Using Research in Mathematics Educational Technology to Inform Classroom Teaching

NCTM Annual Meeting

April 27, 2012

Philadelphia, PA

Presenters

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MathTech Research Team

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Overview of Session

- Purpose of the Session
    - Applying Research to Practice
    - Sources for Research-Based Practices
    - Quality of Sources
- What do you know and/or want to know?
- Results of A Systematic Review of the Literature
    - Quality
    - Calculator Studies
    - NCTM Research Brief (Ronau et al., 2011) http://www.nctm.org/news/content.aspx?id=31192
    - Technology Studies Over Time
    - Types of Technologies Studied
    - Content Areas Studies
    - Meta-analysis findings
- Next Steps
- Wrap up

Practical Considerations

1. Why should teachers use technology in mathematics classes?
2. How should teachers use technology in mathematics classes?
3. What sources do teachers have to answer questions 1 and 2?
4. What is the quality of those sources?

Research to Practice Questions

1. What is the quality of educational technology research literature available for classroom decisions?
2. How useful is mathematics educational technology research?
3. How do we make research useful for classroom teachers?
4. How should research be evaluated for classroom use?
5. What technologies have been studied?
6. What content areas have been studied with respect to educational technology ? (Whole Numbers, Rational Numbers, Algebra, Geometry, etc.)
7. How does such research inform teacher preparation?

Sources of Research-Based Practices

- NCTM Journals (TCM, MTMS, MT)
- Professional Development Sessions
- District or State Materials
- Textbooks
- Other Commercial Products
- State and/or Federal Reports, e.g., Practice Guides: http://ies.ed.gov/ncee/wwc/publications_reviews.aspx
- Internet
- Peers

How reliable and valid are these sources?

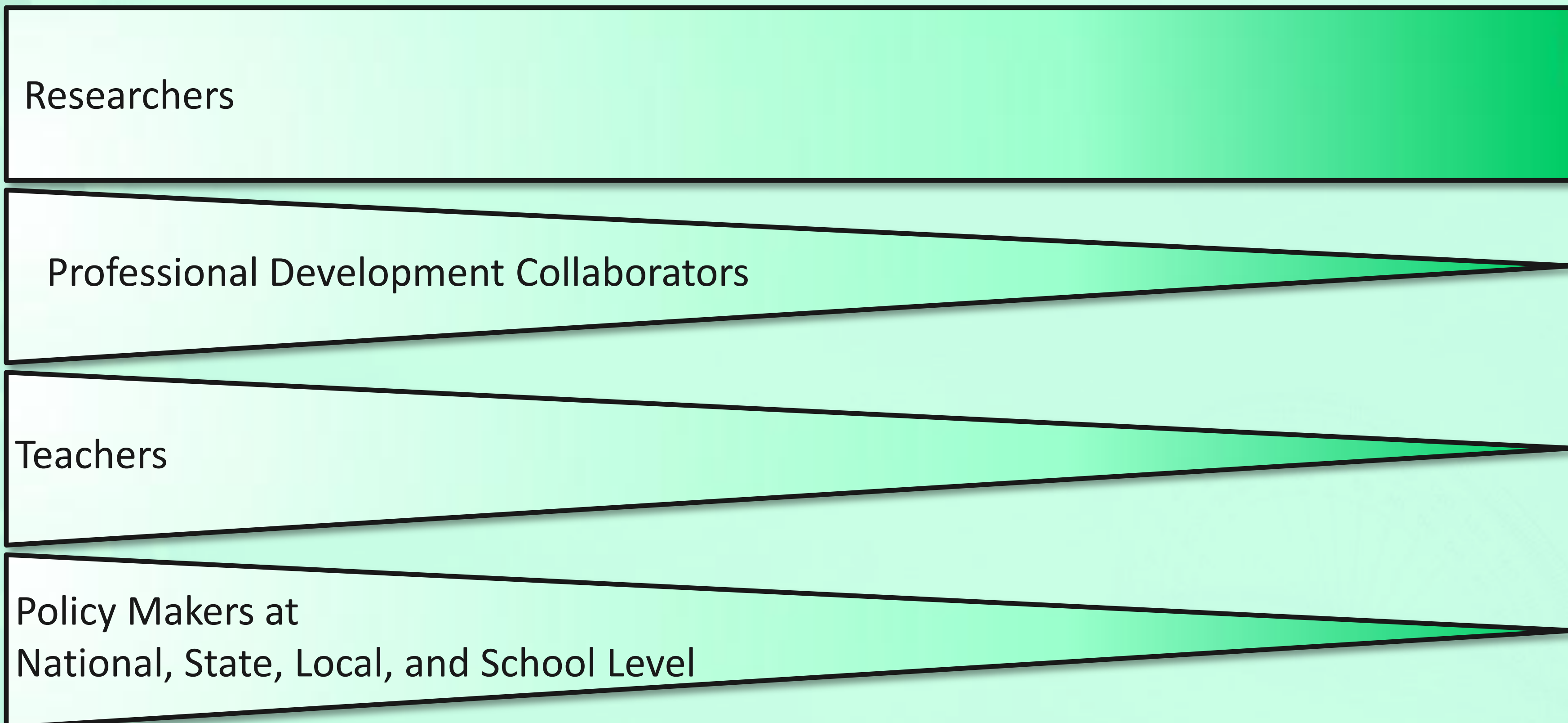
Educational Research: A Spectrum of Purpose (Goldstein, 1998)

