Abstract

Spatial Competence in Texas High School Students

Research on geographic education has exploded since the 1980s, producing everything from articles to books to national curricular standards. Geographic learning, however, begins long before any student steps into a classroom. Spatial competence, the perceptions of the relationships of objects that determine our understanding of place, is a critical life skill that begins to develop at an early age. Several studies have shown a gap between the development of spatial competence in girls and boys, a gap that continues to grow throughout childhood and adolescence. I will investigate the concept of spatial competence and examine the existence of a gap between high school girls and boys in Texas. Using the Texas Assessment of Knowledge and Skills (TAKS), I will study both the specific TAKS questions that test spatial competence and the performance difference between girls and boys on those certain questions. In looking at the results, I hope to find in what areas and at what age girls perform lower than boys on spatial competence questions. Knowledge of existing spatial incompetence could potentially help educators across Texas help improve their students' performance and confidence in geography classes.

Review of Literature

On the first day of high school, most incoming freshman trudge from class to class, preparing to learn the same subjects for yet another year. Staring at their schedule, many students find geography, a formerly foreign subject, and ponder exactly what type of torture they will have to endure for the year. As they wander into a classroom filled with maps and charts, each student wonders, “What is geography?” Unfortunately, geography has a very elusive definition. To most students, geography is the memorization of location names. Dr. Brock Brown defines geography as “a widely-applicable, interdisciplinary perspective that allows one to observe and analyze anything distributed across Earth space”(Brown 1994, 16). To an educator, however, geography is a fundamental subject that effectively combines many class lessons and real life experiences; geography gives students a connection with the earth.

Geography education has not received the attention that an all-encompassing, skill-building subject should merit until recently. After World War II, geography became integrated with other social studies in schools; ethnocentric America felt no need to educate its students on the rest of the world (Stoltman 1997, 142). In 1962, most geographical concepts were taught in the seventh grade, leaving many high schools virtually geography free (Stoltman 1997, 150). Without geography at the high school level, students graduated with little knowledge of the natural or cultural world around them. Literature published between 1948 and 1965 lacked any global perspective. Though geography was supposedly being integrated into other social studies courses, research found that most history textbooks failed to discuss geography or geographic concepts(Stoltman 1997, 143). How can students grasp the concept of the American migration West without knowledge of the countless natural obstacles that stood in the early settlers' way? Obviously, combining geography with other disciplines was failing to provide adequate geography instruction. The media influenced geographic perceptions more than any other source. A study in 1974 concluded that students were most familiar with those countries that received a majority of news coverage or were largest in land area (Stoltman 1997, 160). By the early 1980s, the United States lagged behind Japan, Sweden, Mexico and even Nigeria in geographic knowledge (Peterson 1994, i). More than twenty percent of a sampled population of students could not locate the United States on a world map (Joint Committee on Geographic Education 1984, 1-12)!

Beginning in 1984, geographers, politicians, and teachers alike took action to promote geography in education. The National Council for Geographic Education (NCGE) and the Association of American Geographers (AAG) wrote the "Guidelines for Geographic Education" which included the five themes of geography as well as outlined the appropriate sequences to geographic education(Boehm 1997, 2). The five themes of geography are broken down into simple definitions and followed with examples, in order to help teachers actually apply the guidelines in class (Joint Committee on Geographic Education 1984, 3-8). The sequence of geographic education actually lists when to implement certain criteria and when students should be able to perform certain tasks in geography. For example, a kindergarten student begins learning of him or herself in relation to space, then gradually moves to neighborhoods and small communities. After studying theses geographic concepts, he or she should be able to recognize a globe as a model of the earth, use simple classroom maps, follow and give verbal directions, interpret map symbols using a legend, and use cardinal directions (Joint Committee on Geographic Education 1984, 11-12). In 1985, the National Geography Society established statewide alliances comprised of university geography professors and public school teachers by hosting summer training and developing "innovative education materials" (Boehm 1997, 3-4). Across the country, educators everywhere were rebuilding the once weak geography community. By the early 1990s, schools were beginning to reaffirm the vital status of geography and other studies of the natural world. In 1994, the American Geographical Society, Association of American Geographers, National Council for Geographic Education, and the National Geographic Society combined their efforts to create a national set of curriculum standards in geography known as *Geography for Life: What Every Young American Should Know and Be Able to Do in Geography* (Boehm 1997, 6). Up until this book was written, most researchers focused on what and when, rather than how to teach geography. The colorful, innovative book described eighteen geography standards categorized under six essential elements – the world in spatial terms, places and regions, physical systems, human systems, environment and society, and the uses of geography(Geography Education Standards Project 1994, 34-35). *Geography for Life* also outlines five geographic skills, all centered on inquiry-based learning. A student should be able to ask geographic questions, acquire geographic information, organize and then analyze the information, and ultimately answer geographic questions. For the first time, geography became more than dots on a map and involved the student in higher thinking about the natural world.

