GIS in Upper Elementary Classrooms

The Impact of GIS on Student's Higher-level and Spatial Thinking

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Focus of the Presentation

Why GIS in elementary grades?

1. NAEP
2. Early intervention
3. CCSS and NGSS

Two Studies

GIS curriculum

1. Visual presentation
2. Geo-processing tools

Why GIS in Elementary Grades?

National Assessment for Educational Progress (NAEP)

- Only 21% of 4th Grade students are at the proficient or advanced level in geographical skills and knowledge.
- 50 – 90% of the 10 most challenging NAEP questions (4th, 8th,12th) are those that involve the use of maps
- Due to educational policies, time spent on science, social studies, and art in response to statewide testing was reduced up to 71% (Jennings & Renter 2006; Rentner et al., 2006)

Why GIS in Elementary Grades?

Lack of early interventions

- Most of the studies that explored the use of GIS focused on middle and high school (Bodzin et al., 2014, 2013; Radinsky et al., 2013, 2010)
- Already by the age 3-5 months baby boys surpass baby girls in mental rotation tasks (Moore & Johnson, 2008; Quinn & Liben, 2008)
- The top 170 girls and 393 boys in general intelligence at the age of 13 were tracked for 20 years. Those with the highest spatial ability score pursued STEM fields (Wai et al., 2009; Lubinski et al., 2001, 2007, 2009; Shea et al., 2001)

Why GIS in Elementary Grades?

Importance of early intervention

- Early interventions work! 1st grade children, girls and boys, who received a program to improve their spatial skills outperformed a comparative group that received a substitute program (Tzuriel, Egozi, 2010)
- Despite the fact that spatial thinking has an impact on choosing STEM fields and that it can be improved through early intervention, it has not has not received enough attention neither from CCSS nor NGSS.

Why GIS in Elementary Grades?

- In 2012, PCAST offered strategies for improving STEM education during the first two years of college.
- While this is a significant step forward, waiting until students enter college to train their spatial thinking misses a **critical developmental stage** to hone this important skill during compulsory education years in **public schools during which ALL students** can be reached (Committee on the Support for the Thinking Spatially, 2006).

Spatial Thinking

NRC Committee on the Support of Thinking Spatially

1. Concepts of space
2. Tools of representation
3. Reasoning processes
   - Our research focuses on the third element including a set of higher-level thinking processes: Systems thinking, logical reasoning, analogical reasoning, spatial thinking, and counterarguments.

National Science Foundation DRK12

Discovery Research K-12

- Exploratory small-scale studies
  - Two small local schools and 4 classrooms [today's focus]
  - White affluent communities
- Actual data collection
  - Fours schools and 10 classrooms
  - Minority students and students who belong to lower SES families.

Grant # 1316660

Study One

5TH GRADE

Study One: Setting

5th Grade Experimental Classroom

Last session of school day

GIS as a visual tool to explain certain parts of the textbook |westward expansion

