

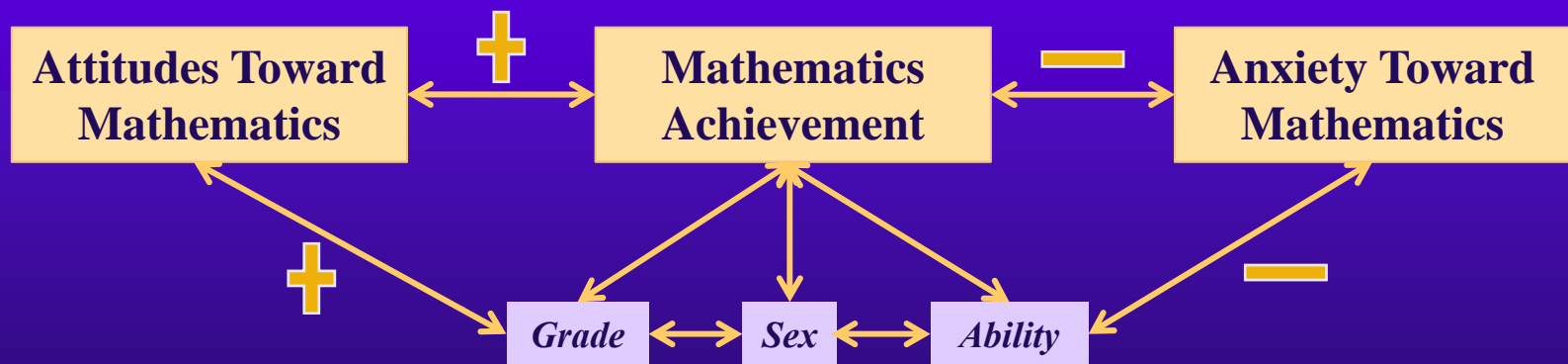


The relationship of achievement and orientation differences

A meta-analysis of mathematics educational technology studies

Literature Support - Foundations

- ◆ Neale, D. C. (1969). The role of attitudes in learning mathematics. *Arithmetic Teacher*, 8, 631-640.
- ◆ Aiken, L. R. (1970). Attitudes toward mathematics. *Journal for Review of Educational Research*, 40, 551-596.
- ◆ Aiken, L. R. (1976). Update on attitudes and other affective variables in learning mathematics. *Journal for Review of Educational Research*, 46, 293-311.