Applied Research:
Address Visible Issues

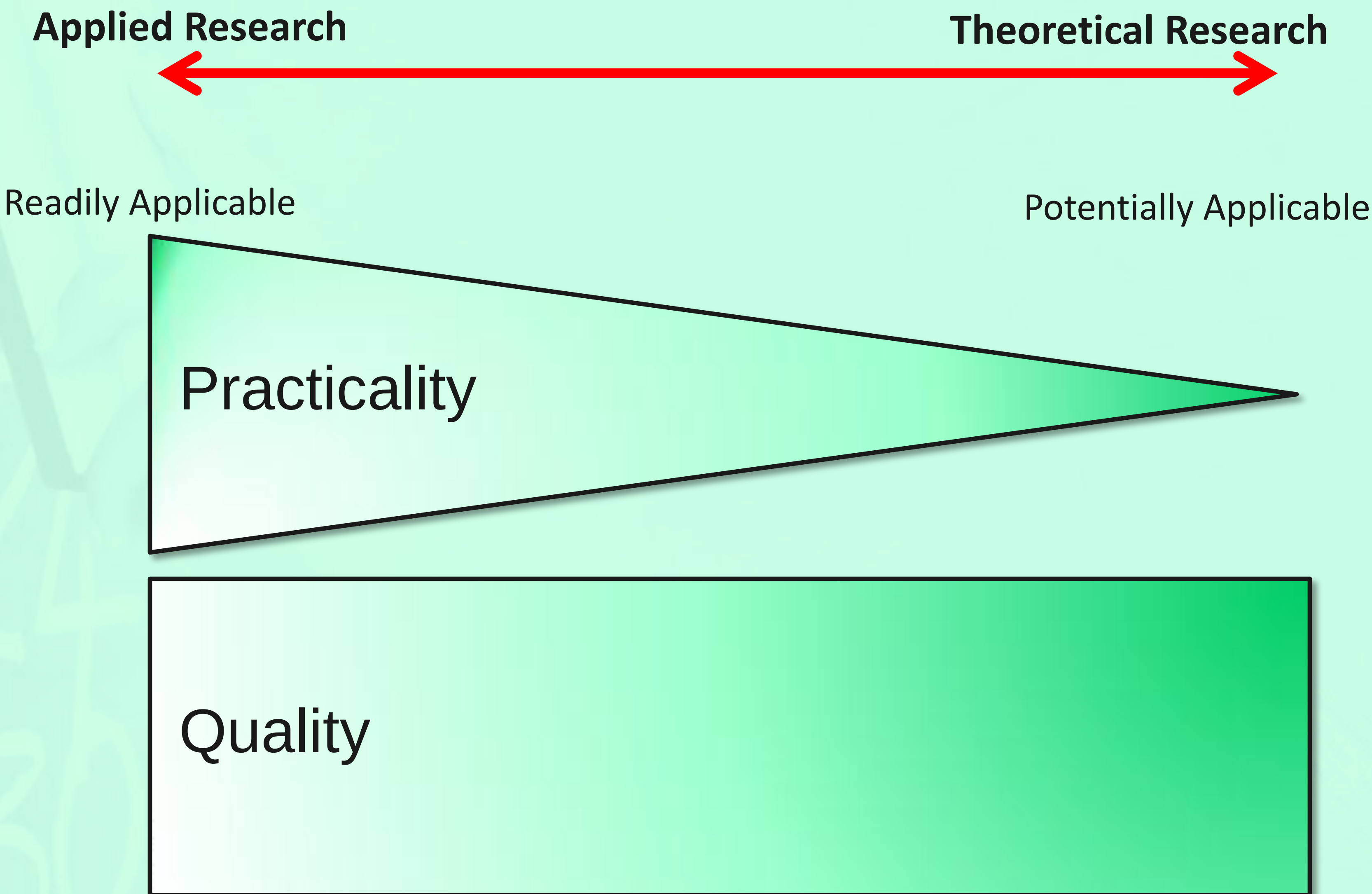
"Pure" Theoretical Research:
Advance Human Knowledge & Understanding

How can Classroom Connectivity Technology be Used to Enhance Student Achievement?

Does Educational Technology Activate Students' Brains in a Unique Way?



What Makes Research Valuable



A Framework for Measuring Quality

- This framework was developed to capture how well manuscripts identified important information for determining the credibility and usefulness of findings.
- This framework examines non-research manuscripts along with three types of studies: quantitative, qualitative, and mixed methods.
- This framework is based on the Scientific Principles for Education Research (Shavelson & Towne, 2002) and accepted research design structures (Shadish, Cook, & Campbell, 2002; Cresswell, 2009; Lipsey & Wilson, 2001; Patton, 2002; Teddlie & Tashakkori, 2009).

Why Did We Include Non-Research Papers?

Congdon & Dunham (1999)

Mixed Methods (up to 16 pts)

Non-Research (up to 5 pts)

Theoretical Connections (up to 4 pts)

- **Literature Support (up to 2 pts)**
  - Well Grounded (2 pts)
  - Partially Grounded (1 pt)
  - Not Grounded (0 pts)
- **Framework/Theory Connections (up to 2 pts)**
  - Well Connected (2 pts)
  - Partially Connected (1 pt)
  - Not Connected (0 pts)

Design Clarity and Validity (up to 1 pt)

- **Purpose Statement (1 pt)**

Quantitative (up to 15 pts)

Theoretical Connections (up to 4 pts)

- **Literature Support (up to 2 pts)**
  - Well Grounded (2 pts)
  - Partially Grounded (1 pt)
  - Not Grounded (0 pts)
- **Framework/Theory Connections (up to 2 pts)**
  - Well Connected (2 pts)
  - Partially Connected (1 pt)
  - Not Connected (0 pts)

Design Clarity and Validity (up to 9 pts)

- **Purpose Statement (1 pt)**
- **Research Questions/Hypotheses (1 pt)**
- **Design Robustness (up to 3 pts)**
  - Randomized Experiment (2 pts)
  - Regression Discontinuity Design (2 pts)
  - Quasi-Experimental Design with:
    - Sampling Strategies Unclear (1 pt)
    - Convenience Sample (1 pt)
    - Other Sampling Strategies (2 pts)
  - Use of Control Group (1 pt)
- **Threats to Validity Addressed (up to 4 pts)**
  - Internal (1 pt)
  - External (1 pt)
  - Construct (1 pt)
  - Statistical Conclusion (1 pt)

Measurement Trustworthiness (up to 2 pts)

