The Effects of a Science-Focused STEM Intervention on Gifted Elementary Students' Science Knowledge and Skills

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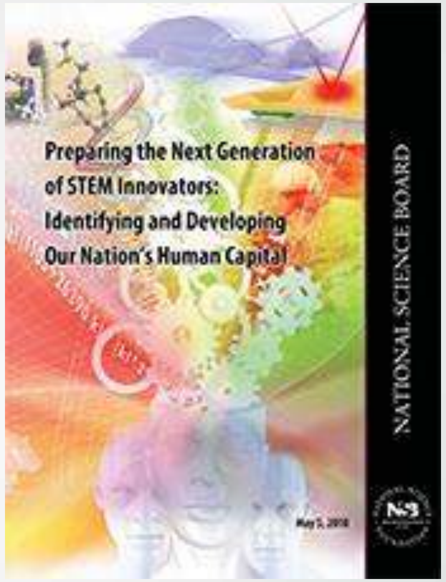
National Science Board (2010) Recommendations "STEM Innovators"



- Provide STEM opportunities in inquiry-based learning, peer collaboration, and open-ended real-world problem solving for all students beginning in the <u>elementary grades</u>.
- Encourage research-based <u>STEM professional development</u> for elementary teachers to cultivate investigative classrooms and to identify promising STEM learners.

Theoretical Framework for the Study

- The implementation of a problem-based curriculum enacted by teachers supported with sustained professional development can positively influence STEM accomplishments in young students (Buczynski & Hansen, 2010; Johnson, Kahle, & Fargo, 2007; Santau, Maerten-Rivera, & Huggins, 2011).

Context

- To encourage the development of STEM talent in the elementary grades, STEM Starters (Grade 2-5 intervention study), was developed and subsequently funded through the Jacob K. Javits Gifted and Talented Students Education Act.
- STEM Starters provided:
  - Professional development for teachers (120 hours across 2 years)
  - Implementation of problem-based curricula in classrooms
- STEM Starters goals included:
  - **Increased science learning for ALL participating students in Grades 2-5**
  - Increased science knowledge and skills for Grades 2-5 teachers, including gifted and talented teachers

<u>Purpose of the Study:</u>

To measure the impact of a STEM intervention on **gifted students'** science learning, including science process skills; content knowledge; and concept knowledge

- <u>Research Questions:</u>
  - To what degree are elementary gifted students' understandings of science-process skills impacted by participation in a STEM intervention?
  - To what degree is elementary gifted students' science-content knowledge impacted by participation in a STEM intervention?
  - To what degree is elementary gifted students' science-concept knowledge impacted by participation in a STEM intervention?

Method

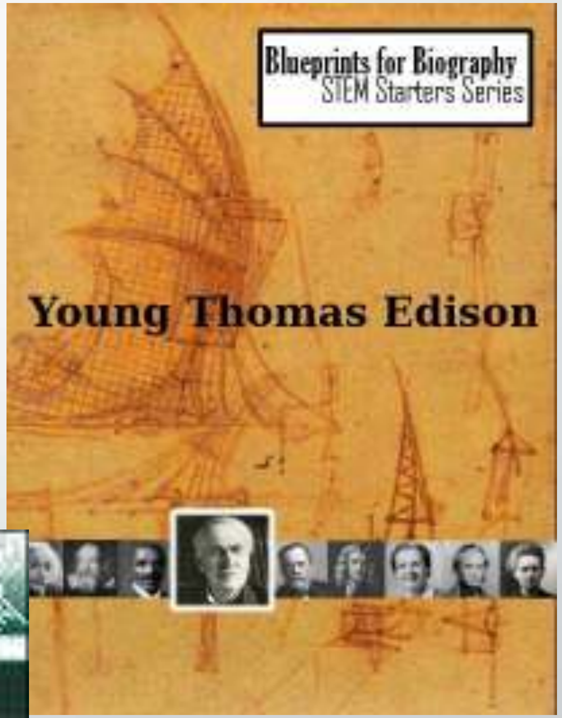
- The current study was part of a larger randomized field study (Cotabish et al., 2013); only data for gifted students are included in the present study.
- 70 teachers (Grades 2-5), from 5 low-income schools in a southern state, were randomly assigned to experimental or control groups.
- Students assigned to experimental teachers were designated as experimental students and those assigned to control teachers were designated as comparison students.