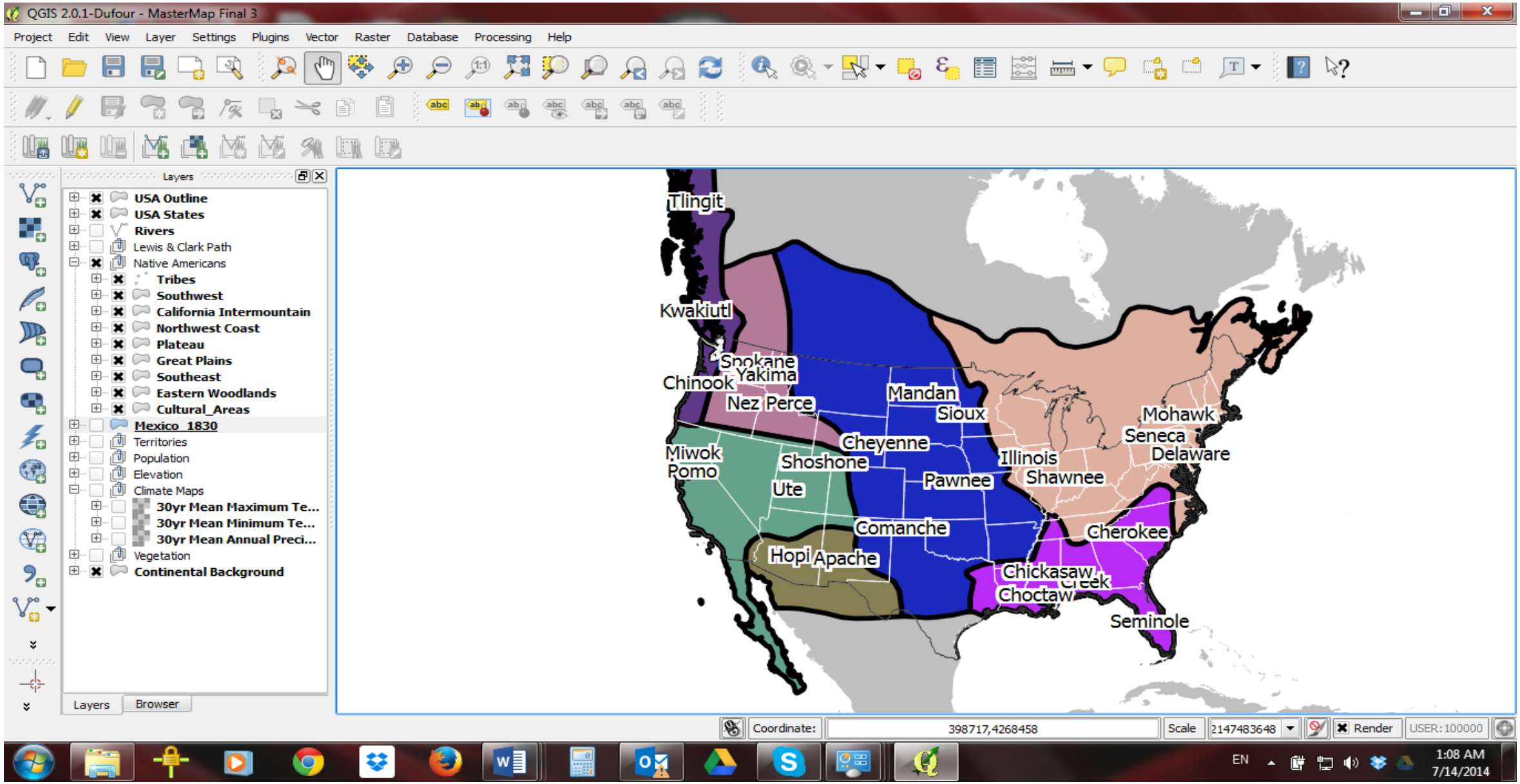
- Native tribes
- Regions
- Population 1970-200
- Elevation
- Temperature and Precipitation
- Vegetation

5th Grade Control Classroom

Session before last of school day

No GIS used. Only the typical textbook was used

- The revolutionary war
- Constitution
- The Bill of Rights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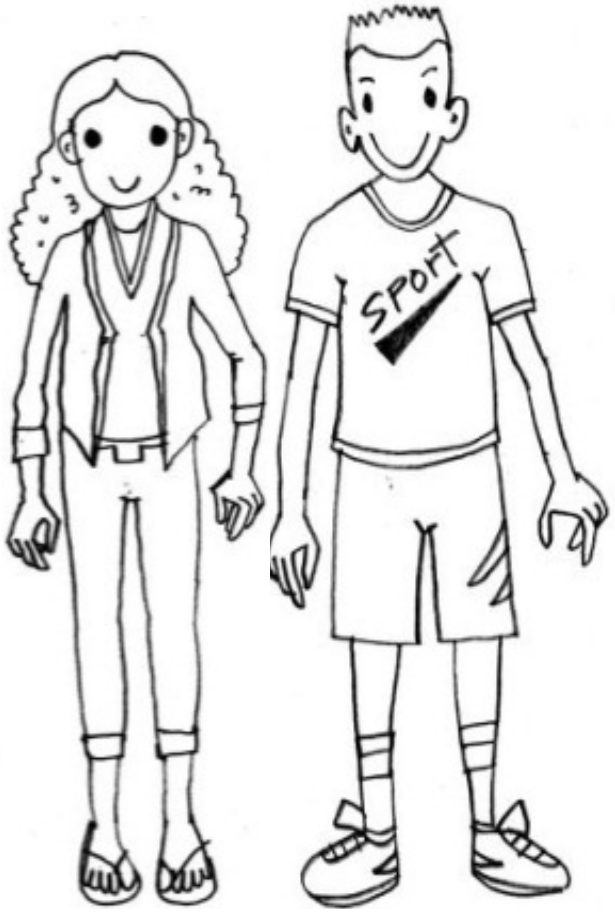
Study One: Specifics