Spatial Competence

The development of geographical skills, however, does not begin in the geography classroom. Spatial competence and spatial abilities begin to develop at a very early age, and research suggests that by the time high school students take geography, there is already a “spatial competence gap” between males and females (Nabhan and Trimble 1994, 184). As an educator, it is imperative to understand the cognitive development of one’s students. The purpose of this section is to define spatial competence, outline the categories of spatial competence, and describe several theories for the differences in spatial competence.

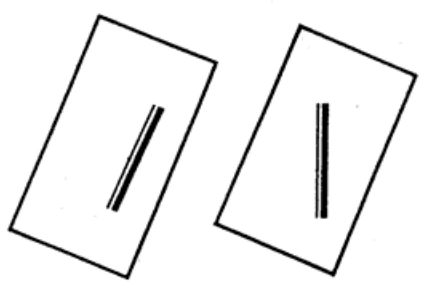
Spatial competence is commonly defined as “the perceptions of the relationships of objects that determine our understanding of place” (Nabhan and Trimble 1994, 184). Spatial competence is a critical life skill that aids in complex problem-solving as well as allow one to successful navigate through the world. Spatial competence allows one to “picture in one’s mind the shape of things, their dimensions, coordinates, proportions, movement, and geography” (Pease and Pease 2000, 102).Many assume that females naturally exhibit a lack in spatial competence, but a variety of methods and tests have produced mixed results. Gary Allen (2000) nicely summarizes the current state of spatial competence research:

> Currently, psychologists, philosophers, and biologists appear to be rather distant from a mutually satisfactory account of how co-actions between genetic and environmental influences have resulted in cognitive differences so pervasive that often they can be detected statistically in modest-sized samples differentiated only on the basis of sex. (Allen 2000, 3)

Categories of spatial competence

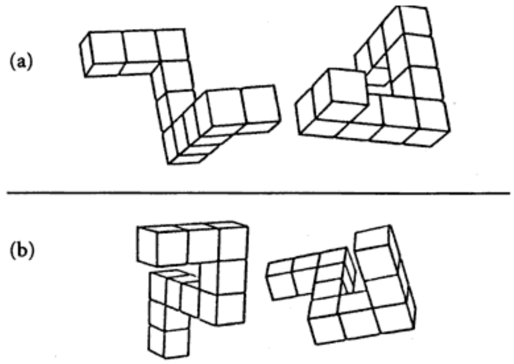
Although researchers disagree on the number of categories or the definition of each category, three main categories are generally agreed upon.

Spatial perception is the ability of a person to “determine spatial relationships with respect to the orientation of their own bodies, in spite of distracting information” (Linn and Petersen 1985, 1479-1498) Spatial perception is often tested using the Rod and Frame Test or the water level task.   An Example of the Rod and Frame Test:



Rod and Frame test—Align a rod within these frames so that the rod is vertical.

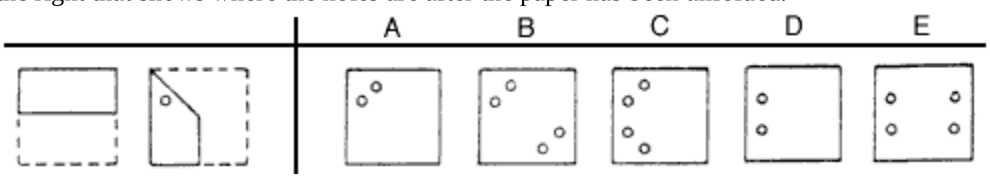
Mental rotation is “the ability to rotate a two or three dimensional figure rapidly and accurately” (Linn and Petersen 1985, 1479-1498) Mental rotation tasks measure the speed of the response rather than accuracy. Researchers have encountered problems with this category because young children cannot successfully complete the test due to a lower concentration level. Mental rotation tests also show that men do perform more quickly than females, but many attribute female’s slower performance to caution, or a desire to double-check their work. An example of a mental rotation test:



Mental Rotation Test—Are these two figures the same except for their orientation?

Spatial Visualization involves "complicated, multistep manipulations of spatially presented information" (Linn and Petersen 1985, 1479-1498) Spatial visualization often includes mental rotation and spatial perception but uses them in combination with other processes, an emample of which is paper folding. Both sexes have been shown to have an equally difficult time with spatial visualization. An example of a paper folding test:

Paper Folding Test
The two figures on the left represent a square piece of paper being folded. In the second figure a small circle shows where a hole has been punched through all of the thicknesses of paper. Choose the drawing on the right that shows where the holes are after the paper has been unfolded.