- **Reliability (1 point)**
  - Internal Consistency
  - Split Half
  - Test-Retest
  - Inter-Rater
  - Alternate Forms
- **Validity (1 point)**
  - Content
  - Concurrent Criterion
  - Predictive Criterion
  - Construct
  - Discriminant
  - Convergent

Qualitative (up to 11 pts)

Theoretical Connections (up to 4 pts)

- **Literature Support (up to 2 pts)**
  - Well Grounded (2 pts)
  - Partially Grounded (1 pt)
  - Not Grounded (0 pts)
- **Framework/Theory Connections (up to 2 pts)**
  - Well Connected (2 pts)
  - Partially Connected (1 pt)
  - Not Connected (0 pts)

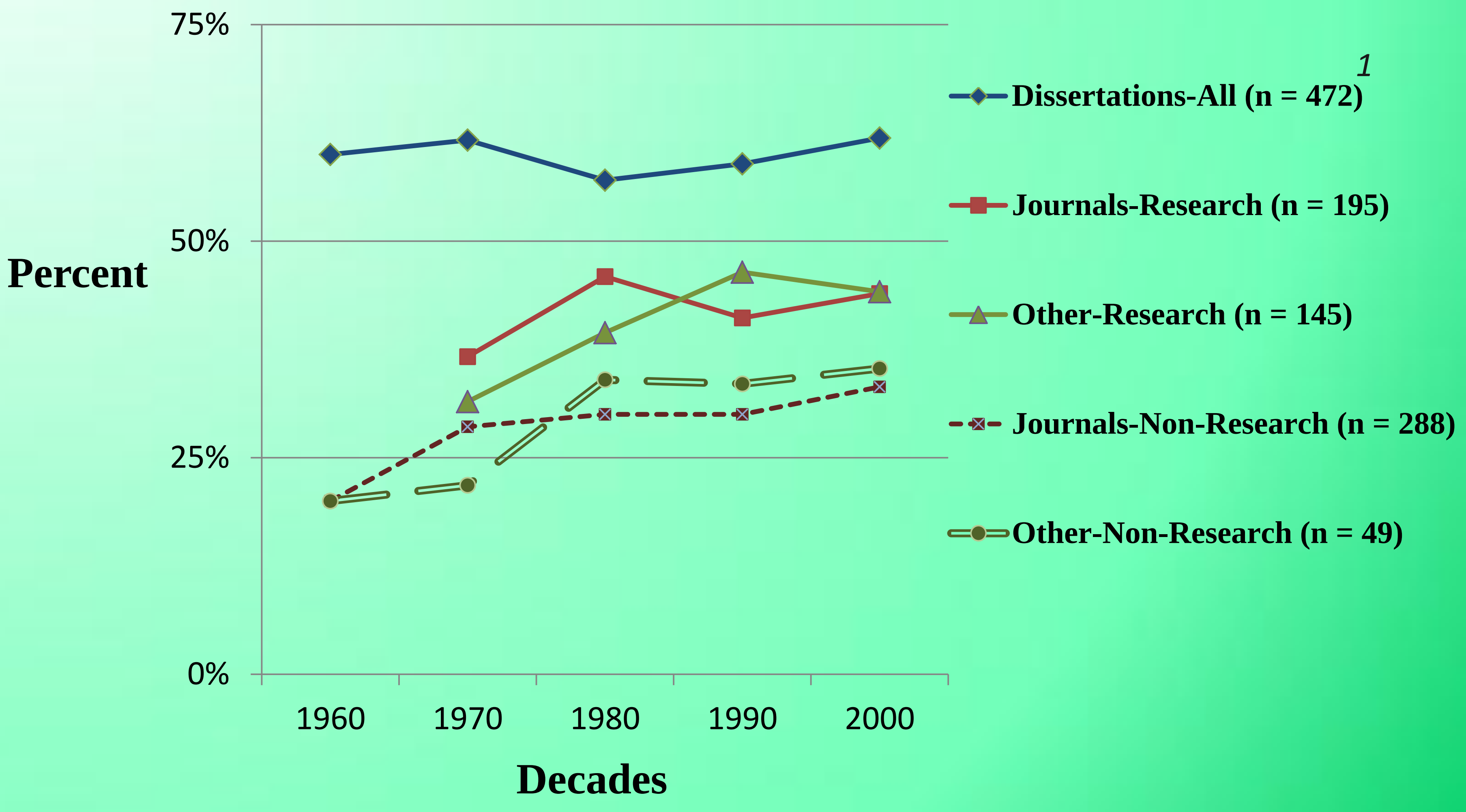
Design Clarity and Validity (up to 5 pts)

- **Purpose Statement (1 pt)**
- **Research Questions/Hypotheses (1 pt)**
- **Threats to Validity Addressed (up to 3 pts)**
  - Internal (1 pt)
  - External (1 pt)
  - Construct (1 pt)

Measurement Trustworthiness (up to 2 pts)

- **Reliability (1 point)**
  - Internal Consistency
  - Inter-Rater
- **Validity (1 point)**
  - Persistent Observation
  - Triangulation
  - Peer Debriefing
  - Negative Case Analysis
  - Referential Adequacy
  - Member Checks
  - Thick Description
  - Dependability Audit
  - Confirmability Audit
  - Reflective Journal

Percent of Quality Points Possible for the Relevant Research Design



[1]One Dissertation Classified as Non-Research (Quality Index = 20%)

What Questions Do You Have?

A quick start

1. How do you (and/or your colleagues/school/district) make decisions about using technology in your classes?
2. How is mathematics educational technology evaluated in your classroom or school?
3. How have you changed your classroom technology use over the last 5-10 years?
4. What might you predict will be your classroom use in the next 5-10 years?
5. What do you know about the positive and negative effects of technology use across grade levels?
6. What factors impact the use of classroom technology?
7. What hinders you from being able to use the mathematics educational technology that you want to use?
8. What do new teachers need to know about technology?