- Study was conducted over a 2-week period
- Students used GIS for about 15 min/day; 3 hrs total
- Students completed the following assessments

1. NAEP geography items focused on spatial dynamics (no differences)
2. Nonverbal CogAT (no differences)
3. Written transfer test to locate red fox dens on a blank map of the state of Illinois

Red Fox in Illinois

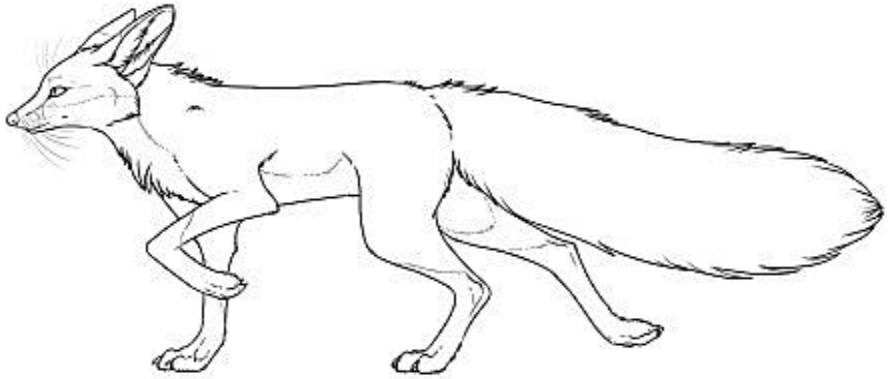
- **Foxes avoid areas where people live**
- **Foxes prefer to live next to corn fields where field mice can be found**
- **Foxes prefer to live close to a water source**
- **Foxes avoid areas that might flood during storms**



Drawing courtesy of FreePhoto.in.th

Jensen and Lucie are your friends from Britain. They would like to come to the United States to visit you and your classmates. They would also like your class to take them out to the fields where they can observe a red fox and track it to its den.

Write a letter to Jensen and Lucie to let them know about your plan.

