the test portion of this project will not affect their grade in geography during this particular unit of activity. Student responses will benefit not only the research objectives, but will aid in improving geographic education in secondary school settings.

If you have any questions about this study, you may contact me at [kwestgard@dgf.k12.mn.us](mailto:kwestgard@dgf.k12.mn.us). Overall results of this study will be available to you upon request.

Again, I thank you for your understanding as I gather this important information so that I can in turn be of greater service to geographic educators.

Sincerely,

Kerri S. W. Westgard  
Principle Investigator  
Researcher  
Teaching & Learning

If you have questions regarding your child's rights as a research subject, or if you have any concerns or complaints about the research, you may contact the University of North Dakota Institutional Review Board at (701) 777-4279. Please call this number if you cannot reach research staff, or you wish to talk with someone else.

## APPENDIX G

### OSAE ACTIVITY

#### Observe, Speculate, Analyze, Evaluate

OSAE is a method geographers use to investigate locations. OSAE helps to organize your thoughts and notes, and systematically survey a site. It can be used to study a city block, a neighborhood, a district, city, town, suburb, and rural and wilderness landscapes. No matter how large or small the area, **OSAE** is applicable. It includes physical, cultural, political, and economic aspects of the place. All of them are important to understand the landscape of a location.

How do you use OSAE?

1. *Observe* by beginning with the obvious: what catches your attention? Then, look more closely at the details and finally at the larger landscape. You are trying to answer the question "What is it?" These are some questions (there are many!) you could answer while making an observation:

#### **Buildings –**

- What are the buildings used for?
- What about things such as murals, billboards, road signs?

#### **On the street –**

- What are the roads made out of?
- What could you smell if you were here?
- What sounds could you hear if you were standing at this location?

#### **People –**

- What are they doing?
- Types of clothing?

**Unique characteristics-** sculptures, monuments, parks, etc. What do you see?

**What time of year is it?**

**What is familiar and unfamiliar about the scene?**

2. *Speculate* on what is happening in the landscape, based upon your best observation skills. You are trying to gather evidence to answer the question “Where is it?”

- What is going on in this picture?
- What do you see that makes you draw certain conclusions?
- What are the lives like for the people who live here? (work, school, home, etc.)
- How do people, goods and ideas move around here?
- Where could this location be?

3. *Analyze* why things are as they are, based on the best evidence possible from your observation. Here you are trying to provide an answer to your speculations and answer the question “Why is it there?” In other words, why do you think it is like this?

4. *Evaluate* - What can you figure out about this city? How could this landscape be used more productively?

Activity: Look at Photograph #1 and practice OSAE by filling in the chart below. An example has been provided:

What is it? Observation	Where is it? Speculation	Why is it there? Analysis	Should it be there? Evaluation	What is the result of it being there? Evaluation
City bus	On street	To carry large amounts of people from place to place	Yes	Mass transit=less pollution, traffic, gas consumption

OSAE Photograph # 2

What is it? Observation	Where is it? Speculation	Why is it there? Analysis	Should it be there? Evaluation	What is the result of it being there? Evaluation

