



Research in Mathematics Instructional Technology: Current Trends and Future Demands

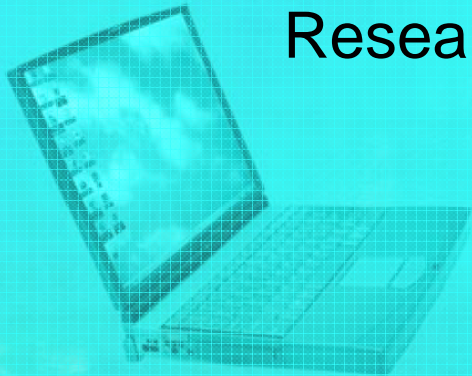
Christopher Rakes
Robert Ronau
Margaret Niess
Sarah Bush
Shannon Driskell
David Pugalee





Symposium Overview

- Introduction to the study (Rakes and Ronau)
- The Role of Educational Technology in Student Achievement and Learning (Pugalee and Bush)
- The Impact of Educational Technology on Student Orientation (Rakes and Driskell)
- The Interaction of Teacher Knowledge Aspects in Educational Technology Research (Ronau and Rakes)
- The Use of TPACK to Guide Educational Technology Research (Ronau and Niess)





Introduction to the Study



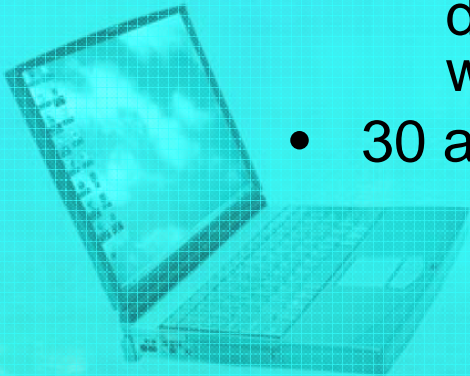
Systematic review of literature: Validity issues

- **Relevance:** search terms chosen. Peer Debriefing used to refine terms.
- **Representativeness:** literature database platforms chosen to produce the broadest sample
 - EBSCOWeb (ERIC, Academic Search Premier, PsychInfo, Primary Search Plus, Middle Search Plus, Educational Administration Abstracts)
 - JSTOR (limited to the following disciplines: Education, Mathematics, Psychology, Statistics)
 - OVID
 - ProQuest (Research Library, Dissertations & Theses, Career & Technical Education)
 - H.W. WilsonWeb (Education Full Text)
- **Results:** 1356 manuscripts



Coding: Reliability Issues

- Development of coding database and convergence of coder decisions (i.e., inter-rater reliability)
 - Initial development
 - Pilot tested with 3 articles and 2 coders and refinement
 - Re-tested with same 3 articles and 5 additional coders; refinement
 - Re-tested with 5 additional articles, all 7 coders; refinement
 - Re-tested with 10 additional articles; Refinement
 - Re-tested with 12 additional articles; Approval of database and a priori coding decisions (i.e., how will we code X?)
- 30 articles coded by all coders



Coding: Reliability Issues (cont'd)

- 12 articles randomly chosen for reliability checks throughout the coding process
- Remaining sample randomly divided among 6 coders (N=226 each); 7th coder to do reliability checks and assist with obtaining full text
- Total coded to date: 473
- Manuscripts deemed not relevant: 24
 - Not mathematics or not technology
- Relevant N = 449





Scientifically Based Research Requires...

the application of rigorous, systematic, and objective procedures to obtain reliable and valid knowledge relevant to education activities and programs; and includes research that

- (i) employs **systematic, empirical methods** that draw on observation or experiment;
- (ii) involves **rigorous data analyses** that are adequate to test the stated hypotheses and justify the general conclusions drawn;
- (iii) **relies on measurements or observational methods that provide reliable and valid data across evaluators and observers, across multiple measurements and observations, and across studies by the same or different investigators;**
- (iv) is evaluated using **experimental or quasi-experimental designs** in which individuals, entities, programs, or activities are assigned to different conditions and with appropriate controls to evaluate the effects of the condition of interest,
- (v) ensures that experimental studies are presented in sufficient detail and clarity to **allow for replication** or, at a minimum, offer the opportunity to build systematically on their findings; and
- (vi) has been accepted by a peer-reviewed journal or approved by a panel of independent experts through a comparably **rigorous, objective, and scientific review** (NCLB, 2002, p. 1964-1965).