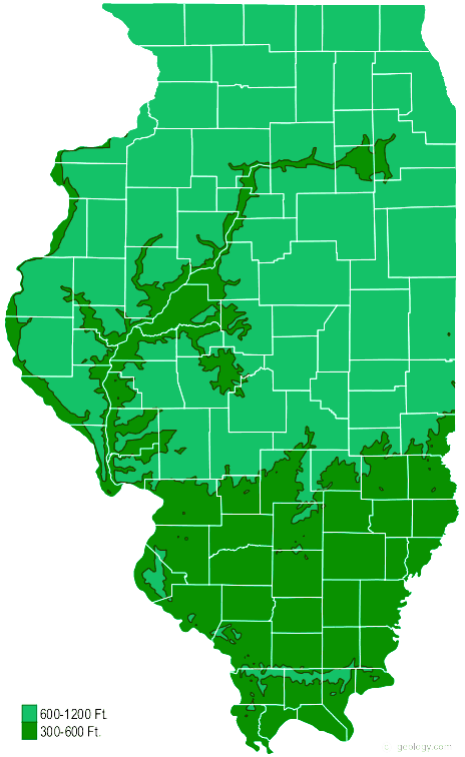


Dirtiran.Deviantart.com

Maps of Illinois

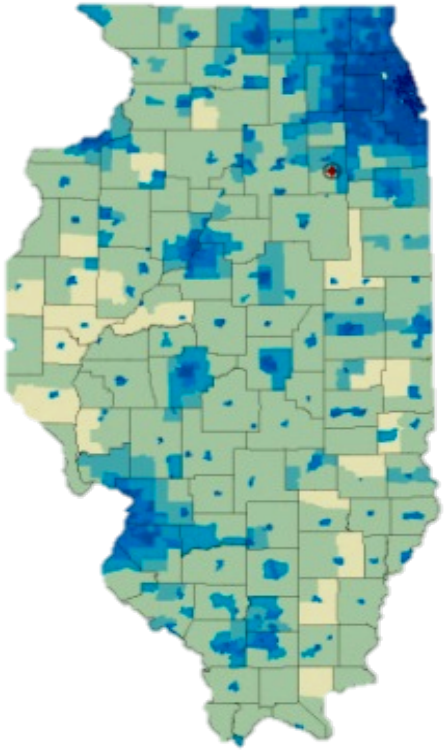
Main Roads

The lines in the map indicate main highways in Illinois



Elevation

The darker green areas in the map are lower



Population

The darker areas in the map have more people there

Rivers and Lakes

The darker lines in the map indicate rivers and lakes

Study One: Transfer Task Results

Compared to the control group, the experimental group generated significantly more:

1. Local information in the ratio of 3:1
2. Global information 2:1
3. Explanations
4. On average 35 more words

Study Two

4TH GRADE

Study Two: Setting

4th Grade Experimental

GIS lessons focusing on four modules

1. Classroom mapping
2. Venn Diagrams
3. Illinois Capitol Building
4. Box Turtles

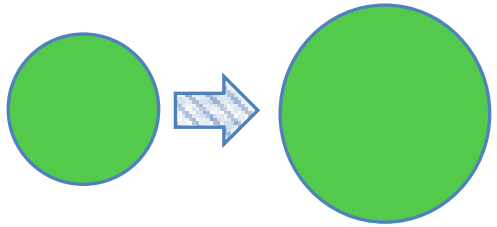
Sessions early in the day

4th Grade Control

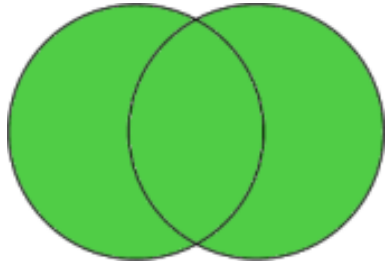
Every day science

Sessions early in the day

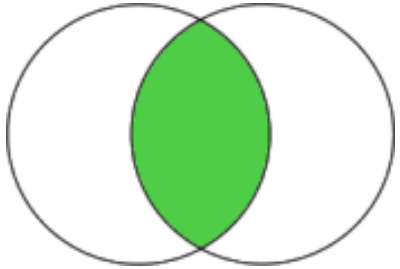
Geoprocessing Tools in Set Operations



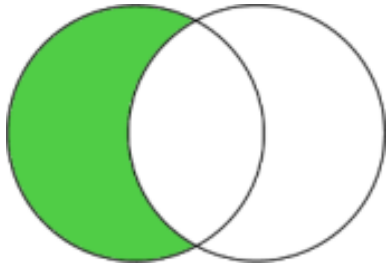
Buffer
The increase of space around a layer