These categories are generally tested using psychometric tests with pencil and paper, but many geographers and scientists have realized that real-world environmental and geographic skills should also be taken into consideration. Montello et al. tested skills such as route learning, map learning, extant geographic knowledge, object location memory, and verbal spatial descriptions in addition to traditional psychometric tests. (Montello et al. 1999, 515-534)

Development of spatial competence

Structuralists argue that children attain spatial understanding due to developmental stages. A well known structuralist, Piaget, argues that “spatial understanding does not reach an adult level until a child is between nine and ten years old” (Newcombe and Learmonth 2005, 213)

Incrementalists believe that “environmental knowing is an outcome of the piecing together of bits of information in an incremental way over time” (Matthews 1992). Within incrementalists are two categories. Empiricists contend that external forces shape behavior and knowledge. Nativists claim that knowledge is innate, but can only emerge with the appropriate maturity (Matthews 1992)

Explanations of differences in spatial competence

Deficiency theory points to differences in male and female physiology and hormonal levels. Scientists hypothesize that “patterns of brain organization, variations in the estrogen and androgen content of the human body and genetic factors all influence spatial ability and competence” (Kitchin 1996, 273-286) The idea of bilateral cerebral control proposes that both sides of the brain control spatial ability, but the left hemisphere of females’ brains become dominant at an earlier age. This dominance creates an unbalanced pattern of organization that complicates spatial processing. Research on lateralization theory suggests that “lateralization of the visuospatial processing of the right cerebral hemisphere” (Kitchin 1996, 273-286) is connected to spatial abilities. Supporters of lateralization believe that because males use their right hemisphere more than females, they have better performance in spatial competence. Other advocates of deficiency theory point to the parallel curves of spatial superiority and male androgen production; both peak at around eighteen years of age and then slowly decline.

Difference theory suggests that socio-cultural factors create the division between the sexes. Stereotyping, socialization, childhood boundaries, commuting distances, and even a fear of personal crime have been linked to differences in spatial competence. Hart found that boys were typically allowed to go further than girls and were more likely to break parental boundaries, giving them more knowledge and experience with spatial skills (Hart 1979, 518). Girls, on the other hand, "experience less interaction with the environment and receive stereotypical social and media pressure to move away from activities that build spatial and cognitive mapping abilities" (Kitchin 1996, 273-286).

Inefficiency theory argues that male and female spatial abilities are essentially the same, but testing methods favor male patterns of thinking. Due to an earlier development of verbal skills, girls usually solve visual-spatial problems using verbal solutions. Boys, however, solve these problems with mental-spatial methods, allowing them to complete tasks like mental rotation faster. Researchers also note that females tend to use route-based style maps that use knowledge of landmarks rather than "metric knowledge of distances and directions", which can indicate lack of spatial development, whereas males use area-based maps (Montello et al. 1999, 515-534). Others argue that females organize space topologically, but men "may employ the strategy of using more Euclidean properties in their spatial products" (Kitchin 1996, 273-286).

Some researchers even combine bits and pieces of each of these theories to explain the differences in the way we think spatially. Barbara and Allan Pease wrote a book explaining how the differences in the way men and women think spatially cause relationship problems, appropriately titled Why Men Don’t Listen and Women Can’t Read Maps: How We’re Different and What to do About it. They argue that spatial ability is located in the right front brain in men and this area of the brain is so strong because it “developed from ancient times to allow men, the hunters, to calculate the speed, movement, and distance of prey, work out how fast they had to catch their targets, and know how much force they needed to kill their lunch with a rock or a spear” (Pease and Pease 2000, 102) Their approach combines both deficiency and difference theory by saying that women’s brains are “deficient” because of cultural differences long ago.

Steve Trimbell also has a unique theory; he argues that the spatial competence gap is due to girls moving into puberty earlier:

> “Middle childhood, when so much of cultural learning takes place, lasts from about the age of six, when the brain develops fully, until the beginning of adolescence. For boys, this crucial interlude may last a full two years longer – 40 percent longer – than for girls, for whom puberty comes two years earlier on average, ending ‘the wonder years,’ the magical human interval of general receptivity” (Nabhan and Trimble 1994, 72).

As girls start becoming adults and conforming to the cultural norms of women, boys have extra time to explore their environment and learn about what is around them.

Research on improving spatial competence

Many theories point to why men and women think different spatially, which educators need to be aware of, but the focus of this work is on how educators can improve spatial competence. Since the publication of *Geography for Life* and the rediscovery of the value of geography in the curriculum in the late 1980s, geography has recently shifted its focus away from standards and objectives on paper and turned to researching what actually works in a classroom. Though national standards like *Geography for Life* provide a direction for geography programs, schools must answer to state testing standards, not national standards. Many states modeled their standards after the national programs, but few adopted the standards and skills completely (Bednarz 2003, 100). From the inquiry based method branched several new teaching techniques, all advocating the use of non-traditional teaching methods. The issue-based approach starts with investigating and answering questions about small community problems and the geography behind them, then eventually expands a student's knowledge to global issues. For example, students in San Marcos, Texas could begin learning about the San Marcos River ecosystem and gradually learn to apply what they have learned to larger rivers in different places, such as the Amazon. Rather than teachers lecturing while students passively take notes, students will actively pursue knowledge for themselves, often through projects or field studies. Students learning through issue based materials showed "cognitive gains" on testing measures (Hill 1997, 175). This makes sense; when students can take an interest or have a say in what they are learning, they will learn more. It takes more than just asking questions, however. A follow-up on the implementation of the *Geography for Life* standards found that although the classes studied did use the inquiry teaching methods, the activities used did not develop the student's mental mapping abilities. Students in the study used digital cameras to take pictures of their culture (Bednarz 2003, 107). Though the activity was "inquiry-based" it was not developing an essential geography skill.