Six Scientific Principles (Shavelson & Towne, 2002)

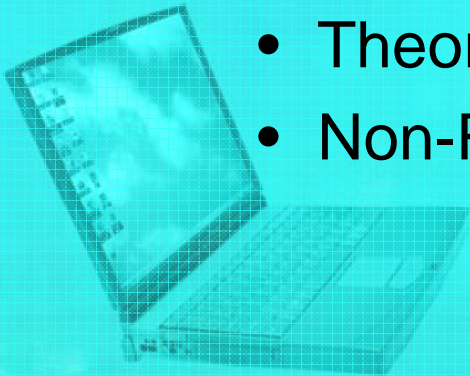
1. Pose Significant Questions That Can Be Investigated Empirically
2. Link Research to Relevant Theory
3. Use Methods That Permit Direct Investigation of the Question
4. Provide a Coherent and Explicit Chain of Reasoning
5. **Replicate and Generalize Across Studies**
6. Disclose Research to Encourage Professional Scrutiny and Critique



Does the manuscript describe the measures used, the reported validity and reliability from previous studies (if applicable), and validity and reliability statistics from the current sample?

(Ronau & Rakes, in press-a)

- Qualitative: Trustworthiness
- Quantitative: Reliability and Validity
- Mixed Methods: Reliability, Validity, and Trustworthiness
- Meta-Analysis: Validity, Inter-Rater Reliability
- Theory Development: Validity
- Non-Research: Validity





The Role of Educational Technology in Student Achievement and Learning





Types of Manuscripts and Research Design

Type of Manuscript by Research Design	Non- Research	Qualitative	Quantitative	Mixed Method	Single Subj	Meta- Analysis/ Syst Review	Theory/ Lit Driven	Grand Total
Book Chapter	0	1	1	0	0	0	1	3
Conference Paper	1	2	1	2	0	0	1	7
Dissertation	0	15	59	34	1	4	0	113
Journal	8	16	35	6	0	1	3	69
Master's Thesis	0	2	18	1	0	0	0	21
Report	0	0	4	0	0	1	0	5
Grand Total	9	36	118	43	1	6	5	218





Sources of Data Used

Sources of Data	Number of Studies (N=218)	
Performance Assessment	162	74.3%
Self-Report Orientation Survey	83	38.1%
Observation	62	28.4%
Interview	44	20.2%
Content Analysis	43	19.7%
Self-Report Poll/Census Survey	11	5.0%
Other (<i>e.g., Subject Dialog</i>)	7	3.2%
Researcher Journal	7	3.2%
Other-Report Orientation Survey	4	1.8%
Subject Journal	4	1.8%
3rd Party Journal	3	1.4%
Other-Report Poll/Census Survey	2	0.9%
Focus Group	1	0.5%
None	4	1.8%



NCTM Standards Addressed

NCTM Standards	Number of Studies (N=218)	
Algebra	159	72.9%
Problem Solving	89	40.8%
Geometry	71	32.6%
Number and Operation	63	28.9%
Data/Probability	20	9.2%
Reasoning and Proof	19	8.7%
Communication	18	8.3%
Representations	16	7.3%
Measurement	8	3.7%
Connections	6	2.8%





Technology Examined - Calculator

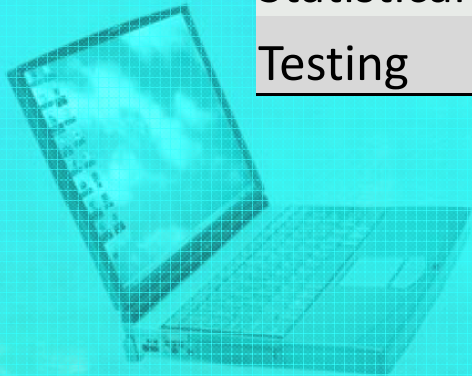
Type	Number of Studies (N=218)	
Graphing	43	19.7%
Non-Scientific	18	8.3%
CAS	10	4.6%
Probeware	5	2.3%
Scientific	5	2.3%
Symbolic Algebra	3	1.4%
Programming	1	0.5%





