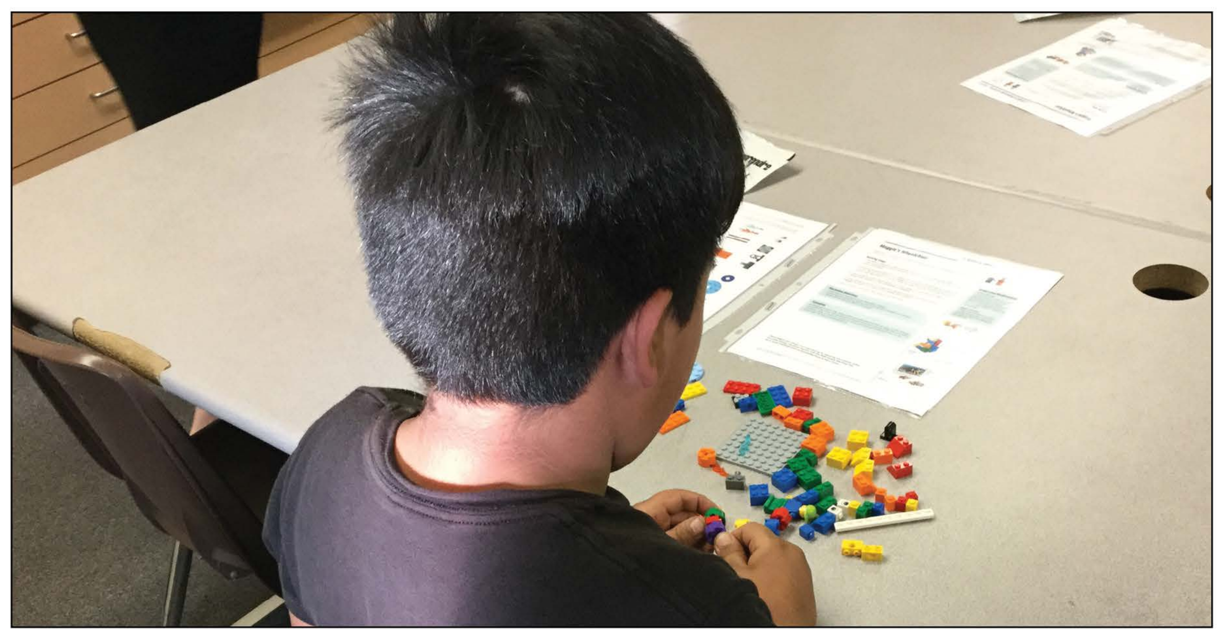
# Spatial STEM+C: Evaluation of a Model Spatial Thinking Curriculum

## Background

Initiated in November, 2015, the *Evaluation of a Model Spatial Thinking Curriculum for Building Computational Skills in Elementary Grades K-5 (Spatial STEM+C)* project, is evaluating strategies for building visuospatial and computational skills in elementary-aged children that underlie success in later gatekeeping STEM courses. Spatial STEM+C is based on emerging research on the role that spatial reasoning plays in supporting STEM success: (1) students with greater spatial reasoning abilities perform better in high school and college-level STEM courses, even when controlling for verbal and mathematical abilities; (2) spatial reasoning abilities are an important component of the computational thinking skills that lead to success in higher-level STEM courses; (3) STEM courses serve as gatekeepers for students entering many professional fields; and (4) spatial reasoning abilities may be improved through training and educational interventions.