Not only do students need to ask questions and learn about issues important to them, students need to develop a deeper knowledge through "active, hands-on engagement" and the use of a variety of teaching methods (Hill 1997, 176). Teachers need to combine lectures, videos, computer games and simulations, student-created projects, and most importantly, field work. When studying the world, it is ironic that many educators choose to teach inside the confines of a cinder-block classroom and the information contained between the covers of a text book. Spatial perception is increased with repetition of "spatial activities" such as mental map building, therefore simply by connecting places in their community more often than girls, boys' spatial perception is stronger, and most girls will never catch up (Nabhan and Trimble 1994, 71). According to Downs and Liben 1997, the absence of fieldwork in nature is what creates the gap between girls and boys in spatial competence and mental rotation. By simply being outside more and going more places on their own, boys gain critical geographic skills that girls will never obtain.

Working in the environment not only creates environmental literacy, it also has been shown to improve critical thinking skills (Ernst and Moore 2004, 521). Critical thinking involves interpretation of facts, analysis of data, evaluation and explanation of the data, and also self regulation (which sound a lot like the five geography skills). In 2004, students participated in an interdisciplinary environmental studies course in their local community using project and issue-based learning. Using the Cornell Critical Thinking Test, both groups of ninth and twelfth grade students who participated in the study showed improvement in critical thinking. Unlike many teaching methods, the environmental course did not favor any particular group or ability level; there was noted improvement across all students (Ernst and Moore 2004, 511). The study found that when students are responsible for learning through planning their own projects, having to hypothesize and investigate, and reflecting on what they were learning, their critical thinking scores will improve (Ernst and Moore 2004, 521). Outdoor education may feel frivolous to some adults, but ninety percent of children feel the environment is the most important issue in their lives (Nabhan and Trimble 1994, 40). Nature education develops vital critical thinking and geography skills and also allows students to study what matters to them. No longer should nature education be “a contradiction of terms, because formal education is where you’re supposed to be, and nature is where you go when you’re truant” (Nabhan and Trimble 1994, 39).

With so many innovative teaching methods and a set of national standards to fall back on, geography educators should have a wealth of materials and experiences to offer, but often rely on textbooks and lectures to provide students with knowledge that could be obtained simply by stepping outside the classroom doors. Geography, although it is one of the few subjects actually forming a link between students and the environment, is still not forming these ties strongly enough. Much research has been done on the development of standards and teaching methods, but few studies have been done on the results of these works or the number of schools accepting them. Geographers started a huge project beginning with “Guidelines for Geographic Education” in the early 1980s, but “it would be a shame if geography educators missed out on the opportunity to study the achievements of that program” (Hill 1997, 178). An excellent seed for geography education has been planted, but it will take inspired teachers, adequate funding, and revolutionary administrators to grow geography into the stimulating program it could be.

Maps

Researchers may not completely agree on how to develop or improve spatial competence, however, the utility of spatial competence is undisputed. Spatial competence allows one to read maps, understand where you are, give directions, and navigate successfully. Texas high school students may care more about how to get around in their new car, but the state tests their spatial competence by testing their ability to read and interpret maps.

A map, simply defined is “an attempt to portray things that are distributed across space” (Brown 1994, 29) . Maps take what is on the earth and display the data in a way that is easier to see and understand. Cartographers simplify real places by choosing what data they want to convey, categorizing the data into classes or groups, and turning data into symbols, shapes, and colors.

In order to understand maps, students must be able to comprehend the concept of representation – that there is a relationship between the images on the map and the real world place. The first level of comprehension is the holistic level. At the holistic level, students are able to understand that models represent real objects, for example, that a globe represents the earth. The second level of comprehension is the componential level. Students at the second level understands the relationship between specific elements of reality and the model, for example, that lines and dots symbolize roads and cities (Downs, Liben, and Daggs 1988, 686).

An experiment done in the late 1990s combined several different tests of spatial competency to search for gender differences. The experiment included psychometric tests, campus route learning, map learning, extant geographic knowledge, object location memory, and verbal spatial descriptions. Psychometric tests confirmed earlier research – males did score higher than females. There were no differences, however, in the map learning portion of the experiment. Both males and females were able to accurately re-create simple, large-scale maps after studying them for a short time. This study states that "it is quite wrong, however, to say that males in general have better spatial ability than females. There are many 'spatial tasks' on which the two sexes do not differ, or at least differ to such a small degree that research with reasonable power does not detect the difference" (Montello et al. 1999, 530). However, Montello does acknowledge that some researchers have discovered different results. Beatty and Tröster found that males out-performed females when locating cities and other features on U.S. and state maps, and Henrie et al. found that male college students out-performed female college students on multiple choice tests of "map skills and map-based geographic knowledge" (Montello et al. 1999, 517).