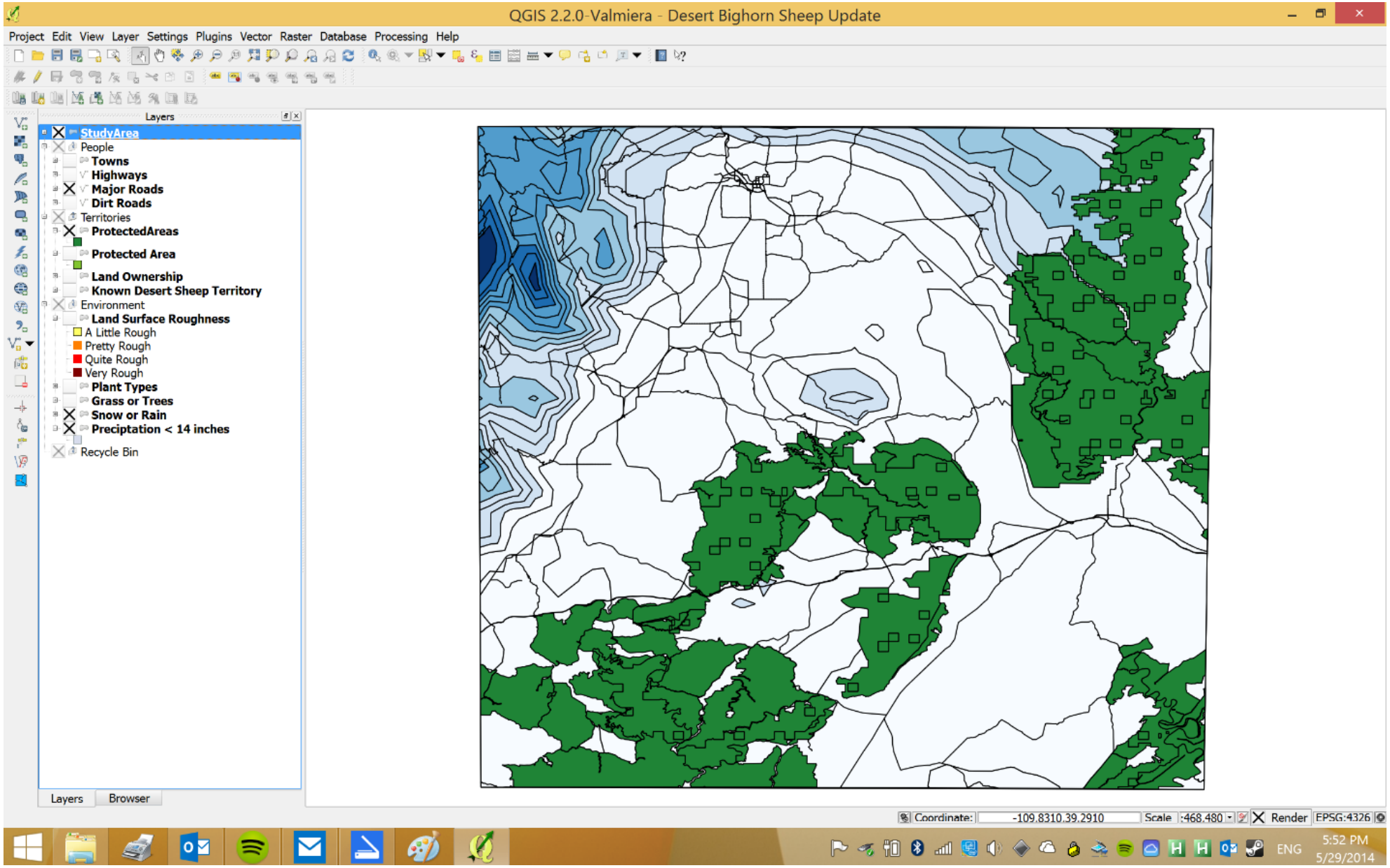
Union
The combination of two layers into one



Intersect
The space two layers have in common



Difference
The space that is unique to one layer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Quite Rough
Very Rough
Plant Types
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Snow or Rain
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Study Two: Specifics