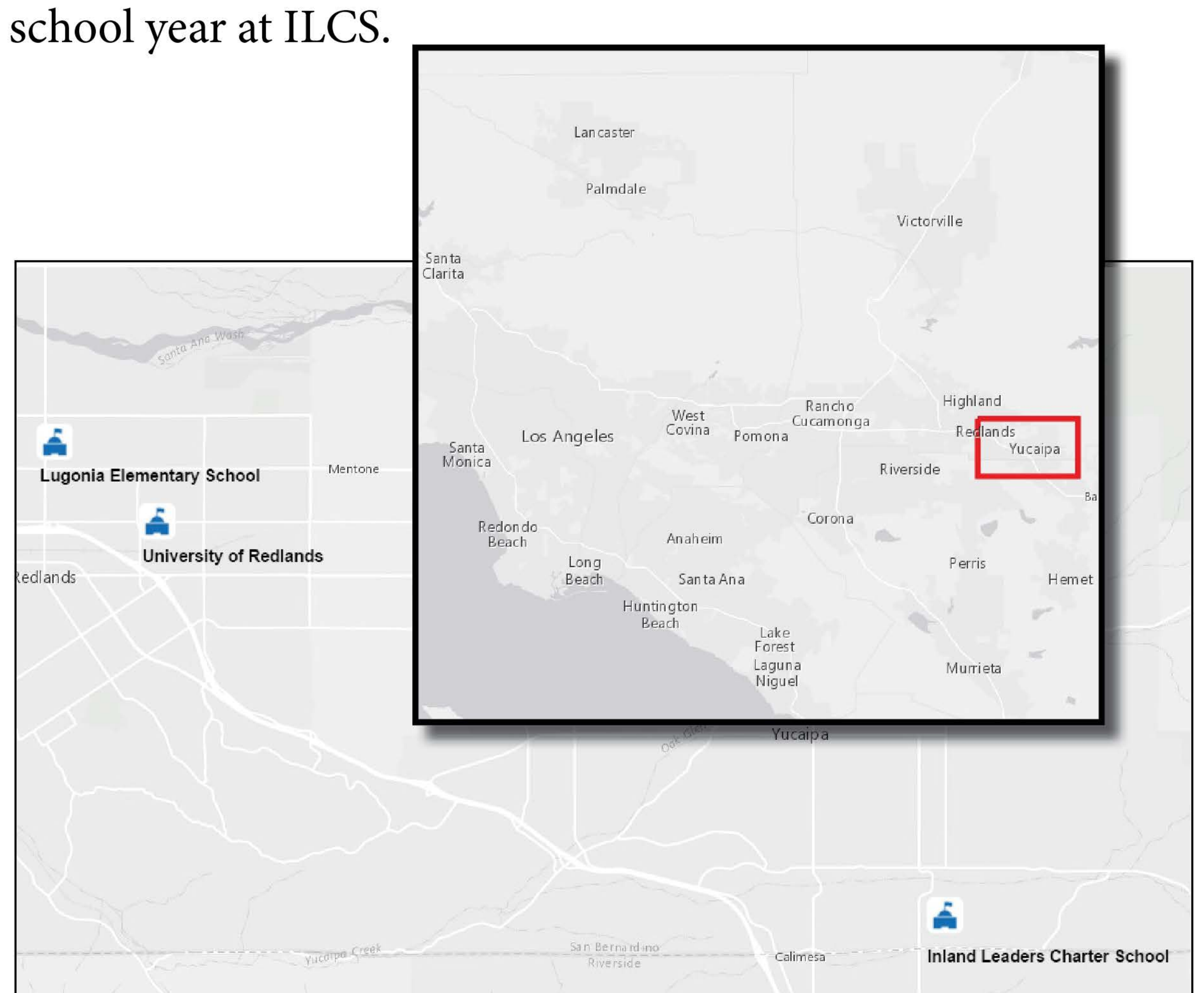


## Project Goals

The goals of the project are to (1) document relationships among spatial thinking abilities, computational thinking skills, and mathematical performance in K-5 children; (2) evaluate the effectiveness of hands-on activities designed to build spatial thinking abilities in K-5 students; and (3) evaluate the impact of spatial thinking training on computational thinking ability and mathematical performance.

## Study Sites

Pilot testing took place at Lugonia Elementary School in Redlands, California, and Inland Leaders Charter School (ILCS) in Yucaipa, California during Spring, 2016. A comparison-group study was conducted during the 2016-17 school year at ILCS.

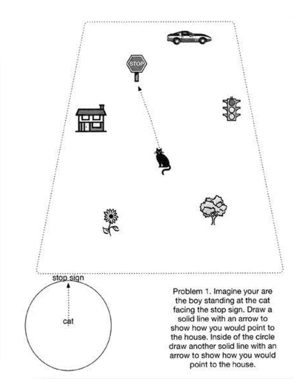


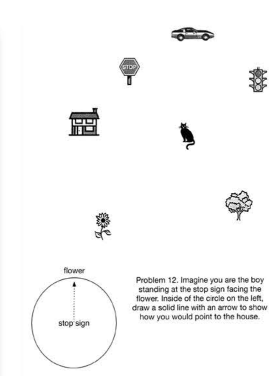

## Targeted Spatial Thinking Abilities

**Mapping and Wayfinding**

**Object Rotation**

**Coordinate Systems/Perspective Taking**





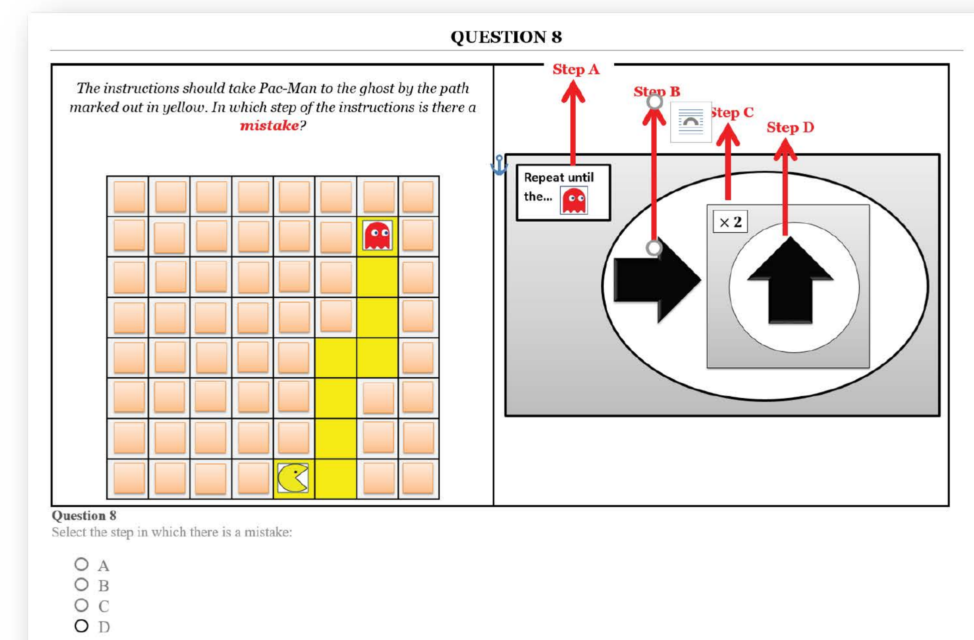
## Targeted Computational Thinking Skills