John and Ashley Simms created a map of England that had two different orientations – one for when traveling north, and one for when traveling south. They received thousands of requests from women, and only a handful of men. Women were interested in the map because it replaces the need for mental rotation; they can drive south and be looking at a map without flipping it around in their head. Men, however, thought it was a joke; they are able to perform the rotation at the same time as they are driving (Pease and Pease 2000, 111).

TAKS

Texas high school students may not have to successfully complete, but the state tests their spatial competence by testing their ability to read and interpret maps. The Texas Assessment of Knowledge and Skills, commonly known as the TAKS test, was first administered during the 2002-2003 school year. The development of the test, however, began in early 1999 with the involvement of "Texas teachers, administrators, parents, members of the business community, professional education organizations, faculty and staff at Texas colleges and universities, and national content-area experts" (Texas Education Agency 2004). Students are given the social studies TAKS at grade 8, 10, and Exit Level (normally taken at the end of 11th grade). Social studies is broken up into 5 objectives: history, geography, economics and social influences, political influences, and social studies skills. Being able to understand, analyze, and construct maps is included in each of these three grade levels under both the geography and social studies skills objectives.

In the objectives for United States history studies since reconstruction:

> The student uses geographic tools to collect, analyze, and interpret data. The student is expected to : (A) create thematic maps, graphs, charts, models, and databases representing various aspects of the United States; and (B) pose and answer questions about geographic distributions and patterns shown maps, graphs, charts, models and databases." The student also "applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology. The student is expected to: (H) use appropriate mathematical skills to interpret social studies information such as maps and graphs" (Texas Education Agency 1998, 1-41).

In the objectives for world history studies:

> The student uses geographic skills and tools to collect, analyze and interpret data. The student is expected to: (A) create thematic maps, graphs, charts, models, and databases representing barious aspects of

world history; and (B) pose and answer questions about geographic distributions and patterns in world history shown on maps, graphs, charts, models, and databases."

The student understands the impact of geographic factors on major historic events. The student is expected to: (C) interpret historical and contemporary maps to identify and explain geographic factors such as control the Straits of Hormuz that have influenced people and events in the past.

The student applies critical thinking skills to organize and use information acquired from a variety of sources including electronic technology. The student is expected to: use appropriate mathematical skills to interpret social studies information such as maps and graphs.

The student communicates in written, oral, and visual forms. The student is expected to: (C) interpret and create databases, research outlines, bibliographies, and visuals including graphs, charts, timelines, and maps

The map-related objectives for world geography studies:

The student understands the types and patterns of settlement, the factors that affect where people settle, and processes of settlement development over time. The student is expected to: (A) locate settlements and observe patterns in the size and distribution of cities using maps, graphics, and other information.

The student understands the growth, distribution, movement, and characteristics of world population. The student is expected to: (A) construct and analyze population pyramids and use other data, graphics, and maps to describe the population characteristics of different societies and to predict future growth trends.

The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology. The student is expected to: (C) construct and interpret maps to answer geographic questions, infer geographic relationships, and analyze geographic change.

The student communicates in written, oral, and visual forms. The student is expected to: (A) design and draw appropriate maps and other graphics such as sketch maps, diagrams, tables, and graphs to present geographic information including geographic features, geographic distributions, and geographic relationships.

The map-related objectives for United States government:

The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology. The student is expected to: (E) evaluate government data using charts, tables,

graphs, and maps; and (F) use appropriate mathematical skills to interpret social studies information such as maps and graphs.
(Texas Education Agency 1998, 1-41)