Technology Examined – Computer Software

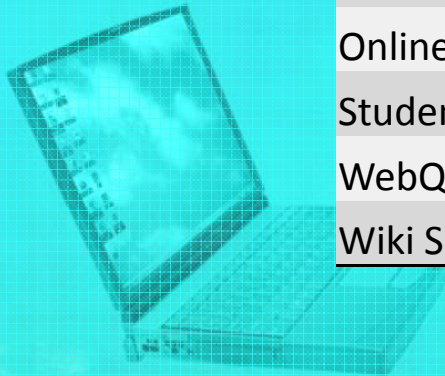
Type of Software	Number of Studies (N=218)	
Tutorial	39	17.9%
Dynamic Geometry	25	11.5%
Algebraic	16	7.3%
Spreadsheet	11	5.0%
Graphing	7	3.2%
Statistical Computation	6	2.8%
Game/Puzzle	5	2.3%
Statistical Instruction	3	1.4%
Testing	1	0.5%





Technology Examined - Internet

Type of Technology	Number of Studies (N = 218)	
Distance Learning	9	4.1%
Virtual Manipulatives	4	1.8%
Online Applets	2	0.9%
Online Tutorials	2	0.9%
Web Sites	2	0.9%
Blogs	1	0.5%
Document Sharing	1	0.5%
Video Conferencing	1	0.5%
Facebook/MySpace/Twitter	0	0.0%
Online Game/Puzzle	0	0.0%
Online Testing Software	0	0.0%
Online Video Sharing	0	0.0%
Student Response Systems	0	0.0%
WebQuests	0	0.0%
Wiki Spaces	0	0.0%



Findings

- **Most Studied Technology:**
Graphing Calculators (43/218), Tutorial Software (39/218), Dynamic Geometry Software (25/218)
- **Common Research Design:**
Quantitative (118 + 43 mixed methods/ 218)
- **Common Data Source:**
Performance Assessments (162/218)
- **Common NCTM Standard Addressed:**
Algebra – examined far more (159/218)
Additionally, content area standards were addressed more often than “process” area standards.





Critical Areas for New Research/ Missing in the Literature

- **Technology Type:**

Online technology (multiple areas), Interactive Whiteboards, Programming, Probeware

It should be noted that some of these technology types are relatively new.

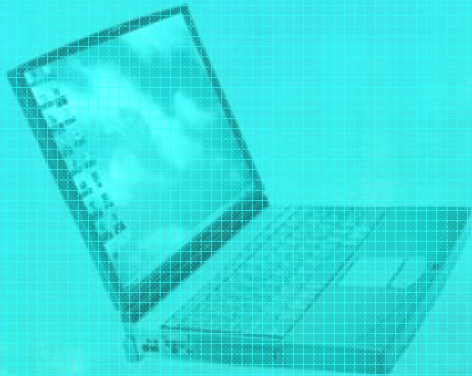
- **NCTM Standards:**

Measurement and Connections standard are least studied.





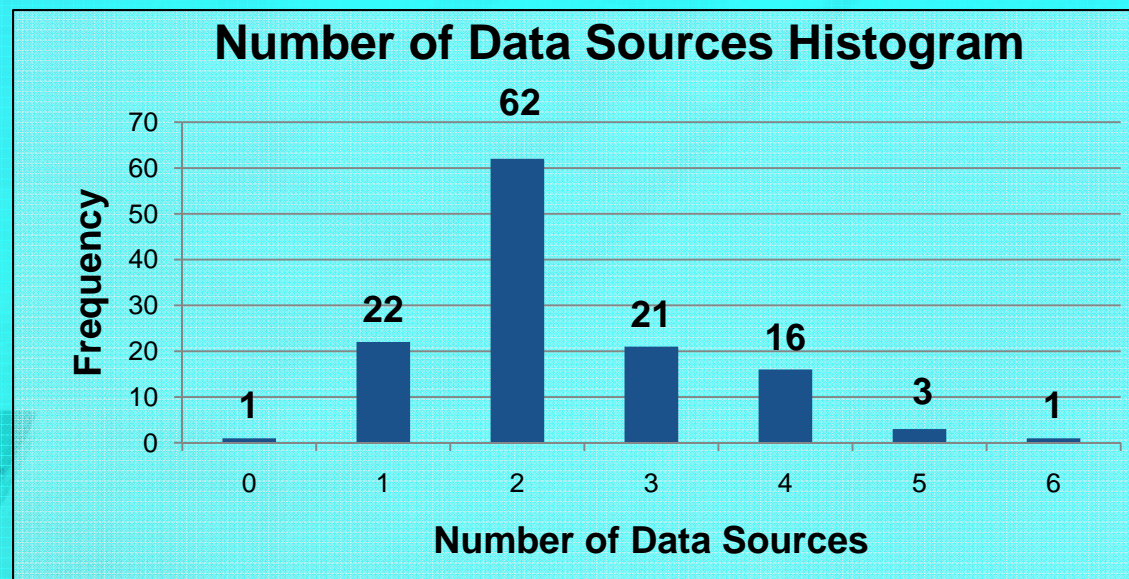
The Role of Educational Technology in Student Orientation, Discernment, and Learning Behavior