Study was conducted over a 2-week period

Experimental group had 90 min/day for a total of 12 hrs of GIS exposure

Measuring assessments

1. Group cognitive interview
2. NAEP geography items

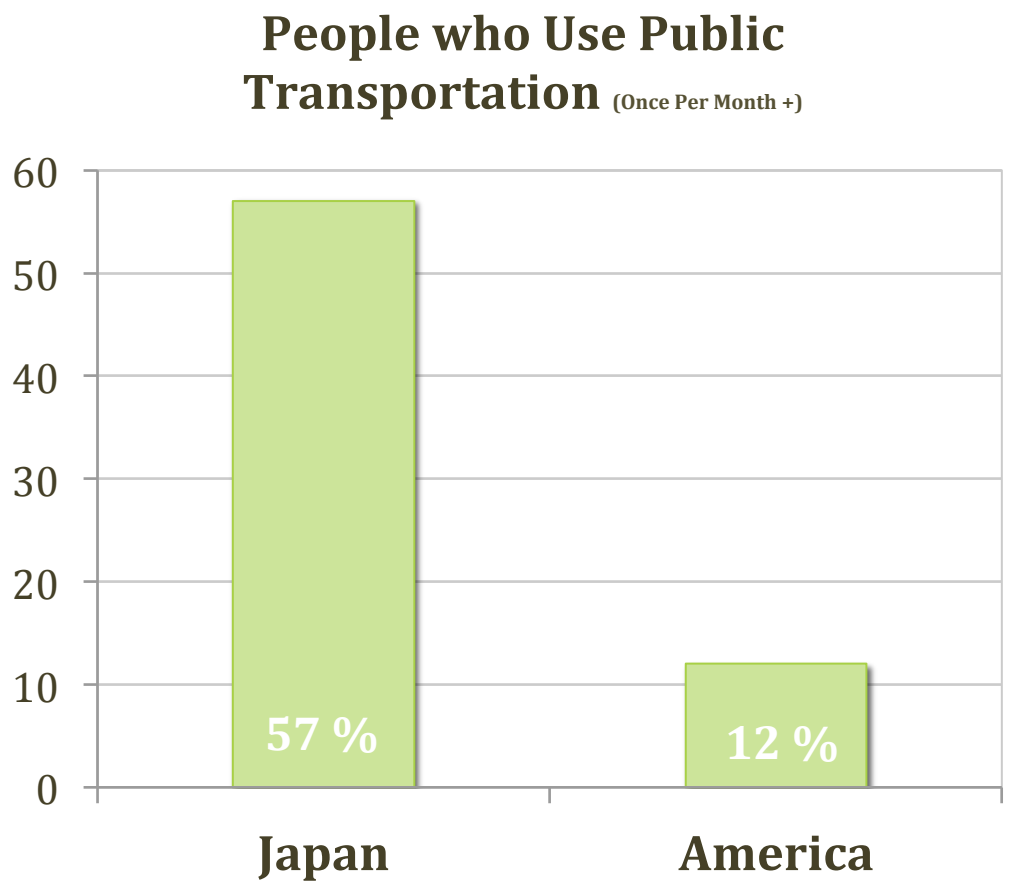
Study Two: Results

The interviews were coded using five higher-level reasoning categories:

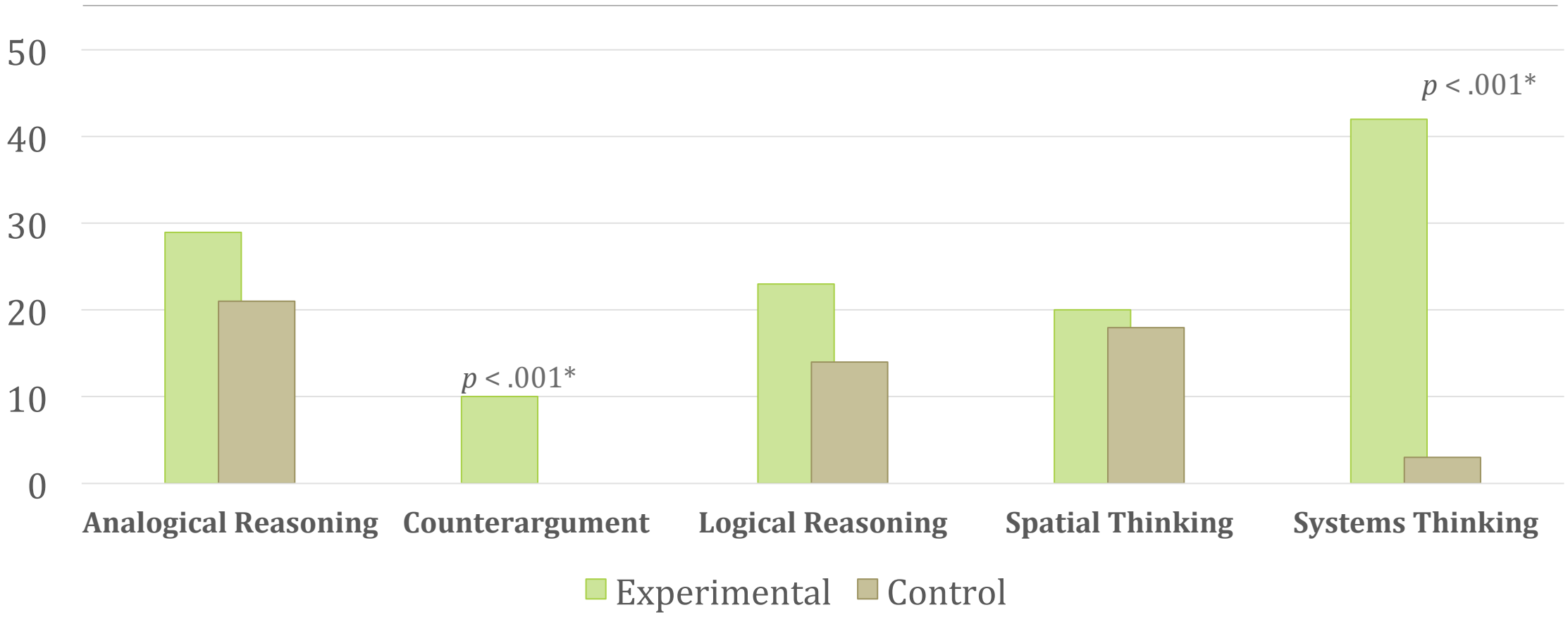
1. **Analogical Reasoning**, using analogies to make a point;
2. **Counterargument**, considering alternative perspectives;
3. **Logical Reasoning**, using if-then statements to explain the sequence of events or cause-effect relationships;
4. **Spatial Thinking**, referencing space;
5. **Systems Thinking**, combining ecological, economic, health, and practical issues in the construction of the answer.