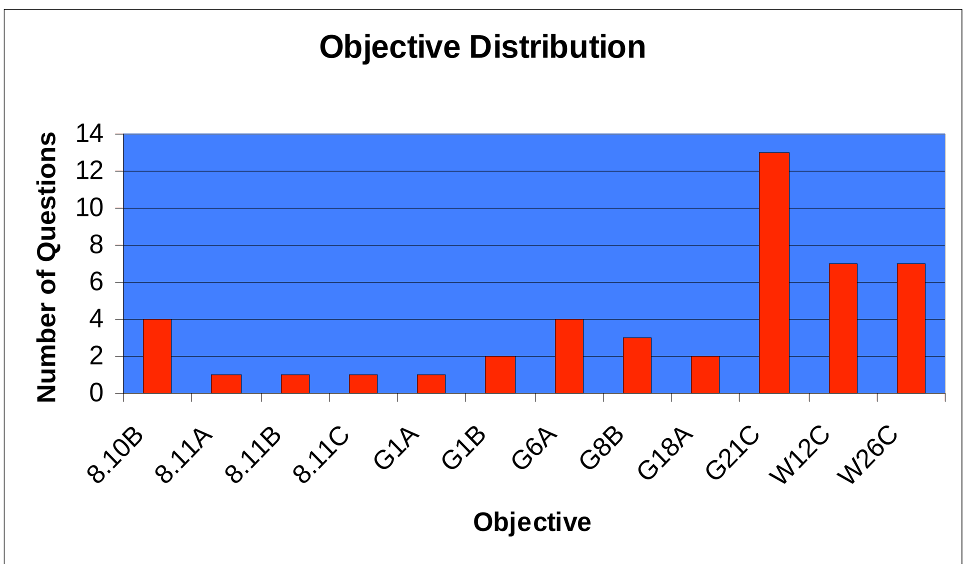
Each grade level also has a specific number of TAKS questions devoted to each of the five objectives:

TAKS Objective	**Grade 8**	**Grade 10**	**Exit Level**
Objective 1: History	13	7	13
Objective 2: Geography	6	12	9
Objective 3: Economics and Social Influences	9	7	13
Objective 4: Political Influences	12	12	9
Objective 5: Social Studies Skills	8	12	11
Total Number of Items	**48**	**50**	**55**

(Texas Education Agency 2004, 6)

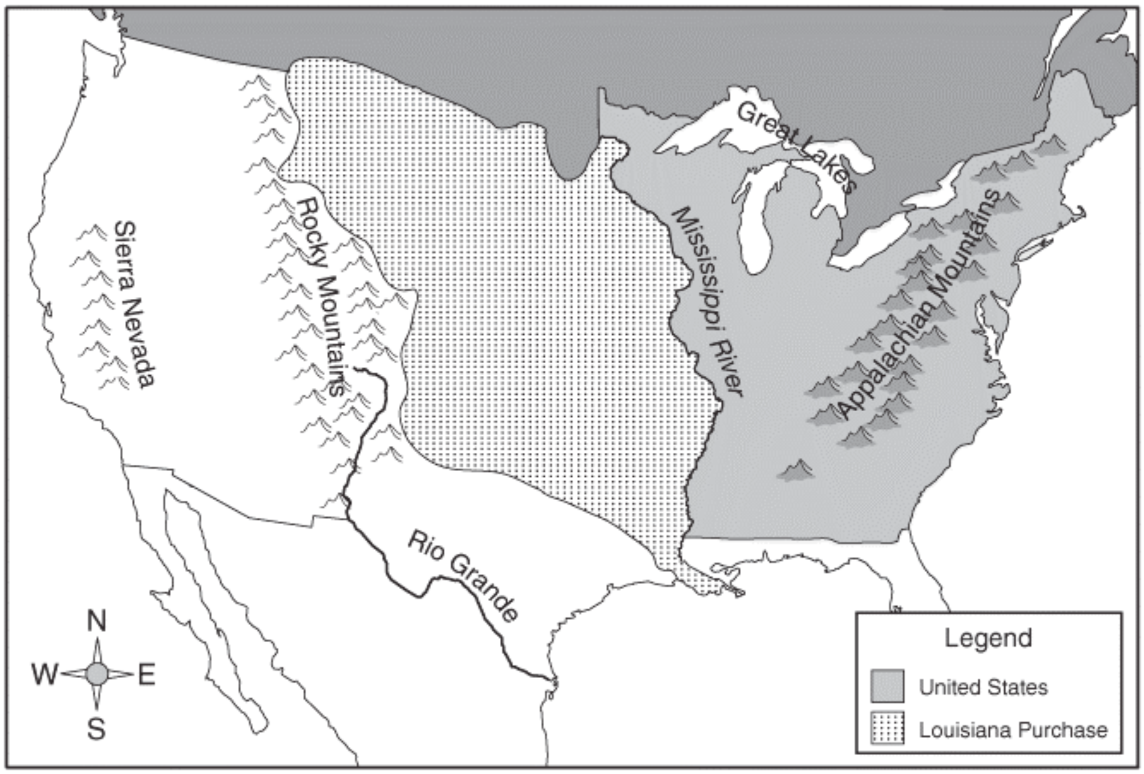
Research Design

For this investigation, TAKS Social Studies tests from eighth, tenth, and eleventh grade were examined. If females at this age truly are lacking in spatial competence, it is hypothesized that females would answer map questions incorrectly more often than males. From eight released TAKS tests, any question that assessed map skills was selected. The objectives for the questions ranged from assessing the students ability to locate items on a map to being able to interpret and analyze information from the map. The total number of questions analyzed was forty six questions. Out of the forty six questions, five were from eighth grade tests, thirty were from tenth grade tests, and eleven were from eleventh grade tests. The table below displays how many times each objective was selected:



An example of a map question from the eighth grade 2006 test:

The Louisiana Purchase



Which conclusion can best be made by examining the map ?
A The Louisiana Purchase almost doubled the size of the United States.
B France gained control of much of the North American continent.
C The Louisiana Purchase was designated for Native American ownership.
D Both Spain and the United States would share control of the Louisiana Purchase

The correct answer is A: The Louisiana Purchase almost doubled the size of the United States(Texas Education Agency 2007).