Photo 1

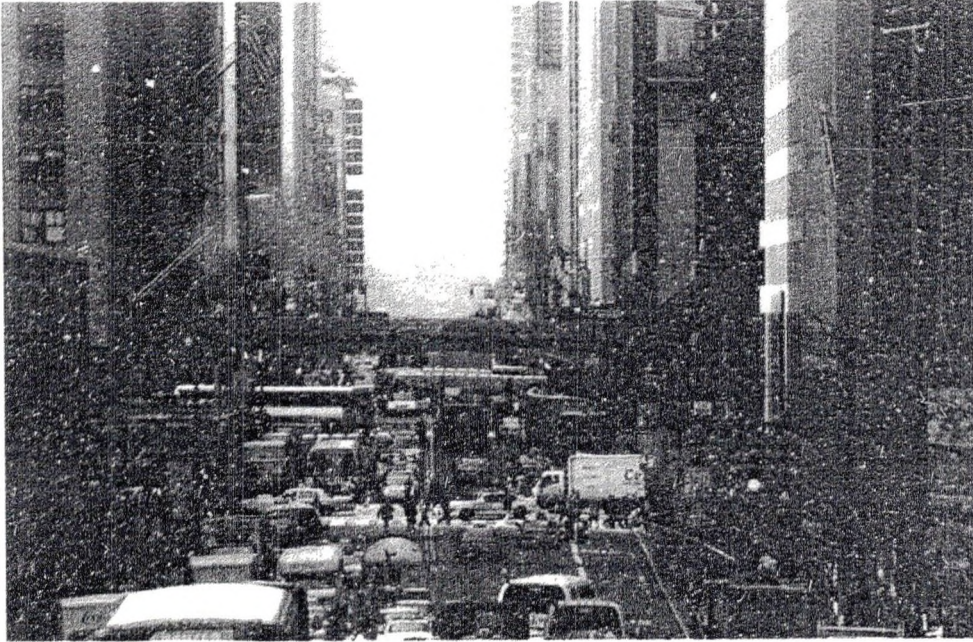
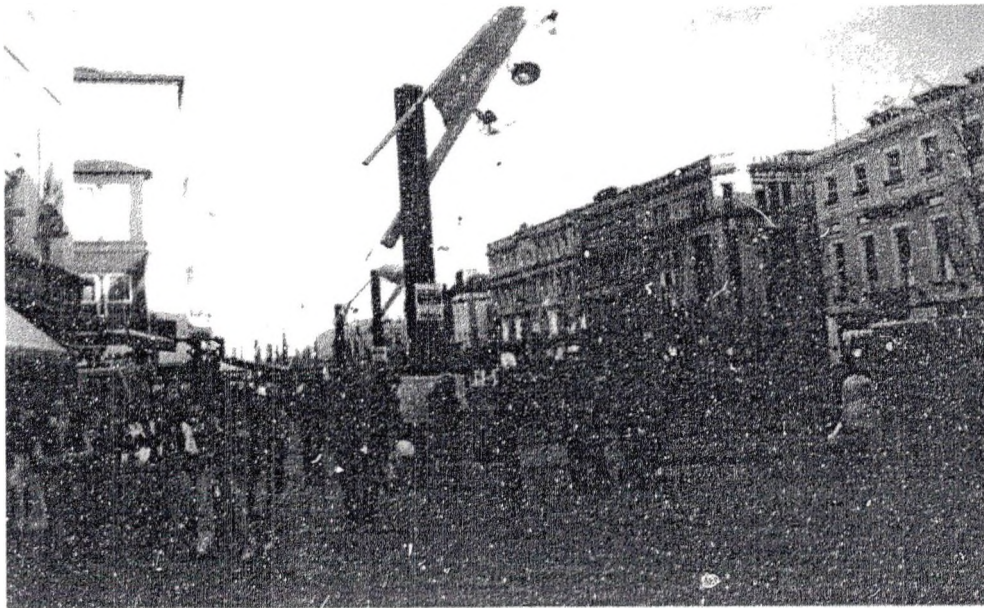


Photo 2





## APPENDIX H

### GOOGLE EARTH DEVELOPMENT ACTIVITIES

#### *Classroom Activity #1*

#### Introduction to Google Earth

Today you will:

- learn to navigate Google Earth; and
- use Google Earth to go on a fact-finding scavenger hunt

You will be tested Monday, February 8, on how to navigate in Google Earth, so take your time and ask questions **now** if you do not understand how to do something!

On your test, you may be asked to show me how to do any of the following:

- Log on to Google Earth from the computer
- Center any given location using the hand icon to “grab” and drag
- Open the Layers panel
- Open the Places panel
- Turn on the following layers: Terrain, 3D
- Tilt the view so what you see is items on the horizon (for 3d buildings/landforms)
- Go back to a bird’s eye view from a tilt view
- How to find elevation of any given location
- Any skill not mentioned above that we have covered in Google Earth

**Directions:** In this lesson, you will learn to navigate a Web site called Google Earth. Google Earth uses many satellite images that fit together like a puzzle to create an accurate image of Earth from space.


Imagine that a friend wants you to go with them on a trip around Brazil, South America. Your friend has several questions about the places they want to visit. Use Google Earth to find the answers to the questions on the Google Earth Scavenger Hunt worksheet. Check off each item when completed.

Please read and follow directions carefully. Complete each “WHAT TO DO” in the order listed below; checkmark the DONE column after you finish each required item.

The items with a ☆ next to it require you to write down an answer.

Take your time to understand **how** to do what is asked of you. If you need help, please raise your hand and wait quietly for assistance.