Number of Manuscripts by Decade

Year	Number of Manuscripts
1960-1969	2
1970-1979	22
1980-1989	41
1990-1999	295
2000-2009	789

n = 1149

Technology Studies by Content Area

	Content Areas														
Grade Level	Unspecified	Algebra	Calculus	Fraction	Function	Geometry	Mathematics	Number	Precalculus	Probability	Proof	Ratio	Statistics	Trigonometry	Other
Unspecified	60	13	6	0	1	13	27	4	0	6	0	0	6	0	2
K-5	64	5	0	2	1	13	78	31	0	4	1	1	3	0	5
6-8	85	28	1	2	0	21	75	24	0	8	3	3	7	0	3
9-12	127	96	24	0	6	59	68	11	9	16	5	2	15	3	9
Ugrad	76	65	34	1	2	7	33	7	7	25	1	0	26	2	8
Grade Level	10	0	1	0	0	2	1	0	1	2	0	0	2	0	0
Teacher Prep	32	4	0	0	1	8	28	5	0	2	1	0	2	0	3
Teacher Development	47	12	3	0	1	6	42	2	1	0	0	1	0	1	3
Adult Ed	3	1	1	0	0	1	5	0	0	0	0	0	0	0	0
Total	504	224	70	5	12	130	357	84	18	63	11	7	61	6	33

Meta-Analysis 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?

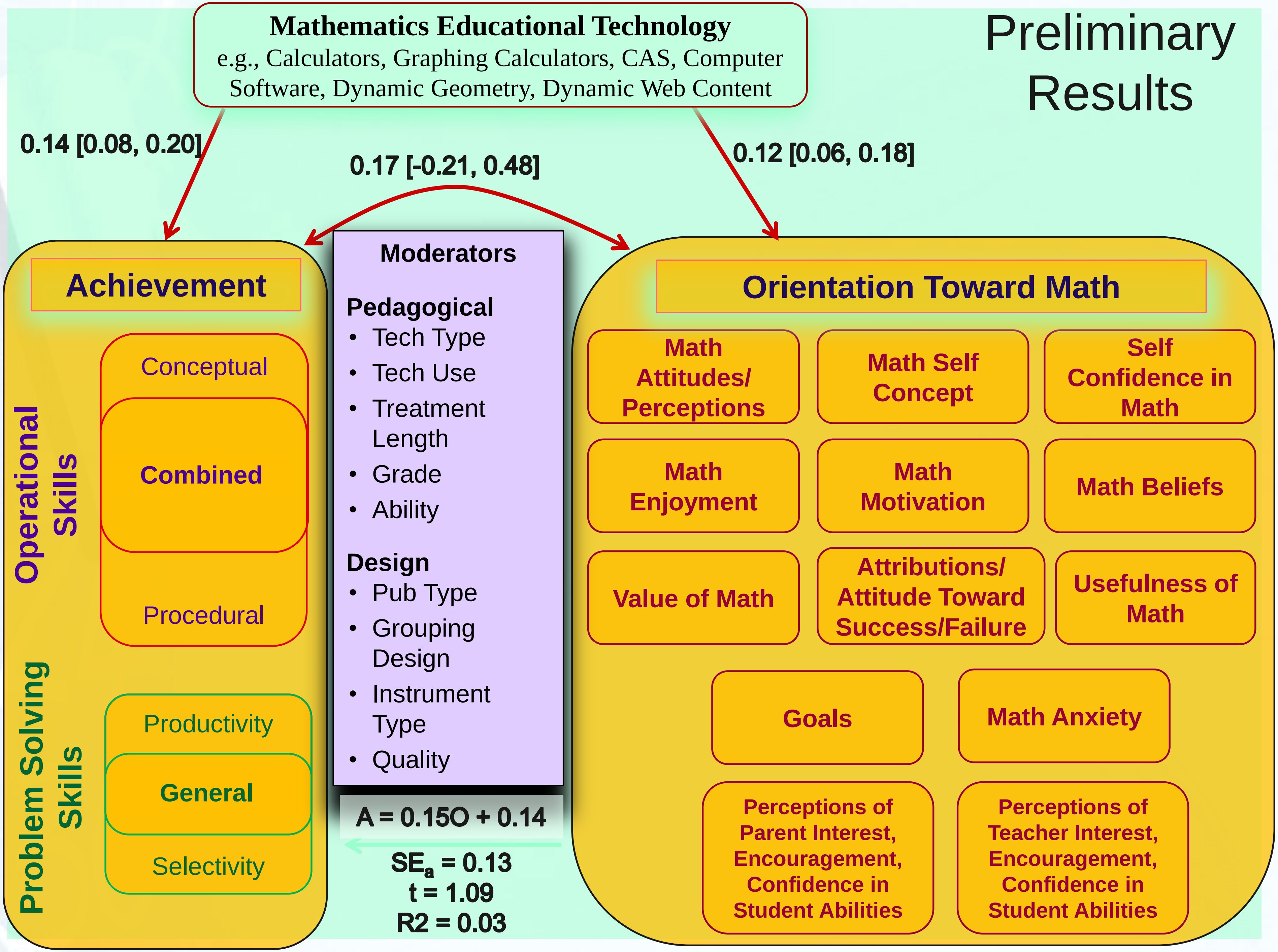
2. What is the average standardized mean difference effect size for mathematics educational technology interventions on orientation when achievement is also measured?

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?

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.)

