Student Learning and Inquiry-Based Science Instruction: Testing Effectiveness in a Randomized Trial

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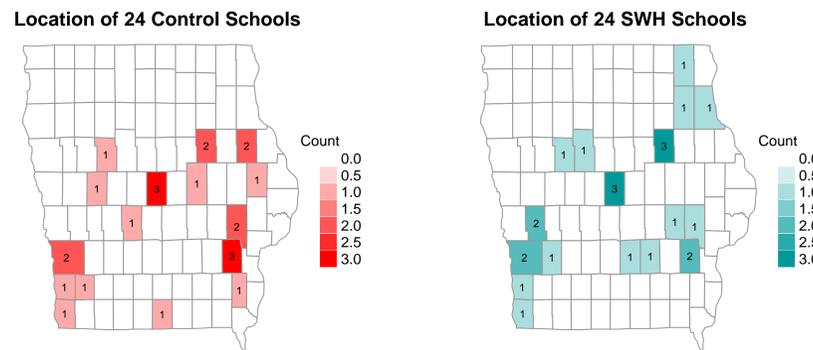Brian Hand[2], William Therrien[2]

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IOWA STATE UNIVERSITY
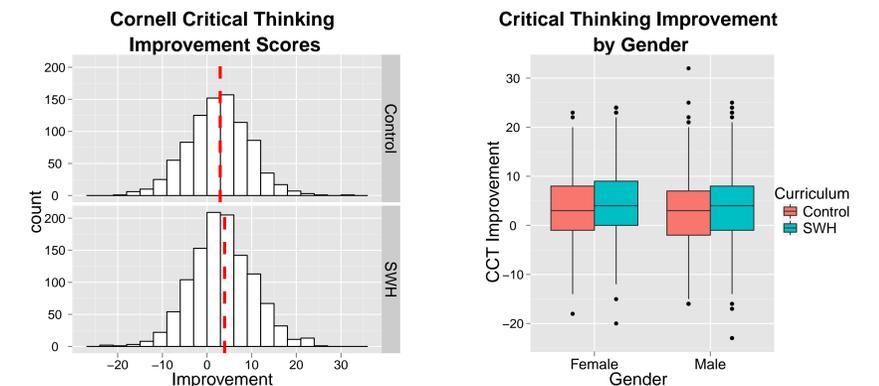### OF SCIENCE AND TECHNOLOGY

Abstract

An experimental-design study of the effects of the Science Writing Heuristic approach to providing elementary science instruction on student science content knowledge and critical thinking skills was implemented in 48 elementary school buildings in Iowa, with cluster random assignment of buildings to treatment and control groups based on percentage of students eligible for free and reduced lunch, enrollment in third through fifth grades, and private vs. public status. Confirmatory factor analysis of Level-1 (student) and Level-2 (building) characteristics for enhancing child outcomes shows statistically significant (p<.05) direct effects on students' Iowa Tests of Basic Skills (ITBS) results in mathematics and science from race, free and reduced lunch eligibility, English language learner status, gifted and talented status, special education status.

Science Writing Heuristic (SWH)