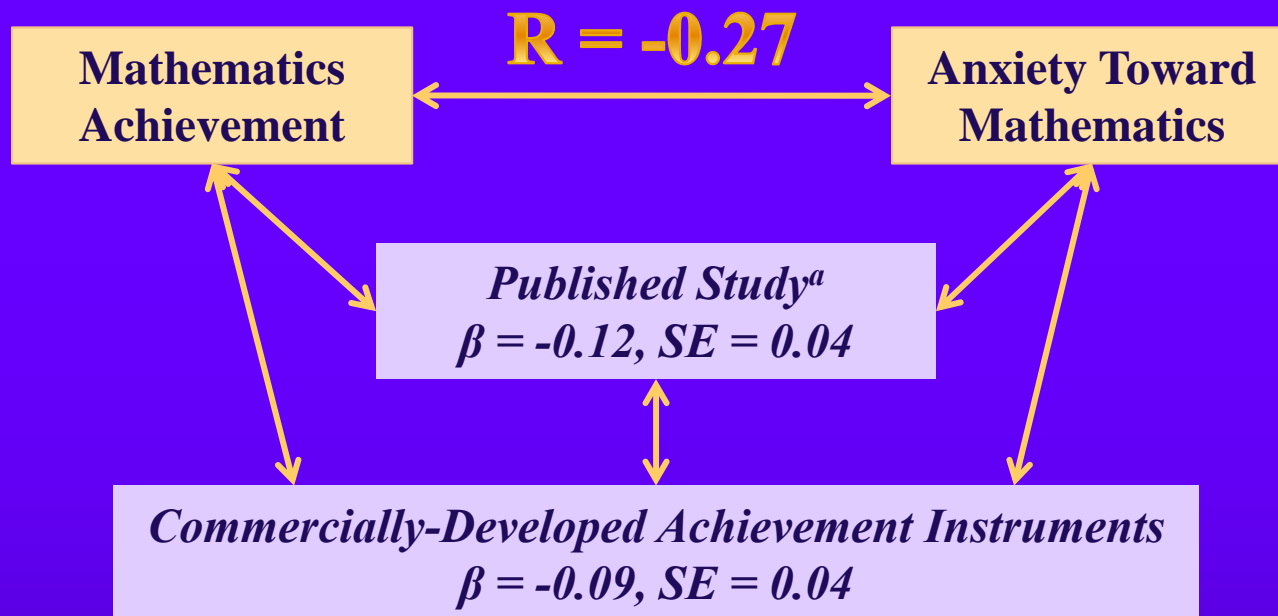


Achievement, Attitudes, Anxiety in Mathematics: Reciprocal Relationships



Building on Foundations

- ◆ Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education*, 30, 520-540.
 - Examined 26 studies for correlations ($ES = r$) between anxiety toward mathematics and achievement in mathematics.
 - Inclusion criteria:
 - Investigation of relationship between math anxiety and achievement
 - No experimental interventions on either anxiety or achievement
 - Students were either in elementary or secondary level



^aNo significant effect of being a *dissertation*, $\beta = 0.04, SE = 0.06$

• *Anxiety Instrumentation*: No significant effect, $\beta = -0.04, SE = 0.05$

• *Grade Level*: No Significant Effect

4-6 vs 10-12, $\beta = -0.02, SE = 0.03$

7-9 vs 10-12, $\beta = 0.05, SE = 0.04$

• *Sex*: No significant effect, $\beta = -0.12, SE = 0.09$

• *Interaction of Publication Year and Published Studies*: “Results show that the differences in effect sizes between published and unpublished articles decreased over time in the period examined in this meta-analysis” (Ma, 1999, p. 531).

Interaction effect not given.

• *Ability*: Not Tested.



Technology Intervention Effects: Calculators, Achievement, and Attitudes

- ◆ Hembree, R., & Dessart, D. J. (1986). Effects of hand-held calculators in precollege mathematics education: A meta-analysis. *Journal for Research in Mathematics Education*, 17, 83-99.
 - Examined 79 studies to determine effects of calculators on student achievement and attitude levels.
 - **Achievement constructs:**
 - Basic Operational Skills
 - Computation: Used when posttests provided a separate measure
 - Concepts: Used when posttests provided a separate measure
 - Composite: Used when posttests did not provide separate measures
 - Problem Solving Skills
 - Productivity: Number of problems attempted
 - Selectivity: Number of proper strategies used
 - Composite: Number of problems solved correctly
 - **Attitude Constructs:**
 - Attitude Toward Math = Enjoyment of Math
 - Anxiety Toward Math
 - Self-Concept in Math
 - Motivation to Increase Math Knowledge
 - Attitude Toward Math Teachers
 - Perceptions of Value of Math in Society



Hembree & Dessart (1986)

-0.18 to 0.74

Calculators

-0.04 to 0.31

Achievement

Attitude



Operational Skills

Conceptual

Composite

Computation

Problem Solving Skills

Productivity

Composite

Selectivity

High Ability

Low Ability

All Other Grades

(-)

Grade 4

Average Ability

Grades 4 and 7

Retention

All Other Grades

Attitudes Toward Math (+)

Self Concept in Math (+)

Perception of Usefulness of Math in Society

Attitude Toward Math Teachers

Anxiety Toward Math

Motivation to Increase Math Knowledge

- Calculators used for instruction and assessment
- ⋯→ Calculators used for instruction only

All significant ES except one are for acquisition
 One significant ES for Retention
 No significant ES for Transfer



Technology Intervention Effects: Calculators, Achievement, and Attitudes

- ◆ Ellington, A. J. (2003). A meta-analysis of the effects of calculators on students' achievement and attitude levels in precollege mathematics classes. *Journal for Research in Mathematics Education*, 34, 433-463.
 - Examined 54 studies (1983 to 2002) to determine effects of calculators on student achievement and attitude levels. Achievement constructs: Operational, computational, conceptual, and problem-solving skills. Attitude Constructs: Attitude toward math, self-concept in math, attitude toward use of calculators in math.
 - **Achievement constructs (acquisition, retention, transfer):**
 - Operational Skills
 - Computation: Used when posttests provided a separate measure
 - Concepts: Used when posttests provided a separate measure
 - General Operational: Used when posttests did not provide separate measures
 - Problem Solving Skills
 - Productivity: Number of problems attempted
 - Selectivity: Number of proper strategies used
 - General Problem Solving Skills: Number of problems solved correctly
 - **Attitude Constructs:**
 - Attitude Toward Math
 - Anxiety Toward Math
 - Self-Concept in Math
 - Motivation to Increase Math Knowledge
 - Perception of Math Teachers
 - Value of Math in Society



Calculators

-0.05 to 0.44

0.05 to 0.32

Achievement

Attitude

Operational Skills

Conceptual

General

Computation

Problem Solving Skills

Productivity

General

Selectivity

- 0-3 Wk
- 4-8 Wk
- ≥ 9 Wk
- Journal
- Dissertation
- Other
- All Calcs
- Basic/Sci
- Grphing
- Pedagogy
- Functional
- Elem
- Middle
- High
- Mixed Ability
- High Ability
- Rndm
- Non-Rndm
- Standardized
- Non-Stndrdzd

Attitudes Toward Math

Self Concept in Math

Perception of Usefulness of Math in Society

Attitude Toward Math Teachers

Anxiety Toward Math

Motivation to Increase Math Knowledge

?

