Using Geographic Information Systems to Improve Elementary Students' Geography Knowledge & Spatial Skills

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Support - National Science Foundation Grant #1316660

Introduction

- Improving success in **Science, Technology, Engineering, and Mathematics (STEM)** is important.
- For example, STEM job growth has been 3 times larger than non-STEM job growth in the last 10 years; however, STEM employees are in short supply in the U.S. (Kuenzi, 2008; Langdon, McKittrick, Beede, Khan, & Doms, 2011).
- Research shows a positive relation between **spatial skills** and STEM performance (Uttal, & Cohen, 2012; Wai, Lubinski, & Benbow, 2009), and we know that spatial skills are malleable (Uttal et al., 2013).
- **Geographic Information Systems (GIS)** may provide one avenue for improving spatial skills and STEM outcomes.
- Most previous research with GIS has focused on outcomes for high school and college students (Hall-Wallace & McAuliffe, 2002; Kerski, 2003), with recent extensions to middle school students (Goldstein, & Alibrandi, 2013).
- Our focus was testing the effects of GIS during elementary school by implementing GIS with **4th and 5th grade students.**
- We predicted that students using GIS curriculum would show more growth in geography knowledge than would students using traditional social studies curriculum. We also predicted growth in spatial skills.

Method

Participants

- 78 4th & 5th grade students and 2 teachers from 4 classes in 2 elementary schools in an urban public school district

Design and Procedure

- **Pre/Post Design**
  - **National Assessment of Educational Progress (NAEP) Geography Test:** Tested geography knowledge using 14 items matched for item difficulty (20 minutes timed). Maximum score = 27.
  - **Cognitive Ability Test (CogAT) Nonverbal Scales:** Measured spatial skills using Figure Matrices (22 items), Paper Folding (16 items), and Figure Classification (22 items) subscales (10 minutes timed for each subscale). A composite of universal scaled scores was used in analyses (200 = 50th percentile).

Paper Folding

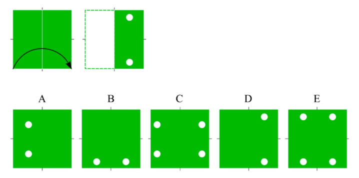


Figure Matrices

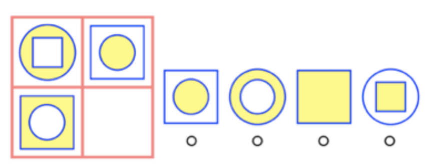
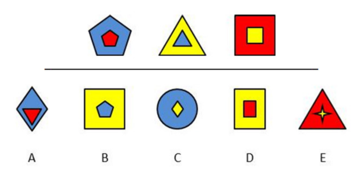