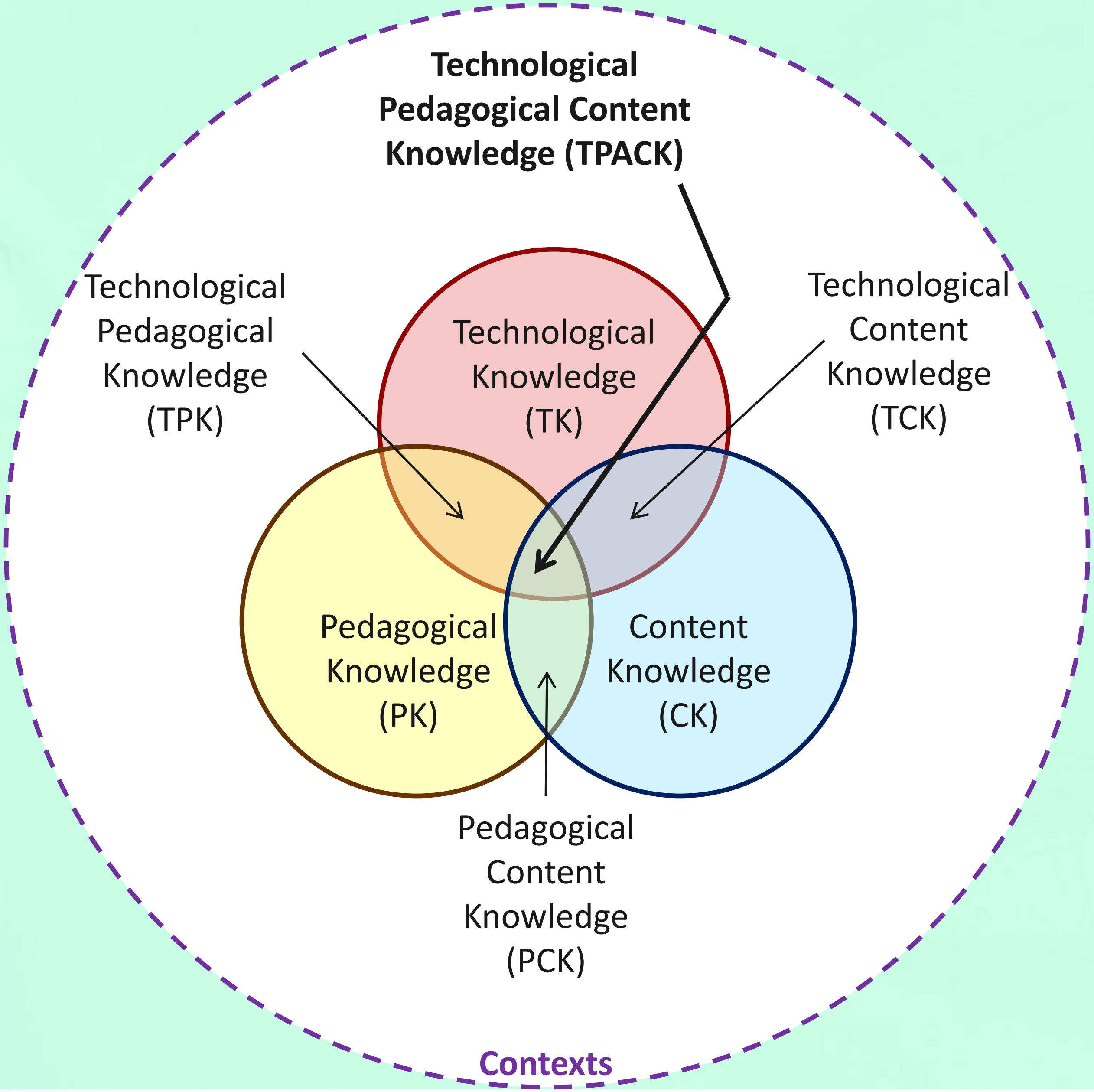

Preliminary Results
Mathematics Educational Technology
e.g., Calculators, Graphing Calculators, CAS, Computer Software, Dynamic Geometry, Dynamic Web Content
0.14 [0.08, 0.20]
0.17 [-0.21, 0.48]
0.12 [0.06, 0.18]
Achievement
Operational Skills
Conceptual
Combined
Procedural
Problem Solving Skills
Productivity
General
Selectivity
Moderators
Pedagogical
Tech Type
Tech Use
Treatment Length
Grade
Ability
Design
Pub Type
Grouping Design
Instrument Type
Quality
A = 0.15O + 0.14
SE_a = 0.13
t = 1.09
R2 = 0.03
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