All significant ES are for acquisition (no retention/transfer)

Moderators: Treatment Length, Calculator Use, Calculator Type, Grade Level, Ability, Grouping Assignment, Journal Status, Test Instrument

—————> Calculators used for instruction and assessment
-> Calculators used for instruction only



Technology Interventions: Graphing Calculators, Achievement, and Attitudes

- ◆ Ellington, A. J. (2006). The effects of non-CAS graphing calculators on student achievement and attitude levels in mathematics: A meta-analysis. *International Journal of Instructional Media*, 106, 16-26.
 - Examined 43 studies using graphing calculators as the intervention. Achievement constructs were procedural, conceptual, and combined skills. Orientation constructs examined: anxiety toward math, attitudes toward math, self-concept in math, attitudes toward calculators in math
 - **Achievement constructs (acquisition, retention, transfer):**
 - Operational Skills
 - Computation: Used when posttests provided a separate measure
 - Concepts: Used when posttests provided a separate measure
 - General Operational: Used when posttests did not provide separate measures
 - Problem Solving Skills
 - Productivity: Number of problems attempted
 - Selectivity: Number of proper strategies used
 - General Problem Solving Skills: Number of problems solved correctly
 - **Attitude Constructs:**
 - Attitude Toward Math
 - Anxiety Toward Math
 - Self-Concept in Math
 - Motivation to Increase Math Knowledge
 - Perception of Math Teachers
 - Value of Math in Society



Non-CAS Graphing Calculators

-0.21 to 0.72

0.05 to 0.42

?

Achievement

Attitude

Operational Skills

Conceptual

(+), +

(+)

Combined

(+)

Procedural

(+)

Problem Solving Skills

Productivity

General

Selectivity

No Moderator Tests Reported

Attitudes Toward Math

Self Concept in Math

Perception of Usefulness of Math in Society

Attitude Toward Math Teachers

Anxiety Toward Math

Motivation to Increase Math Knowledge

Attitude Toward Calc Use in Math

(+)

+ Calculators used for instruction and assessment
(+) Calculators used for instruction only



Orientation: The Affective Domain

- ◆ Aiken (1976): Attitudes, Anxiety
- ◆ Fennema & Sherman (1976): Attitude Toward Success; Confidence; Perception of Parental Interest, Encouragement, and Confidence; Perceptions of Teacher Attitudes
- ◆ Hoffman (2010): Efficacy, Anxiety
- ◆ Ma (1999): Anxiety
- ◆ Phillip et al. (2007): Beliefs, Values, Goals
- ◆ Schoenfeld (1982, 1985, 1989, 2005): Beliefs
- ◆ Tapia & Marsh (2004): Value, Self Confidence, Enjoyment, Motivation



Orientation Toward Math

**Math Attitudes/
Perceptions**

**Math Self
Concept**

**Self Confidence
in Math**

**Math
Enjoyment**

**Math
Motivation**

Math Beliefs

Value of Math

**Attributions/
Attitude Toward
Success/Failure**

**Usefulness of
Math**

Goals

Math Anxiety

**Perceptions of
Parent Interest,
Encouragement,
Confidence in
Student Abilities**

**Perceptions of
Teacher Interest,
Encouragement,
Confidence in
Student Abilities**

Current Study – Research Questions

1. What is the average standardized mean difference effect size for mathematics educational technology interventions on achievement when orientation toward mathematics is also measured?
2. What is the average standardized mean difference effect size for mathematics educational technology interventions on orientation when achievement is also measured?
3. What is the relationship of mathematics achievement and orientation outcomes to an educational technology intervention?
4. What moderators influence the relationship between achievement and orientation effects from mathematics educational technology interventions?



Conceptual Framework

Mathematics Educational Technology
e.g., Calculators, Graphing Calculators, CAS, Computer Software, Dynamic Geometry, Dynamic Web Content

?

?

?