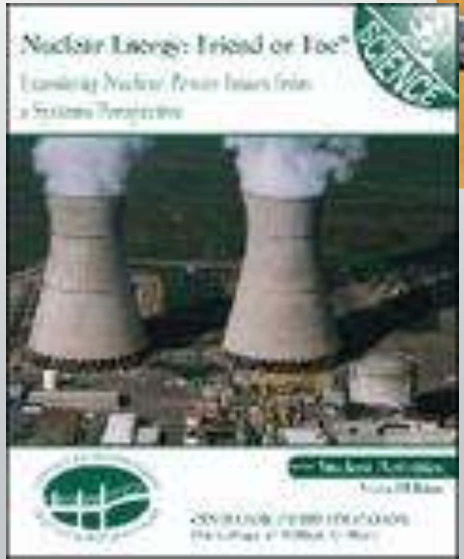
Number of Experimental and Comparison Students in the Gifted Program and School Population by Grade Level and Year

Grade Level	Experimental Students				Comparison Students			
	Year 1		Year 2		Year 1		Year 2	
	Gifted	Total	Gifted	Total	Gifted	Total	Gifted	Total
2	20	197	3	206	17	220	*2	216
3	25	206	18	220	20	256	17	182
4	24	194	25	273	20	235	20	203
5	18	221	21	206	13	221	21	205
Total	87	818	67	905	70	932	60	806
Total E & C Gifted Students (*N*) Year 1 = 157					**Total E & C Gifted Students (*N*) Year 2 = 127**			

Intervention: Experimental Teachers and Classrooms

- Teacher Professional Development
  - Summer Institutes (60 hours across 2 years)
  - Embedded peer coaching (60 hours across 2 years)
- Inquiry or Problem-based Science Curriculum Units
  - William and Mary Science Curriculum Units
  - *Blueprints for Biography®* STEM Series





Intervention: Teacher Professional Development

	Summer Institute	Peer Coaching
Year-1	• 30 hours (out-of-school) • curriculum units • inquiry-based strategies • differentiation for high-ability learners • identification of gifted students from underrepresented groups	• 30 hours (in-school) • implementation of curriculum units • model teaching • instructional facilitator • materials facilitator • science content expert
Year-2	• 30 hours (out-of-school) • science content development • inquiry-based strategies • classroom management	• 30 hours (in-school) • instructional facilitator • materials facilitator • science content expert

Intervention: Curriculum

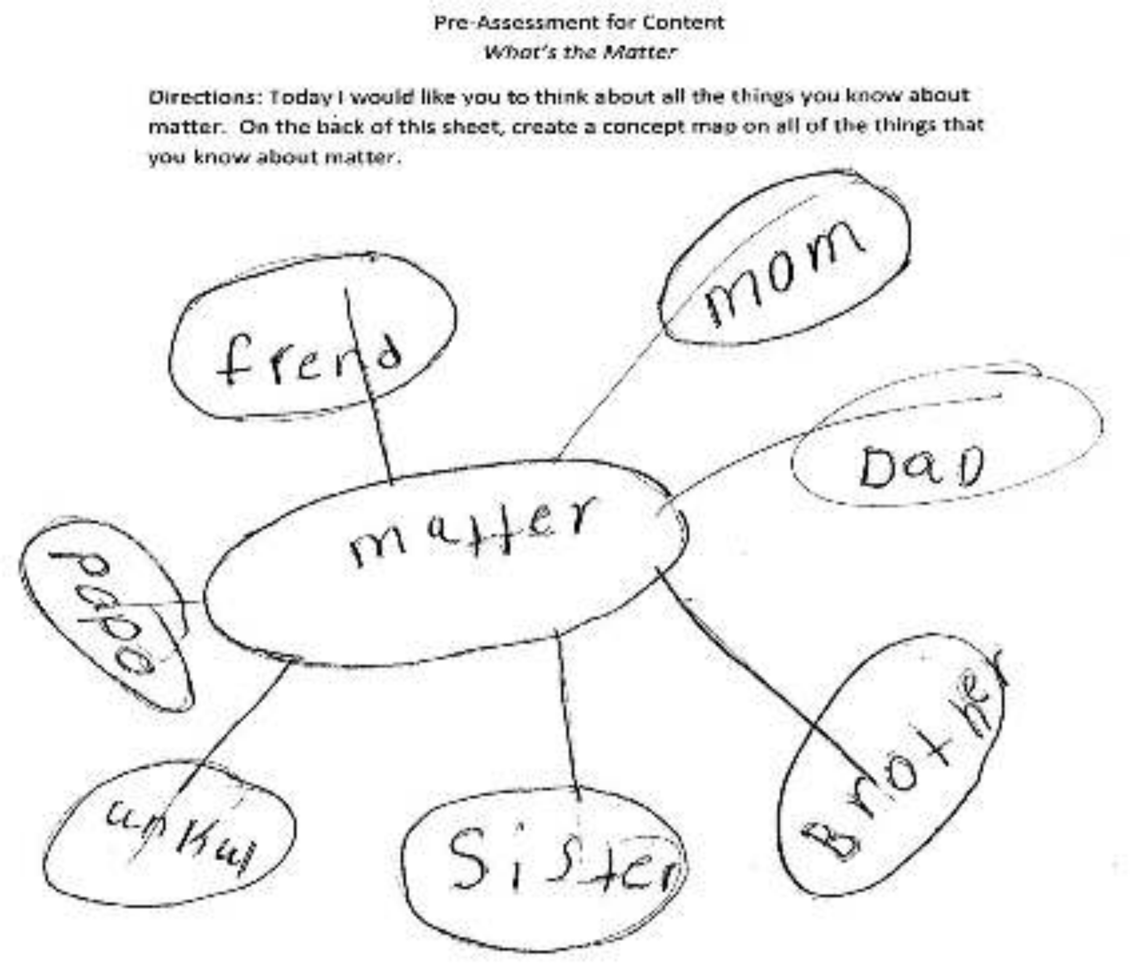
Grade Level	Problem-Based Learning Units	Blueprints for Biography®
2	Weather Reporter Budding Botanist	George Washington Carver Louis Pasteur
3	What's the Matter Dig It	Galileo Galilei Albert Einstein
4	Electricity City Invitation to Invent	Thomas Edison Michael Faraday
5	Acid, Acid Everywhere Nuclear Energy	Marie Curie Alexander Graham Bell

