The relationship of achievement and orientation differences

A meta-analysis of mathematics educational technology studies


Achievement, Attitudes, Anxiety in Mathematics: Reciprocal Relationships
Building on Foundations

  - 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
Mathematics Achievement $\rightarrow R = -0.27 \rightarrow$ Anxiety Toward Mathematics

Published Study$^a$
$\beta = -0.12, SE = 0.04$

Commercially-Developed Achievement Instruments
$\beta = -0.09, SE = 0.04$

$^a$No 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of Publication Year and Published Studies: “Results show that the differences in effect sizes between published and unpublished articles decreased over time in the period examined in this meta-analysis” (Ma, 1999, p. 531).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


- 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
Calculators

Achievement

Conceptual

Composite

Computation

Operational Skills

Problem Solving Skills

Productivity

Composite

Selectivity

Composite

High Ability

Low Ability

Average Ability

Grade 4

Grades 4 and 7

All Other Grades

Retention

Attitude

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

Hembree & Dessart (1986)
Technology Intervention Effects: Calculators, Achievement, and Attitudes


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
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


- 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
Ellington (2006)

Non-CAS Graphing Calculators

Achievement

Conceptual

Combined

Procedural

Operational Skills

Productivity

General

Selectivity

Problem Solving Skills

Attitude

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

(+), +

(+) No Moderator Tests Reported

0.05 to 0.42

-0.21 to 0.72

(+)

(+) Calculators used for instruction only

(+)

Calculators used for instruction and assessment
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
- Tapia & Marsh (2004): Value, Self Confidence, Enjoyment, Motivation
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?
Mathematics Educational Technology
  e.g., Calculators, Graphing Calculators, CAS, Computer Software, Dynamic Geometry, Dynamic Web Content

Conceptual Framework

Achievement
  - Conceptual
  - Combined
  - Procedural

Operational Skills
  - Productivity
  - General
  - Selectivity

Problem Solving Skills

Moderators

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

Design (Report)
  - Pub Type
  - Grpg 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
  Attributes/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 = \text{number of groups}; \ \rho = \text{ICC})*
Mathematics Educational Technology
- e.g., Calculators, Graphing Calculators, CAS, Computer Software, Dynamic Geometry, Dynamic Web Content

Preliminary Results

Achievement
- Conceptual
- Combined
- Procedural

Operational Skills
- Productivity
- General
- Selectivity

Problem Solving Skills

Moderators
- Pedagogical
  - Tech Type
  - Tech Use
  - Trtmnt Length
  - Grade
  - Ability
- Design
  - Pub Type
  - Grpgng 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

\[ A = 0.15O + 0.14 \]
\[ SE_a = 0.13 \]
\[ t = 1.09 \]
\[ R^2 = 0.03 \]
Questions
Bibliography