The Texas Education Agency Analysis and Reporting team reported for each question the number of male correct and incorrect responses, female correct and incorrect responses, and unidentified correct and incorrect responses.

Year: The year the test was given
Items #: The number of the question. C represents the number of correct responses; I represents the number of incorrect responses.
Obj: The Objective assessed
M: Male responses
F: Female Reponses
U: Unidentified Responses

8th Grade

Year	*Item #*	*Obj.*	*M*	*F*	*U*
2004	**Total**		**142732**	**145250**	**275**
	14C	8.10B	107341	109008	171
	14I		35391	36242	104
	36C	8.11A	99675	96299	164
	36I		43057	48951	111
2006	**Total**		**146501**	**147917**	**212**
	7C	8.11C	125044	114154	143
	7I		21457	33763	69
	37C	8.10B	111515	111390	147
	37I		34986	36527	65
	42C	8.11B	114385	112738	26
	42I		32116	35179	86

(Eaton 2007)

10th Grade

Year	*Item #*	*Obj.*	*M*	*F*	*U*
2003	**Total**		**124050**	**125077**	**273**
	2C	G21C	99240	97718	176
	2I		24810	27359	97
	5C	W12C	114613	111939	228
	5I		9437	13138	45
	8C	G6A	107001	104783	212
	8I		17409	20294	61
	16C	W12C	84115	71720	122
	16I		39935	53357	151
	29C	G1A	65142	61049	123
	29I		58908	64028	150
	34C	W12C	89007	89864	157
	34I		35043	35213	116
	36C	G21C	93941	89802	169
	36I		30559	35275	104
	39C	G21C	96388	96140	176
	39I		27662	28937	97
	41C	G1B	78122	75776	150
	41I		45928	49301	123
	43C	W12C	98955	98820	175
	43I		25095	26257	98
	46C	G21C	104184	107190	197
	46I		19866	17887	76
	49C	G18A	95020	100705	183
	49I		29030	24372	90
	50C	G18A	108211	113093	218
	50I		15839	11984	55
2004	**Total**		**130743**	**131543**	**264**
	1C	8.10B	122265	120309	220
	1I		8478	11234	44
	6C	W12C	110230	106475	192
	6I		20513	25068	72
	10C	G6A	120406	119211	216
	10I		10337	12332	48
	14C	G21C	112207	111188	192
	14I		18536	20355	72
	17C	G8B	96400	100666	177
	17I		34343	30877	87
	33C	G21C	76123	61041	107
	33I		54620	70502	157
	40C	G1B	118107	117433	211
	40I		12636	14110	53
	50C	G8B	117710	119957	204
	50I		13033	11586	60

10th Grade

Year	*Item #*	*Obj.*	*M*	*F*	*U*
2006	**Total**		**135338**	**138822**	**154**
	1C	8.10B	127629	129321	125
	1I		7709	9501	29
	4C	W26C	124575	126992	128
	4I		10763	11830	26
	6C	G6A	124494	126916	126
	6I		10844	11906	28
	8C	W26C	122397	122003	122
	8I		12941	16819	32
	28C	G8B	118756	120586	120
	28I		16582	18236	34
	31C	W12C	92718	86014	81
	31I		42620	52808	73
	35C	W12C	107052	100482	82
	35I		28286	38340	72
	42C	G21C	108328	112880	104
	42I		27010	25942	50
	47C	W26C	116699	112906	107
	47I		18639	15916	47

(Eaton 2007)

11th Grade

Year	*Item #*	*Obj.*	*M*	*F*	*U*
2003	**Total**		**96623**	**99958**	**150**
	1C	G6A	91359	95017	133
	1I		5264	4941	17
2004	**Total**		**106362**	**111163**	**185**
	6C	G21C	98762	98216	155
	6I		7600	12947	30
	11C	W26C	90036	91914	138
	11I		16326	19249	47
	47C	G21C	90073	85536	131
	47I		16289	25627	54
2006	**Total**		**114315**	**119117**	**121**
	2C	G21C	111389	112775	114
	2I		2926	6342	7
	10C	G21C	97511	96853	90
	10I		16804	22264	31
	18C	G21C	88525	89293	73
	18I		25790	29824	48
	20C	W26C	80983	73537	68
	20I		33332	45580	53
	28C	W26C	102034	94609	94
	28I		12281	24508	27
	42C	G21C	92666	90391	75
	42I		21649	28726	46
	50C	W26C	102401	104669	89
	50I		11914	14448	32