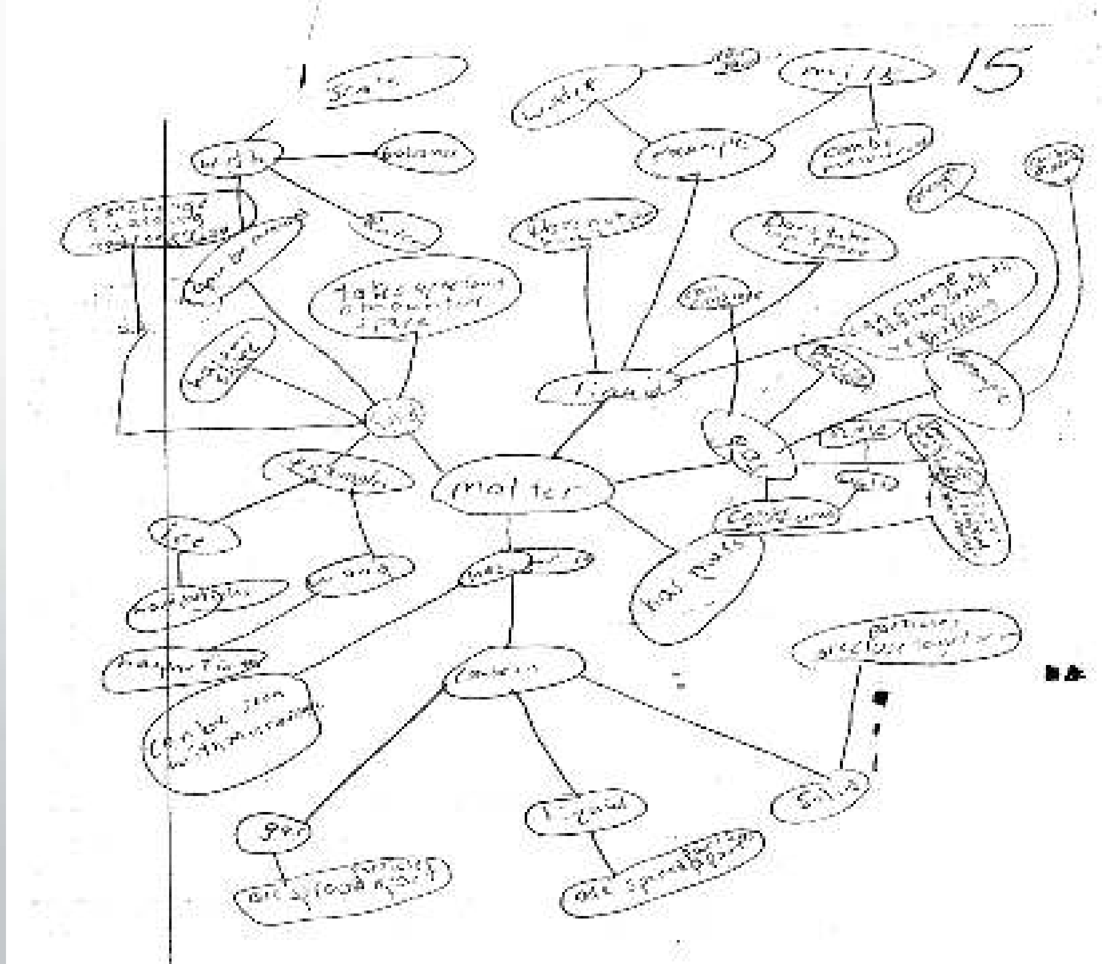
Instrumentation

- *Adapted Fowler Test*:
  - Assesses students' understanding of experimental design
  - Formatted as an open-ended assessment
- Curriculum-embedded content assessments:
  - Specifically tied to content in each curriculum unit.
  - Utilizes concept mapping in Grades 2-3 and short answer questions in Grades 4-5
- Curriculum-embedded concept assessments:
  - Specifically tied to content and overarching concepts in each curriculum unit
  - Utilized open-ended, short answer questions.

Data Collection

Data from the 3 instruments were collected from experimental and comparison students across 2 years





Data Analysis

	Year 1	Year 2
Science Process Skills	ANCOVA Pretest scores as a covariate	*ANOVA: On the difference scores between pre-and posttests
Science Content	ANCOVA Pretest scores as a covariate	ANCOVA Pretest scores as a covariate
Science Concepts	*ANOVA: On the difference scores between pre-and posttests	ANCOVA Pretest scores as a covariate

*Due to a violation of the homogeneity-of-regression slopes assumption

Results: Science Process Skills

Year1 [$F(1, 76) = 10.40$, $p = .002$, = .12]

Year 2 [$F(1, 112) = 11.80$, $p = .001$, = 0.08]

	Pretest Mean (SD)	Posttest Mean (SD)	Adjusted Posttest Mean	n	Effect size
Year 1 Experimental	8.53 (3.27)	11.51 (2.21)	11.59	57	.12
Year 1 Comparison	10.32 (2.40)	9.82 (2.91)	9.60	22[a]	
Year 2 Experimental	7.85 (3.89)	10.24 (2.43)		59	0.08
Year 2 Comparison	7.49 (4.36)	8.11 (3.56)		55	

Note. Total points possible = 17. [a]Parents of students in the comparison group were initially reluctant to sign consent form.

Results: Science Content

Year 1 [$F(1, 72) = 31.03$, $p < .001$, = .30]

Year 2 [$F(1, 79) = 203.01$, $p < .001$, = .72]

	Pretest Mean (SD)	Posttest Mean (SD)	Adjusted Posttest Mean	n	Effect size
Year 1 Experimental	0.80 (1.47)	6.78 (3.14)	6.80	55	.30
Year 1 Comparison	1.45 (1.85)	2.40 (2.56)	2.35	20	
Year 2 Experimental	0.77 (1.03)	9.11 (2.94)	9.12	44	.72
Year 2 Comparison	0.79 (1.07)	1.53 (1.61)	1.52	38	