**Algorithm Design**

**Debugging**

**Deductive, Inductive, and Analogical Reasoning**

**Persistence**




## Mathematics Assessments

Let's Go Learn

enVisionmath2.0

## Comparison-Group Design

Two treatment classrooms in each K-5 grade at Inland Leaders Charter School in Yucaipa, California, implemented spatial thinking activities for approximately 30 minutes each day during a school year; two control classrooms in each grade did not do the designated activities. The spatial activities included creating designs with manipulatives, mapping classrooms and schoolyards, using a map to find treasures, and providing directions with coordinate systems. At the beginning and end of the school year, all students completed spatial and mathematics assessments. A spatial-computational thinking assessment was also piloted with K-2 students.

**Each Grade Level**

| Experimental | Experimental | Control | Control |
|---|---|---|---|

Involved Teachers

ST Interventions and ST, CT, and Math Assessments

Non-Involved Teachers

"Conventional" Curriculum and ST, CT, and Math Assessments

**Total N ≈ 600**

**Full Academic Year**

## Analysis

With each spatial skill as an outcome, several mixed models were conducted, and Type III sums of squares were calculated to find omnibus effects. Fixed effects included time, group (treatment vs. control), grade (centered at the middle grade if applicable), gender, and a time by group interaction as fixed factors. A random classroom effect was also included.

The project evaluators also acquired qualitative data through focus groups with the teachers. Information sought from teachers included feedback on spatial thinking activities, spatial thinking assessments, and computational thinking assessments, and the teachers' perceived outcomes for spatial, computational, and mathematics abilities.

## Results

Qualitative feedback from teachers indicated that the spatial activities increased students' interest and engagement with spatial thinking, as well as the children's confidence and persistence in solving problems. Quantitative analysis revealed that, on five of ten measures of spatial thinking, the treatment classrooms showed significantly better spatial skills than control classrooms across time. However, both treatment and control classrooms improved significantly during the study period. Significant improvement in computational thinking skills was noted in both treatment and control classrooms. Path analysis models revealed correlations among various dimensions of spatial thinking ability and math performance. A bidirectional relationship between computational thinking and math performance was noted. The results indicate a need for spatial and computational assessments that better measure near transfer of skills acquired in the classroom.

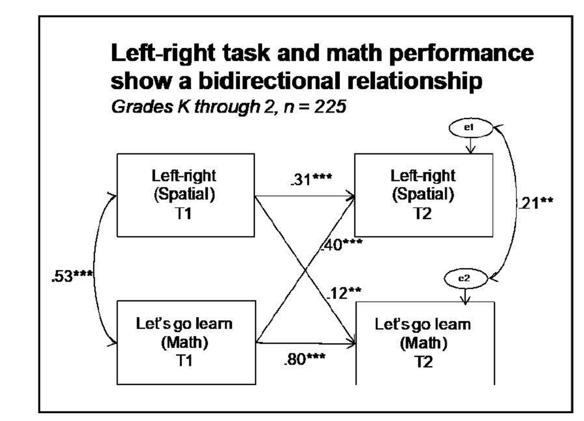



Table 4. *Question 1 - Summary of Effects for Treatment Group, Time, and Gains Over Time for Each Treatment Group*

| | Treatment showed more improvement from pre-test to post-test than control? | Treatment better than control (across time)? | Overall improvement over time (across treatment & control |
|---|---|---|---|
| Grades K-2nd | | | |
| Left-right | N | N | Y |
| Spatial perspective taking - abstract | N | N | Y |
| Spatial perspective taking - contours | N | Y | Y |
| Spatial perspective taking - concrete | N | N | Y |
| Square completion assessment | Y | N | Y |
| Computational thinking ( z-scored) | N | N | Y |
| Grades 3-5 | | | |
| Front-back, left-right (FBLR) | N | N | Y |
| Mapping tasks | N | N | Y |
| Grades 3-4 | | | |
| Ekstrom cube comparison | N | N | Y |
| Grade 5 | | | |
| MASMI cube rotation and comparison | N | N | N |

## People and Partners

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This material is based upon work supported by the National Science Foundation under Grant No. 1543204. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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