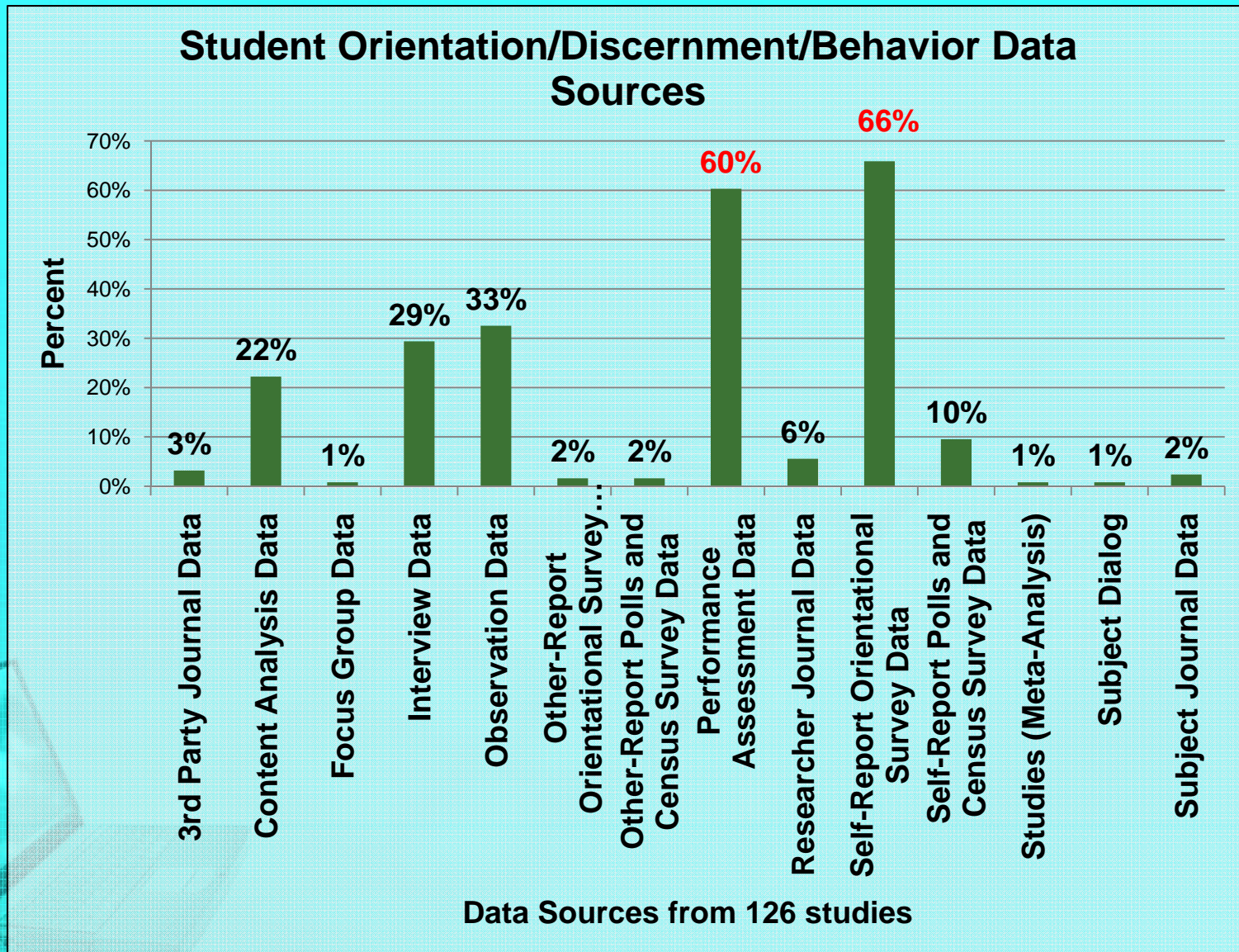
Number of Studies, Outcomes, and Data Sources