Cognitive Interview Prompt

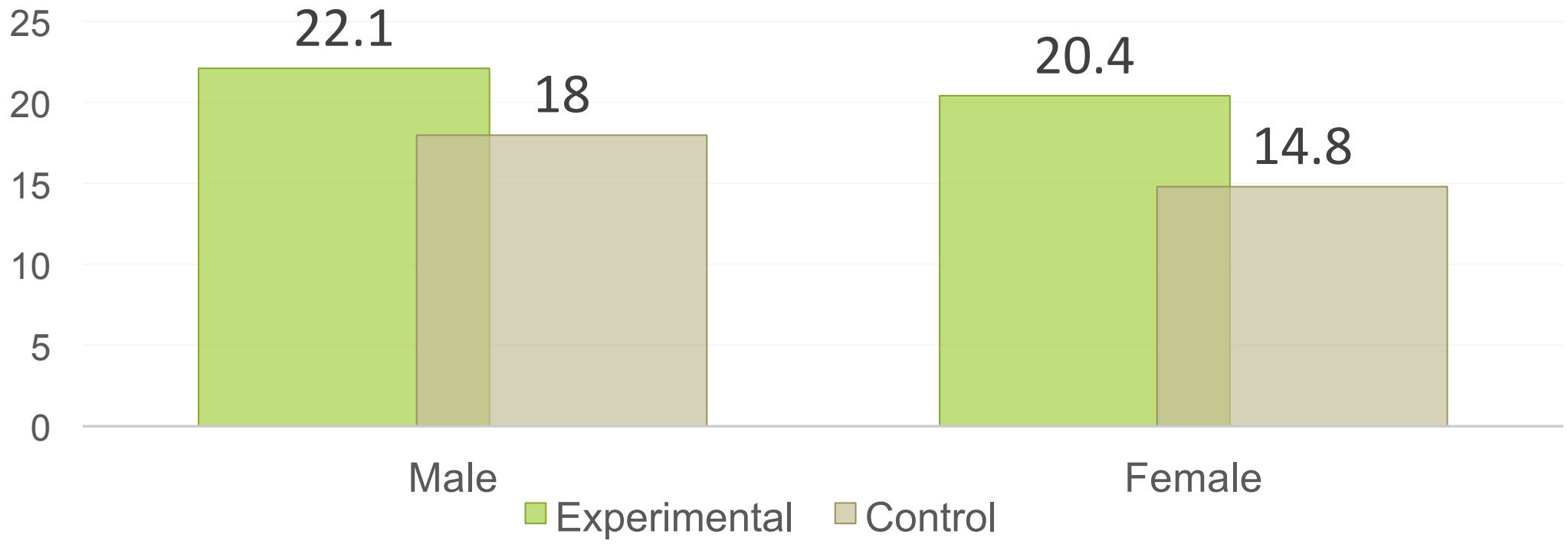
The children were shown the following graph then asked, "Should we in the United States use public transportation more like the Japanese, or should we continue to depend on personal vehicles?" "To encourage people to use buses, where should we construct new bus stops?"



Frequency of different higher-level thinking processes



Gender Comparisons in Post-intervention NAEP Scores



General Conclusions

The experimental groups outperformed the control groups on two areas:

1. Spatial referencing (study 1)
2. Higher-level reasoning (study 2)

These studies support previous studies indicating that early interventions are needed to reduce gaps in spatial reasoning in lower grades.