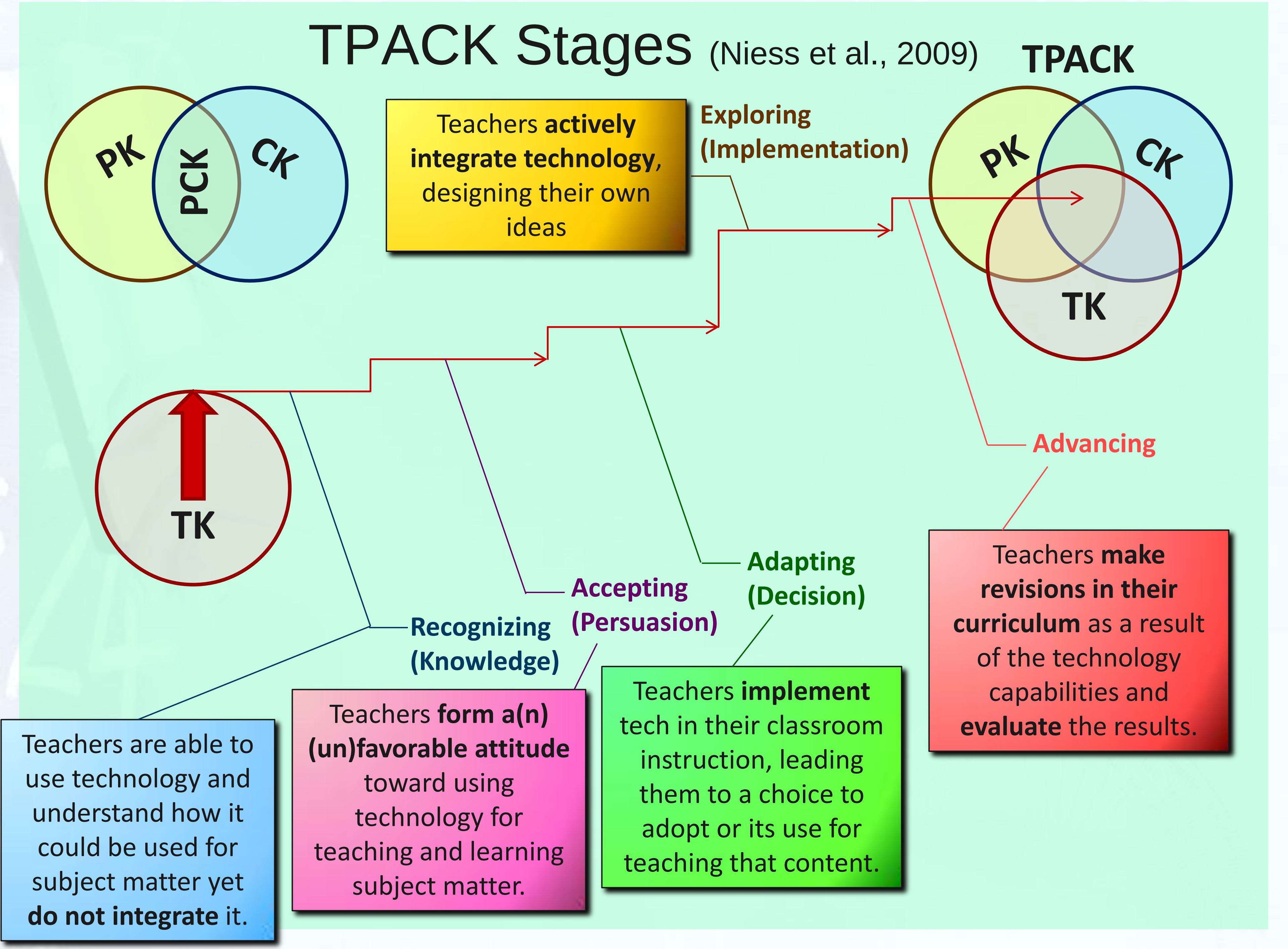
Professional Development

- What is the knowledge that teachers need to use mathematics educational technology effectively?
- What preparation and professional development do teachers need to use educational technology?
- How should such professional development be structured?

- We used two models to help organize the work on teacher knowledge and development
- TPACK
- CFTK

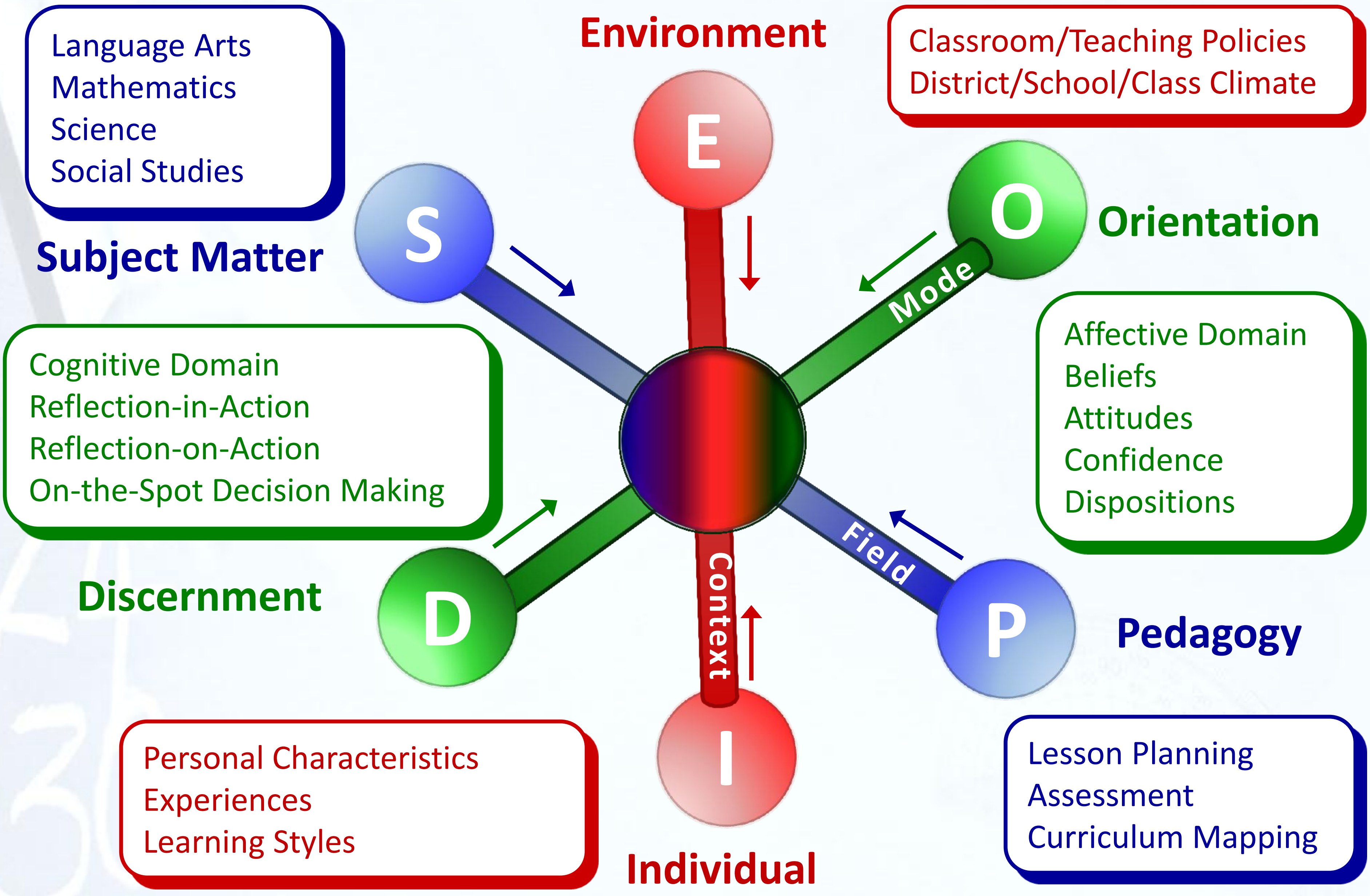
TPACK Model (Koehler & Mishra, 2008)




TPACK Stages (Niess et al., 2009)
TPACK
PK
PCK
CK
PK
CK
TK
TK
Teachers actively integrate technology, designing their own ideas
Exploring (Implementation)
Advancing
Adapting (Decision)
Accepting (Persuasion)
Recognizing (Knowledge)
Teachers are able to use technology and understand how it could be used for subject matter yet do not integrate it.
Teachers form a(n) (un)favorable attitude toward using technology for teaching and learning subject matter.
Teachers implement tech in their classroom instruction, leading them to a choice to adopt or its use for teaching that content.
Teachers make revisions in their curriculum as a result of the technology capabilities and evaluate the results.