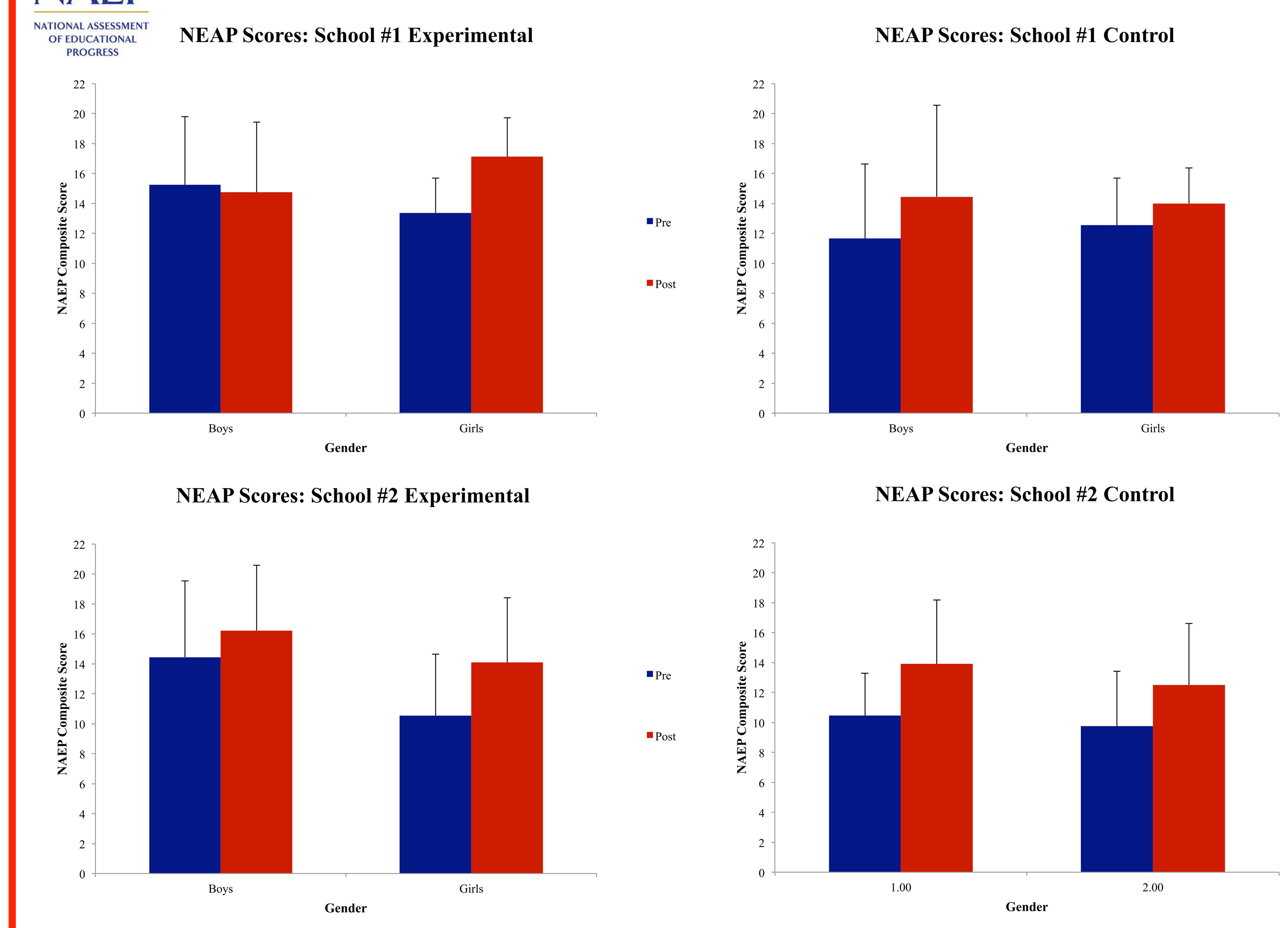
Figure Classification



- **Treatment/Control Design**
  - **Control classes:** standard social studies curriculum
  - **Experimental classes:** 6-week GIS curriculum
  - **GIS Modules Using QGIS:** Students learned to manipulate maps (layers) using geo-processing tools (buffer, intersect, union, and difference) to facilitate higher-level thinking.

Module 0- Cardinal Directions
Module 1- Classroom Map
Module 2- Venn Diagrams
Module 3- American Revolution
Module 4- IL Capitol
Module 5- Box Turtle
Module 6- Bighorn Sheep