Achievement

Operational Skills

Conceptual

Combined

Procedural

Problem Solving Skills

Productivity

General

Selectivity

Moderators

Pedagogical

- Tech Type
- Tech Use
- Trtmnt Length
- Trtmnt Type
- Grade
- Ability
- Sex

Design (Report)

- Pub Type
- Grpng Design
- Instrmnt Type
- Quality

Orientation Toward Math

Math Attitudes/
Perceptions

Math Self
Concept

Self Confidence
in Math

Math
Enjoyment

Math
Motivation

Math Beliefs

Value of Math

Attributions/
Attitude Toward
Success/Failure

Usefulness of
Math

Goals

Math Anxiety

Perceptions of
Parent Interest,
Encouragement,
Confidence in
Student Abilities

Perceptions of
Teacher Interest,
Encouragement,
Confidence in
Student Abilities

Design



- ◆ Inclusion Criteria: Construct Validity
 - Mathematics Educational Technology Intervention
 - Measured Achievement and Orientation for both treatment and control group after the treatment
- ◆ Reasons for Exclusion:
 - Orientation measure qualitative only
 - Orientation measure only given to treatment group
 - Orientation measures not grouped by treatment groups
- ◆ Sample:
 - 132 Potentially Relevant Titles
 - 55 coded so far
 - 33 retained; 36 Effect Size Pairs
 - Control Conditions:
 - Pencil/paper drill and practice
 - Traditional Lecture/Instruction
 - No corresponding technology
 - Lower level technology (e.g. scientific calculator vs. graphing calc.)



Methodology

- ◆ Effect Size: Standardized Mean Difference

$$d = \frac{(Post_T - Pre_T) - (Post_C - Pre_C)}{Post\ SD_{Pooled}}$$

- ◆ Design Effect: Statistical Conclusion Validity

$$1 + (m - 1)\rho$$

Where m = number of groups; ρ = ICC

Preliminary Results

Mathematics Educational Technology
 e.g., Calculators, Graphing Calculators, CAS, Computer Software, Dynamic Geometry, Dynamic Web Content

0.14 [0.08, 0.20]

0.17 [-0.21, 0.48]

0.12 [0.06, 0.18]

Achievement

Operational Skills

Conceptual

Combined

Procedural

Problem Solving Skills

Productivity

General

Selectivity

Moderators

Pedagogical

- Tech Type
- Tech Use
- Trtmnt Length
- Grade
- Ability

Design

- Pub Type
- Grpng Design
- Instrmnt Type
- Quality

Orientation Toward Math

Math Attitudes/
Perceptions

Math Self
Concept

Self Confidence
in Math

Math
Enjoyment

Math
Motivation

Math Beliefs

Value of Math

Attributions/
Attitude Toward
Success/Failure

Usefulness of
Math

Goals

Math Anxiety

Perceptions of
Parent Interest,
Encouragement,
Confidence in
Student Abilities

Perceptions of
Teacher Interest,
Encouragement,
Confidence in
Student Abilities

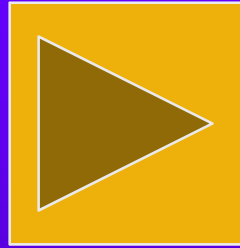
$A = 0.150 + 0.14$

$SE_a = 0.13$


$t = 1.09$

$R^2 = 0.03$

Questions



Bibliography

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- Fennema, E., & Sherman, J. (1976). Fennema-Sherman mathematics attitude scales: Instruments designed to measure attitudes toward the learning of mathematics by males and females. *Journal for Research in Mathematics Education*, 7, 324-326.
- Hoffman, B. (2010). "I think I can, but I'm afraid to try": The role of self-efficacy beliefs and mathematics anxiety in mathematics problem-solving efficiency. *Learning & Individual Differences*, 20, 276-283.
- Philipp, R. A., Ambrose, R., Lamb, L. L. C., Sowder, J. T., Schappelle, B. P., Sowder, L. et al. (2007). Effects of early field experiences on the mathematical content knowledge and beliefs of prospective elementary school teachers: An experimental study. *Journal for Research in Mathematics Education*, 38, 438-476.
- Schoenfeld, A. H. (1982, March). *Beyond the purely cognitive: Metacognition and social cognition as driving forces in intellectual performance*. Paper presented at the annual meeting of the American Educational Research Association, New York, NY.
- Schoenfeld, A. H. (1985, March). *Students' beliefs about mathematics and their effects on mathematical performance: A questionnaire*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.
- Schoenfeld, A. H. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education*, 20, 338-355.
- Tapia, M., & Marsh, G. E. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly*, 8, 16-21.