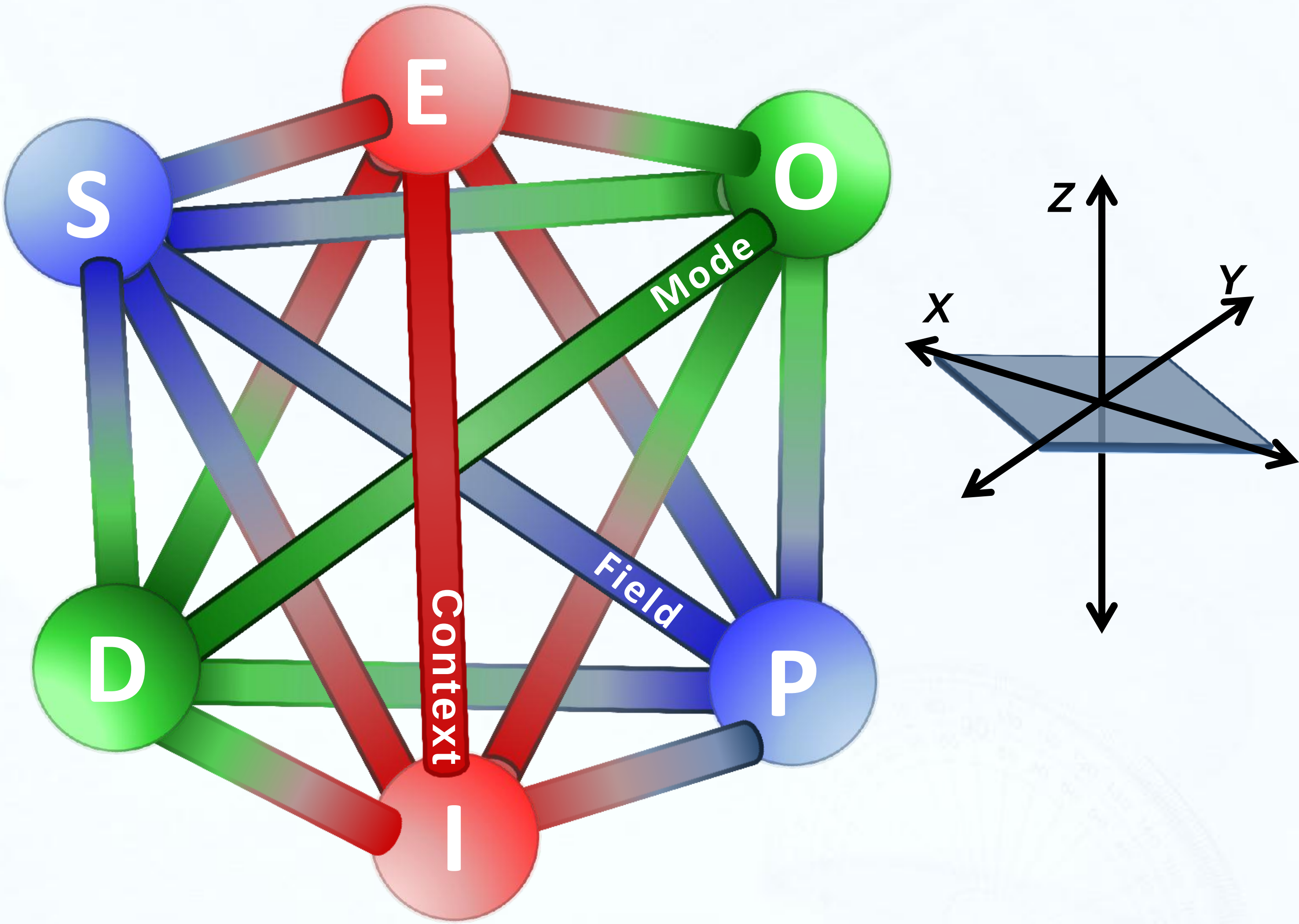
Ronau et al. (2009, February):

Presentation of CFTK for Capturing the Knowledge Components



CFTK Dimensions, Aspects, and Interactions

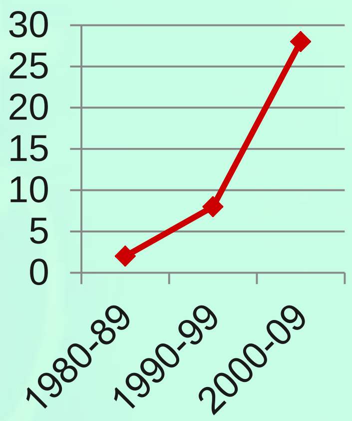
Two-Aspect Interactions **Three-Aspect Interactions** **Four-Aspect Interactions**



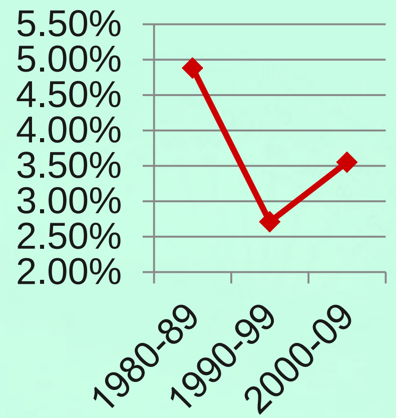
Five-Aspect Interactions **Six-Aspect Interaction**