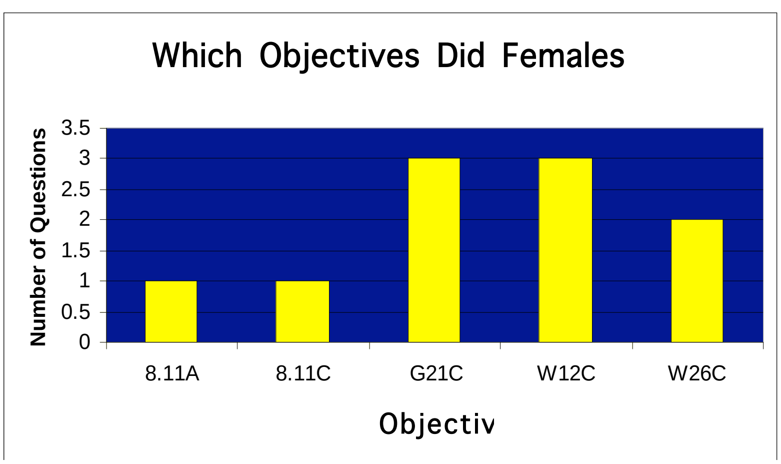
(Eaton 2007)

Results

The first step of the analysis is to find how many questions more females answered incorrectly than males. Out of forty six questions, more females answered incorrectly on thirty seven questions. More males answered incorrectly on nine questions. At a significance level of .05, however, the results are very different. At this significance level, females answered incorrectly more often than males on ten questions, and males did not answer any questions incorrectly more often than females.

Both the mean and the median percent of females with incorrect responses are higher than the percent of males with incorrect responses. The mean female percentage incorrect for all forty six questions is 20.67%, compared to the mean male percentage incorrect of 18.67%. The median female percentage incorrect for all forty six questions is 19.28%, and the median male percentage incorrect is 15.52%. From this analysis, one can clearly see that females DO answer map questions incorrectly more often than males.

The second step of the analysis is to find what types of questions females miss more often than males. Twelve different objectives were tested. Females answered incorrectly significantly more than males on five different objectives, as seen from the table below:



8.11A and C: The student understands the location and characteristics of places and regions of the United States, past and present. The student is expected to: (A) **locate** places and regions of importance in the United States during the 18th and 19th centuries; (C) **analyze** the effects of physical and human geographic factors on major historical and contemporary events in the United States(Texas Education Agency 2004, 15).

G21C: Social Studies skills. The student applies **critical-thinking skills** to **organize** and use information acquired from a variety of sources including electronic technology. The student is expected to: (C) **construct** and **interpret** maps to answer geographic questions, **infer** geographic relationships, and **analyze** geographic change(Texas Education Agency 1998, 22).

W12C: The student understands the impact of geographic factors on major historic events. The student is expected to: (C) **interpret** historical and contemporary maps to **identify** and **explain** geographic factors such as control of the Straits of Hormuz that have influenced people and events in the past(Texas Education Agency 1998, 12).

W26C: Social Studies skills. The student communicates in written, oral, and visual forms. The student is expected to: (C) **interpret** and **create** databases, research outlines, bibliographies, and visuals including graphs, charts, timelines, and maps(Texas Education Agency 1998, 16).

Out of the five objectives, only one assesses the basic skill of locating places and regions (8.11). Four of the objectives assess higher-level skills, such as interpreting and analyzing. Not only do females answer map questions more often than males, but females are missing map questions that require interpretation and analysis of maps more often than males.

Conclusion

Females answered TAKS Social Studies map questions incorrectly more often than males on ten different questions. Nine of these questions tested the geography skills of interpreting and analyzing data presented in maps. Clearly, males do outperform females on questions assessing map skills. Although this research looked only at the variables of gender, it cannot be ignored that females are missing map questions more often.

Research on the gap in spatial competence has just begun to scratch the surface. This investigation does not claim to explain why females answered TAKS map questions more often than males, but further research could be done to possibly explain the major difference. A possible step for further research could be to look at other variables, such as student to teacher ratios, Pre-AP or regular classes, and rural or urban school districts, to determine if any other variables demonstrated such a visible split in the number of map questions answered incorrectly. Research on other state social studies tests could determine if this trend exists with state tests other than the Texas test. Also, with test questions changing every year, following the same type of research on the 2007 and 2008 TAKS tests could determine if the trend continues from year to year.

A qualitative study that investigates why high school students answered questions the way they did could also be a very valuable follow-up study. If we already know that females do miss map questions more often than males, educators and test writers could both benefit from knowing how females think about map questions and what variables, if any, cause them to answer incorrectly.

From the conclusions of this research, it is recommended that educators and administrators make it a priority in every classroom to assure that both males and females have the opportunity to analyze and interpret maps daily. Students with map skills will not only be able to successfully answer TAKS map questions, but also successfully navigate the world around them.

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