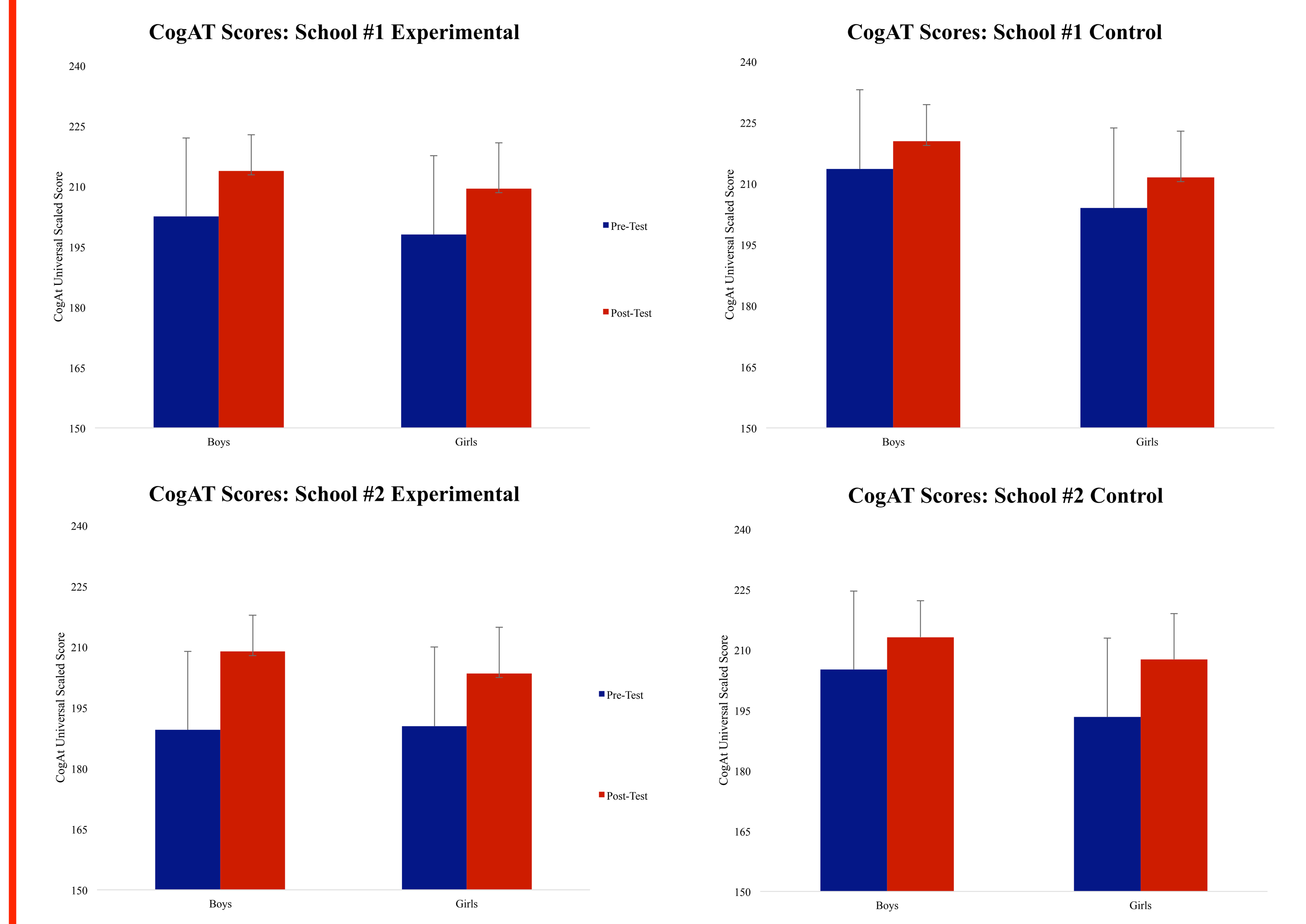
Results and Discussion



- One school was an elementary school using a departmentalized model for 5th grade social studies instruction. The other elementary school was a public charter that included mixed age instruction (4th and 5th graders) with unique scheduling constraints. These contextual differences introduced multiple confounding factors that led us to conduct analyses separately for the two schools.
- Our primary question was whether students using GIS would show larger gains in geography knowledge than would students using traditional social studies curriculum. As expected, **geography knowledge improved significantly over time, School #1:** F (1,32) = 12.55, p = .001, **School #2:** F (1,34) = 18.60, p = .000.
- Importantly, a **significant Time x Condition x Gender interaction effect** was observed in **School #1:** F (1,32) = 6.96, p = .013. Girls in the experimental group and girls and boys in the control group showing marked gains in geography knowledge over time. Boys in the experimental group evinced equivalent performance, likely due to unexpectedly high scores at pre-test.
- Geography knowledge increased over time. There is some evidence that this increase was more pronounced for girls in the experimental group, though additional research is needed to support that claim. These findings are important for demonstrating the utility of GIS for elementary students.

For more information, visit our project website: http://education.illinoisstate.edu/nsf/

CogAT®



- Analysis of CogAT scores revealed a significant **main effect of time** for both schools, conveying growth in spatial skills over time, **School #1:** F (1,22) = 46.72, p = .000, **School #2:** F (1,22) = 17.49, p = .000).
- Visual inspection of means suggested that gains in CogAT scores were larger in the experimental group compared to the control group; however, this interaction effect was not statistically significantly. It is possible that our small sample size limited the statistical power of our analyses.
- We are testing the effects of our GIS curriculum in seven 5th grade classes during the 2015-2016 school year. In addition to increasing our sample size, this investigation tests the effects of GIS curriculum on geography knowledge, spatial skills, and complex aspects of spatial and relational thinking.

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We thank Bianca DiCristofano, Lauren Hutmacher, Chloe Lindstrom, Sean Mullins, and Jill Thomas for their help with data collection and coding.