Literature Emphasis on Professional Development for Technology in Mathematics Education

Decade	Research	Non-Research	Percent of Decade Total
1980-1989	2	0	4.88% (2/41)
1990-1999	8	0	2.71% (8/295)
2000-2009	24	4	3.55% (28/789)



Has not changed relative to the number of studies in each decade



Teacher Professional Development Foci

	Algebra				Prob. & Stat.	General Mathematics or Problem Solving					
	Calc	Comp. Soft.	Probe-ware	Web	Comp. Soft.	Calc	Comp. Soft.	Probe-ware	Pro-gramming	Gen Tech Use	Web
K-5	0	0	0	0	0	0	0	0	0	0	0
1980-1989	0	0	0	0	0	**1**	0	0	0	0	0
1990-1999	0	0	0	0	0	0	0	0	0	0	0
2000-2009	0	0	0	0	0	0	**1**	0	0	0	**2**
6-8	0	0	0	0	0	0	0	0	0	0	0
1980-1989	0	0	0	0	0	0	0	0	0	0	0
1990-1999	0	0	0	0	0	0	0	0	0	0	0
2000-2009	0	0	0	0	**1**	**2**	**7**	**1**	0	**1**	**2**
9-12	0	0	0	0	0	0	0	0	0	0	0
1980-1989	0	0	0	0	0	0	0	0	0	0	0
1990-1999	0	**1**	0	0	0	**1**	**1**	0	0	0	0
2000-2009	**1**	0	0	0	0	**2**	**4**	**1**	0	0	**2**
TD or NA	0	0	0	0	0	0	0	0	0	0	0
1980-1989	0	0	0	0	0	**1**	0	0	**1**	0	0
1990-1999	0	0	0	0	0	**4**	**5**	**2**	0	0	**6**
2000-2009	**4**	**1**	**1**	**1**	**2**	**4**	**10**	**1**	0	**3**	**9**
PS Graduate	0	0	0	0	0	0	0	0	0	0	0
1980-1989	0	0	0	0	0	0	0	0	0	0	0
1990-1999	0	0	0	0	0	0	0	0	0	0	0
2000-2009	0	0	0	0	0	**1**	**1**	0	0	0	**1**
Total	**5**	**2**	**1**	**1**	**3**	**16**	**29**	**5**	**1**	**4**	**22**

Where Do We Go From Here?

Papers Worth Reading

Cheung, A. K., Slavin, R. E., & Center for Data-Driven Reform in Education, (. (2011). The Effectiveness of Educational Technology Applications for Enhancing Mathematics Achievement in K-12 Classrooms: A Meta-Analysis. Best Evidence Encyclopedia (BEE). Center For Data-Driven Reform In Education,

Hembree, R., & Dessart, D. (1986). Effects of hand-held calculators in precollege mathematics education: A meta-analysis. *Journal for Research in Mathematics Education, 17*, 83-99.

Ellington, A. (2003). A meta-analysis of the effects of calculators on students in precollege mathematics classes. *Journal for Research in Mathematics Education, 34*, 433-463.

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.

Pape, S. J., Irving, K. E., Bell, C. V., Shirley, M. L., Owens, D. T., Owens, S. K., Bostic, J. D., & Lee, S. C. (2011). Principles of Effective Pedagogy within the Context of Connected Classroom Technology: Implications for Teacher Knowledge. In R. N. Ronau, C. R. Rakes, & M. L. Niess (Eds.), *Educational technology, teacher knowledge, and classroom impact: A research handbook on frameworks and approaches* (pp. 176-199). Hershey, PA: IGI Global.

Qing, L., & Xin, M. (2010). A Meta-analysis of the Effects of Computer Technology on School Students' Mathematics Learning. Educational Psychology Review, 22(3), 215-243.

Thank You!!

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Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Ronau, R. N., **Rakes, C. R.**, Bush, S. B., Driskell, S., Niess, N. L., & Pugalee, D. (2011). *Using calculators for teaching and learning mathematics. Research Brief.* Reston, VA: National Council of Teachers of Mathematics. Full text available at http://www.nctm.org/news/content.aspx?id=31192

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002).*Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin.

Teddlie, C., & Tashakkori, A. (2009).*Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences*. Los Angeles, CA: Sage Publications.

Research Questions that Guided the Study

1. What types of research and manuscripts are available within the mathematics education technology literature?
2. How useful is the evidence for supporting technology as an intervention to enhance the teaching and learning of mathematics?
3. What types of outcomes are addressed in the mathematics education technology research?
4. How broad are the data sources used to support mathematics education technology research?
5. What is the scientific quality of mathematics education technology research?

Quality of Technology Studies

Table 1: Percent quality Index Scale

Quality Percent	0%	25%	50%	75%	100%	Total
Dissertations						
1960				1		1
1970			3	4	1	8
1980			4	14	1	19
1990		1	44	103	16	164
2000		2	61	171	46	280
Total	**0**	**3**	**112**	**293**	**64**	**472**
Journals						
1960		1				1
1970		6	1	2		9
1980		5	2	3		10
1990		40	28	13	2	83
2000	3	156	122	77	22	380
Total	**3**	**208**	**153**	**95**	**24**	**483**

Quality of Technology Studies

Table 1: Percent Quality Index Scale (cont)

Quality Percent	0%	25%	50%	75%	100%	Total
Other						
1970	1	3		1		5
1980		1	8	3		12
1990		5	25	16	2	48
2000		27	67	23	12	129
Total	**1**	**36**	**100**	**43**	**14**	**194**
All Manuscripts						
1960		1		1		2
1970	1	9	4	7	1	22
1980		6	14	20	1	41
1990		46	97	132	20	295
2000	3	185	250	271	80	789
Total	**4**	**247**	**365**	**431**	**102**	**1149**