Digital Mapping Technology in Elementary Grades:
Effects on Spatial Reasoning and Higher-Level Thinking Processes

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Project website
education.illinoisstate.edu/nsf

Research Questions

Will engaging in GIS activities significantly:

- (a) improve students' spatial thinking?
- (b) minimize the gender gap in spatial thinking?
- (c) improve other higher-level cognitive processes?

Context

This exploratory study aims to promote children's spatial thinking and other higher level thinking skills through the use of Geographic Information Systems (GIS). Using six specially designed GIS modules, children learn to apply a number of geo-processing tools to solve problems and meet environmental challenges. Scaffolding is provided to guide children through the modules while students learn the use the GIS technology. Through peer collaboration, children develop higher-level thinking processes. The modules are designed to complement 4th and 5th grade social studies and science curricula.

Participants

- 55 fourth grade students at a middle school in a small rural affluent community.
  - 30 boys
  - 25 girls
- 2 classroom teachers
- Demographics: 96% White; 0.7% Black; 1.5% Asian; 1% Hispanic.
- ISAT Performance: 86% meet or exceed the standard score in math; 68% meet or exceed the standard score in reading.

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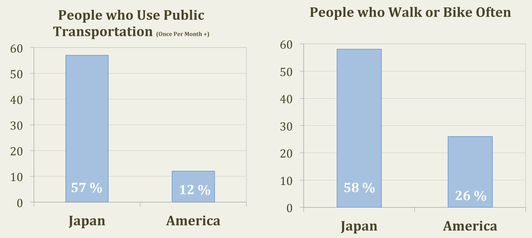
Analyses and Findings

Main Instruments

(a) Group Cognitive Interview
(b) National Assessment of Educational Progress (NAEP) Geography Items focused on spatial dynamics and connections

Cognitive Interview Questions and Coding

The children were shown the graphs below 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?"

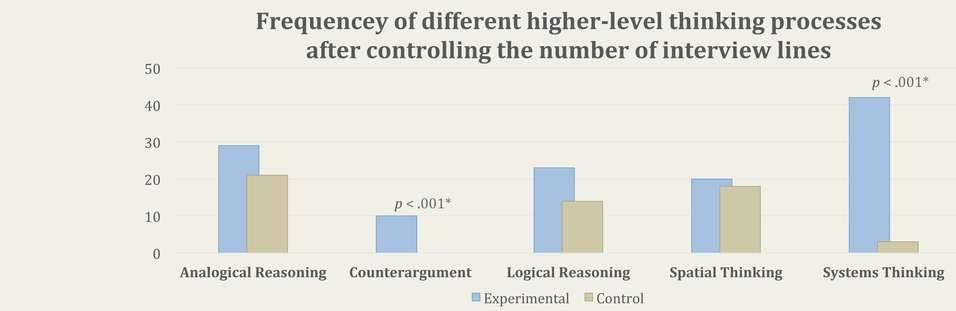


The interviews were coded using five higher-level reasoning categories:

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.

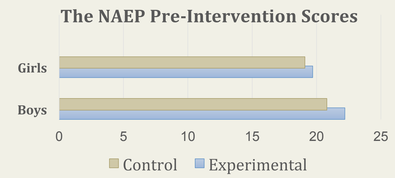
The graph below indicates the differences in higher level cognitive processes between the two groups.

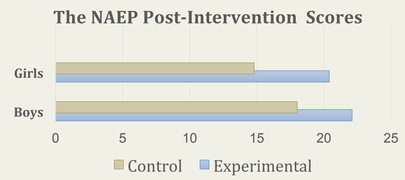
Cognitive Interview Results



NAEP Results

Preliminary analysis of the NAEP geography items revealed that the experimental group did better than the control group, although the difference was not statistically significant. The graphs below depict NAEP scores for boys and girls, revealing no within-group gender differences.





Other Focal Points

- Additional merits of the study include:
  1. Exploring methods of using GIS to promote children's understanding of ecology and their environment
  2. Using peer collaboration and discourse to promote learning and problem solving in the context of using GIS
  3. Developing feedback mechanisms for the ongoing modification and improvement of children's learning and teacher's training materials

Study Limitations

- Lack of Pre-Intervention Group Equivalence:
  - The control group had significantly higher ISAT math scores (p = .04) and marginally higher reading scores (p = .06) than the experimental group.
- Differences in Classroom Testing Conditions:
  - Post-test timing and item difficulty might have been a factor impacting the NAEP results.

Conclusion & Future Directions

- The experimental group outperformed the control group on two higher-level reasoning dimensions: systems thinking and argumentative reasoning.
- The experimental group's spatial thinking remained stable, whereas the control group's spatial thinking declined over time.
- This study supports previous studies indicating that early interventions are needed to reduce the gender gap in spatial thinking.
- We are currently conducting a larger scale study that involves a total of ten classrooms in schools serving higher percentages of children belonging to low-income families and children of color.