Note. 20 points possible for Grades 2 – 3 and 35 points possible for Grades 4 - 5.

Results: Science Concepts

Year 1 [$F(1, 76) = 50.02$, $p < .001$, $= 0.39$]

Year 2 [$F(1, 82) = 52.79$, $p < .001$, $= .40$]

	Pretest Mean (SD)	Posttest Mean (SD)	Adjusted Posttest Mean	n	Effect size
Year 1 Experimental	10.93 (4.14)	15.09 (3.38)		55	0.39
Year 1 Comparison	12.13 (3.28)	8.04 (4.78)		23[a]	
Year 2 Experimental	11.70 (3.86)	16.14 (3.33)	16.09	44	.40
Year 2 Comparison	9.38 (3.54)	10.61 (3.12)	10.62	38	

Note. [a]Parents of students in the comparison group were initially reluctant to sign consent form. 20 points possible for Grades 2-3 and 35 points possible for Grades 4 - 5.

Limitations

- Small sample size and the use of only two school districts (spanning five schools).
- Student attrition from the schools limited the number of two-year participants.
- The lack of psychometric properties for the curriculum-embedded assessments (content and concept).

Conclusions

- The professional development and curriculum intervention resulted in statistically significant, and in several cases practically significant gains in science process skills, science concepts, and science content knowledge by gifted education students in the experimental group when compared with gifted students in the comparison group.

- Results indicated that gifted students in the treatment classrooms were better able to design science experiments when presented with a real-world problem, make scientific connections using overarching concepts such as change and systems, and benefited from being allowed to fully explore the age-appropriate content in an investigatory manner as recommended by the NRC (Duschl et al., 2007) and the NSB (2010).

If you want to know more

Robinson, A., Dailey, D., Hughes, G. & Cotabish, A. (2014). The effects of a science-focused STEM intervention on gifted elementary students'science knowledge and skills. Journal of Advanced Academics.

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