SWH targets improving students' understanding of science by embedding science argument within typical inquiry lessons. This promotes critical thinking and science reasoning into the inquiry approaches, using language to negotiate students' understanding of science. Students are required to pose questions, generate claims and evidence, compare their answers with other students and reflect on changes in their understanding. Finally they put this in written form which improves their English and reasoning abilities.
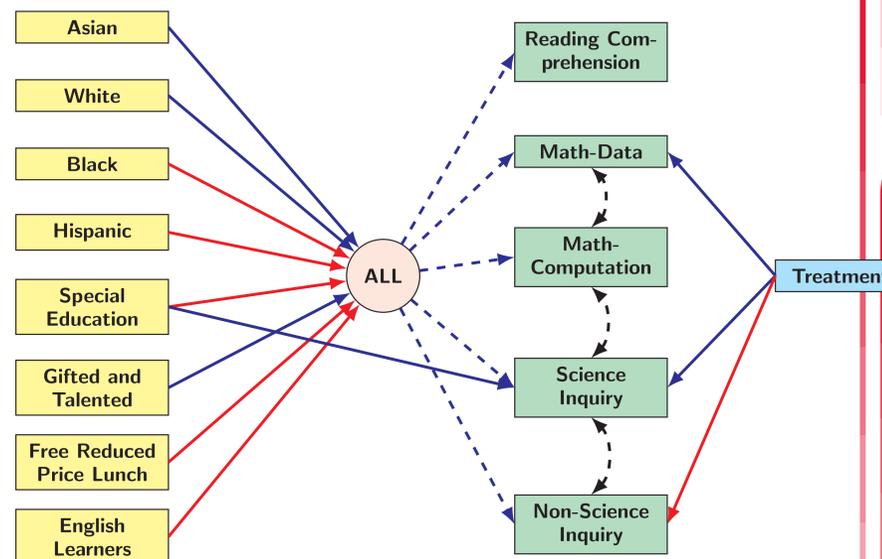
ITBS Summary

The boxplots represent scores for students taking the ITBS exam in March or April allowing at least 6 months of exposure to the SWH curriculum. Science Inquiry was not tested on the 2009-2010 ITBS Exam.

Randomization

Location, by county, of the 24 schools assigned to each of the SWH and Control curriculums.

Structural Equation Model

Figure 1: Model based on ITBS student scores

Sample Size:	2020
Root Mean Squared Error:	0.035
χ^2 Test of Model Fit:	113.78
Degrees of Freedom:	35
P-value:	< 0.0001

Data

- $3^{rd} - 5^{th}$ grade students who were administered the Iowa Test of Basic Skills (ITBS) exam in March or April of the 2010-11 school year.
- The second year of ITBS data is expected in July.

Cornell Critical Thinking Improvement

Indicator	Sample Size	SWH Mean	Control Mean	Cohen's d
Overall	2018	3.937	2.945	0.1427**
Female	998	4.111	3.140	0.1426*
Male	1020	3.765	2.758	0.1416*

An asterisk means that the t-test was statistically significant
Overall: p=0.00149, Female: p=.0264, Male: p=.0245
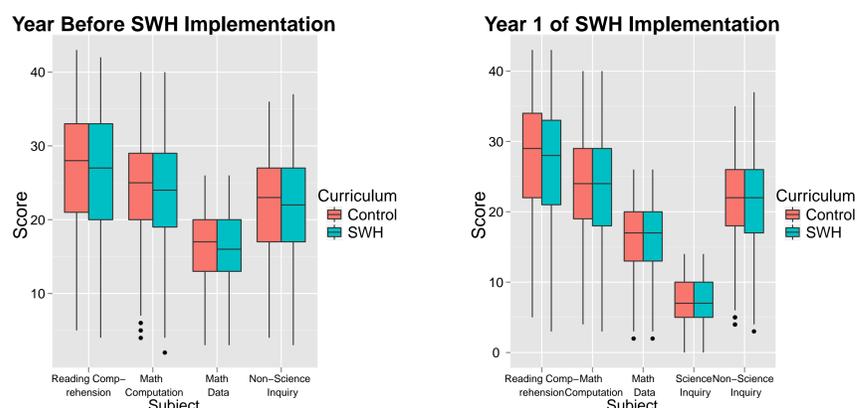
Conclusions

Key findings from the SEM results in Figure 1:

1. All student outcome variables are strongly correlated with each other. These can be considered as forming a single overall measure (ALL) of student achievement.

2. Students' achievement scores are related directly to overall student characteristics.

3. Students receiving the SWH curriculum showed positive increases in Science Inquiry scores and Data Analysis/Interpretation scores.

Key findings from the Cornell Critical Thinking Test:

1. Students receiving the SWH curriculum showed larger gains in critical thinking abilities. This improvement was also observed for both male and female students.

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