### Google Earth Scavenger Hunt

<b>DONE</b>	<b>WHAT TO DO</b>
	<p>1. Double-click on the Google Earth icon located on your desktop. This will open up the Google Earth viewer. It looks like this (blue and white): </p> <p>Check DONE when Google Earth has loaded on the computer.</p>
	<p>2. Move the mouse until the hand is over South America. Click once and “grab” then drag to center Brazil in the globe. Double-click on it once to zoom in.</p>
	<p>3. In the layers menu, on the lower left-hand side of the screen, click on the box next to the layer called “Primary Database”. This will reveal several options. First, click on the box to select “Terrain”. This layer will allow for three-dimensional (3-D) images.</p>
	<p>4. Next, scroll up and click on the box next to the layer called “Places of Interest.” This will reveal several options. First, click on the box to select “Transportation” and select airports. This layer will show many of the airstrips in Brazil.</p>
	<p>5. Finally, click in the box next to the layer called “Borders and Labels” to select it (checkmark it). This layer will identify major cities in Brazil.</p>
	<p>6. Locate Rio de Janeiro, Brazil in your textbook, and then find it on Google Earth.</p>
	<p>7. Hold the mouse over this general area of Brazil and double click once to center the map over this area of Brazil.</p>
	<p>8. If necessary, use the rotation button in the upper corner to rotate the map so that Brazil is correctly oriented to North.</p>
	<p>9. Now find the zoom tool on the upper right corner of the screen. It will have a plus sign (+) at one end and a minus sign (-) at the other end. This tool only appears when you move the mouse over it, and disappears when you move the mouse away.</p>

**DONE****WHAT TO DO**

	<p>10. Zoom in by holding down on the plus sign until the red dot for Rio de Janeiro appears. The round compass is useful if you need to move the image to the east, west, north or south. Experiment by clicking the arrows until Rio de Janeiro is in the center of the screen.</p>
☆	<p>11. Then click on the red dot once to see popular places in Rio de Janeiro. What is the first popular place listed? Write the answer here:</p> <p>_____</p>
	<p>12. Now you will fly from Rio de Janeiro to São Paulo. You want to find out the elevation of the São Paulo airport. Use the zoom tool to zoom back out until all of Brazil is displayed (hold down on the minus sign). Find São Paulo in your textbook, and then find it on Google Earth. Hold the mouse over this spot and double-click once to zoom in over São Paulo.</p>
☆	<p>13. Zoom out and find the Guarulhos International Airport, double click on the symbol, and then hold the mouse over the airstrip to read the elevation (elev in feet) in the lower center of the screen. Write the answer here: _____</p>
☆	<p>14. You and your friend have always wanted to see the Amazon River. The shortest flight from São Paulo to the river will take you both to Eduardo Gomes International in Manaus, Brazil. You need to know if Manaus is on the north or south side of the river. Use what you've learned to find Manaus and write down what side of the river it is on here: _____</p>
☆	<p>15. Now you want to travel to the Brazilian state capitol. Use what you have learned to zoom into this city. What is the elevation here in feet?</p> <p>_____</p>
	<p>16. Finally, you and your friend want to spend some time relaxing at Copacabana Beach, Rio de Janeiro. Use the terrain tool (see below), located in the upper right corner of your screen to tilt the image so that you can see Rio de Janeiro in 3-D! Find the beach!</p>
	<p>17. Then use the rotational tool to take a 360-degree look at Rio de Janeiro until you see the ocean and hotels. NICE JOB!</p>



How to “tilt” for 3D viewing. There are two ways you can do this...

1. Press on the top or bottom arrows inside the circle with the N.  
OR
2. Press down on the mouse scroll wheel, continue holding down and move the mouse forward/backward at the same time.

How to rotate 360 degrees:

Click on the outer ring and while holding down the left mouse button at the same time, move the ring around. You are doing this right when you see the letter N rotate in a circle.

To get back to N at the top, double click on the letter N and the viewer will move back to that northern orientation.

*Modified by K. Westgard (2010) from ACMP ©2006-2008 UAF Geophysical Institute B-3 Google™ Earth Scavenger Hunt*  
6.2

### *Classroom Activity #2*

### Review: Navigating in Google Earth

Note the control panel in the upper right corner of your screen. Use this control panel to zoom in and out (right), tilt up and down (top), and otherwise navigate (arrows, ring). Note that you can also zoom in and out using a mouse with a scroll wheel.



**Layers and Featured Content.** Note the panels on the left side of the screen (Places, Layers).

*Places:* The **Places** panel is where you can store files and folders, and where you can save downloads.

*Layers:* The **Layers** panel allows you to turn on and off other features, such as place names, roads, boundaries, and featured content.

**DONE**

**WHAT TO DO**

	1. Double-click on the Google Earth icon located on your desktop. This will open up the Google Earth viewer.
	2. Find the “Places” panel to the left side of the Google Earth viewer.
	3. Find the “Layers” panel to the left side of the Google Earth viewer.
	4. In the “Places” panel there are folders with (+) or (-) signs. Check DONE when you see these types of folders:   = folder not opened      -  = opened and you can see the contents
	5. In the Layers panel, on the lower left-hand side of the screen, click on the box next to the layer called “Primary Database” to open the folder and view the contents (change the + sign to a – sign).
	6. Clear all boxes that may be “on.” You do this by clicking once in the Primary Data Base box (the empty box, <b>not</b> the + or – box), there should be no color or checkmarks visible after doing this.
	7. Go to the Gallery folder in the Layers panel. Click the + symbol next to the Gallery folder to open this folder, then check the box next to “Gigapxl Photos.”
	8. Now, zoom to the United States and find the state of Washington ( <i>use textbook to find Washington if you don't already know</i> ). Put Washington State in the center of your viewing window (click and drag as you learned in the last lesson).
	9. Double click on the state of Washington to zoom in.
★	10. Find the Gigapxl photo at Mount St. Helens National Volcanic Monument in Washington State. <b>Single</b> click on that icon. A description will open automatically. Read the information to answer the question:  How and when did this crater form?
	11. Inside this informational pop-up window, you will see a blue link towards the top that says “fly into the ultrahigh resolution photo.” Click <b>once</b> on this link.

**DONE****WHAT TO DO**

	12. You can zoom into, out of, and around this photo. Do this by placing the “hand” cursor on the photo and double-clicking and/or scrolling with the mouse wheel. Practice doing this to see the detail of the photo close up.
☆	13. Center the photo, and note/observe the “matchstick-like” pattern on the side of the green hill.  What are the long, whitish objects, and what caused this pattern?
	14. When you are done looking at the Gigapxl Photos, exit the photo. You can exit the photo by clicking on the “Exit Photo” box in the top right corner of the viewing screen.
	15. Turn the Gigapxl layer off (uncheck the box).
	16. Zoom out until you can see the summit (top) of Mount St. Helens. The Eye Alt (in the bottom right corner of your screen) should be about 52377 feet.
☆	17. Try clicking the “Terrain” layer in the Layers panel on and off.  How does having the Terrain layer on change what you see at Mount St. Helens? Write a short description below:
	18. Double-click once in the middle of the crater to zoom in.
	19. Now “tilt” the view as you learned in the last lesson. You should now be able to see Mount St. Helens in “3D.”
☆	20. Use the control panel in the upper right of the screen so that you are facing directly into the crater. What direction are you facing?

When you are done, stop at four different places around the base (two places) and summit (two places) of Mount Saint Helens. Use the rotational tool at the top right of your screen to see in 360 degrees from each of your stops. When you can do this, raise your hand and show the teacher.

## APPENDIX I

### GOOGLE EARTH PROFICIENCY DEMONSTRATION

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Student Name _____	SUCCESSFUL?
TASK	YES OR NO
Log on to Google Earth from the computer	
Center any given location using the hand icon to “grab” and drag	
Open/Close the Layers panel	
Open/Close the Places panel	
Turn on the Terrain Layer AND 3D Layer	
Tilt the view so what you see is items on the horizon (for 3D buildings/landforms)	
Go back to a bird’s eye view from a tilt view	
How to find elevation of any given location	
Rotate the view 360 degrees	
Zoom in or out	
Turn on/off Borders/Labels	
Open/Close folders using + and - signs	
Clear all layers using Primary Database	

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APPENDIX J

STUDENT SELF-REPORTING OF TECHNOLOGY USAGE

Statistics		Internet	Cell Phone Use	Television use	Computer use	Video game use	Experience with computer technology
<i>N</i>	Valid	84.00	84.00	84.00	84.00	84.00	84.00
	Missing	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	1.80	2.26	1.87	1.60	1.06	2.43
	Std. Error of Mean	0.12	0.16	0.10	0.11	0.10	0.09
	Std. Deviation	1.11	1.45	0.95	1.01	0.91	0.83
	Variance	1.22	2.10	0.91	1.01	0.83	0.68



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