Type of Study	Number of Outcomes			Grand Total
	1	2	3	
Meta-Analysis/Systematic Review	2	1	0	3
Mixed Methods	21	6	0	27
Non-Research Paper	3	0	0	3
Qualitative	22	5	1	28
Quantitative	59	2	1	62
Theory Development/Literature Driven	2	1	0	3
Grand Total	109	15	2	126





What data sources are used?





Technology Examined - Calculators

Calculator Features	Number of Studies (N=126)	
Graphing	24	19%
Non-Scientific	16	13%
Scientific	6	5%
CAS	5	4%
Programming	1	1%
Applications	0	0%
Classroom Calculator Networks	0	0%
Document Management	0	0%
Dynamic Geometry	0	0%
Probeware	0	0%
Simulation	0	0%
Statistics	0	0%
Symbolic Algebra	0	0%
Symbolic Calculus	0	0%



Technology Examined – Computer Software

Type of Software	Number of Studies (N=126)	
Tutorial	15	12%
Dynamic Geometry	13	10%
Algebra	12	10%
Spreadsheets	9	7%
Graphing	4	3%
Games/Puzzles	3	2%
Statistics Computation	2	2%
Statistics Instruction	2	2%
Presentation	1	1%
SmartBoards	1	1%
Testing	1	1%
Applets	0	0%



Technology Examined – Internet Tools

Type of Software	Number of Studies (N=126)	
Distance Learning	10	7.9%
Online Applets	2	1.6%
Blogs	1	0.8%
Document Sharing	1	0.8%
Online Tutorial Software	1	0.8%
Virtual Manipulatives	1	0.8%
Web Sites	1	0.8%
Facebook/MySpace/Twitter	0	0.0%
Online Game/Puzzle	0	0.0%
Online Testing Software	0	0.0%
Online Video Sharing	0	0.0%
Student Response Systems	0	0.0%
Video Conferencing	0	0.0%
WebQuests	0	0.0%
Wiki Spaces	0	0.0%

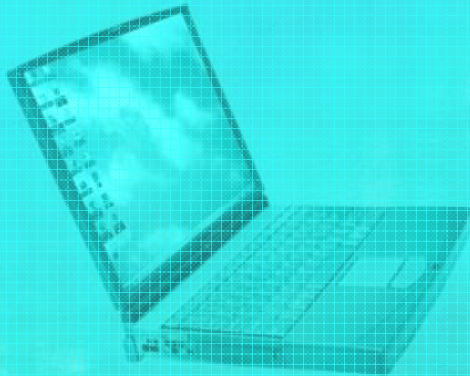


Quality of Evidence

	Valid/Reliable	Total	% Valid/Reliable	% Grand Total
1 Outcome	34	109	31%	87%
Systematic Review	0	2	0%	
Mixed Methods	4	21	19%	
Non-Research Paper	0	3	0%	
Qualitative	17	22	77%	
Quantitative	13	59	22%	
Theory Development	0	2	0%	
Orientation	22	87	25%	
Discernment	2	11	18%	
Learning Behavior	6	11	55%	
2 Outcomes	4	15	27%	12%
Systematic Review	0	1	0%	
Mixed Methods	0	6	0%	
Qualitative	3	5	60%	
Quantitative	1	2	50%	
Theory Development	0	1	0%	
Orientation & Discernment	2	3	67%	
Orientation & Learning Behavior	1	6	17%	
Discernment & Learning Behavior	2	6	33%	
3 Outcomes	1	2	50%	2%
Qualitative	0	1	0%	
Quantitative	1	1	100%	
Grand Total	39	126	31%	



The Interaction of Teacher Knowledge Aspects in Educational Technology Research



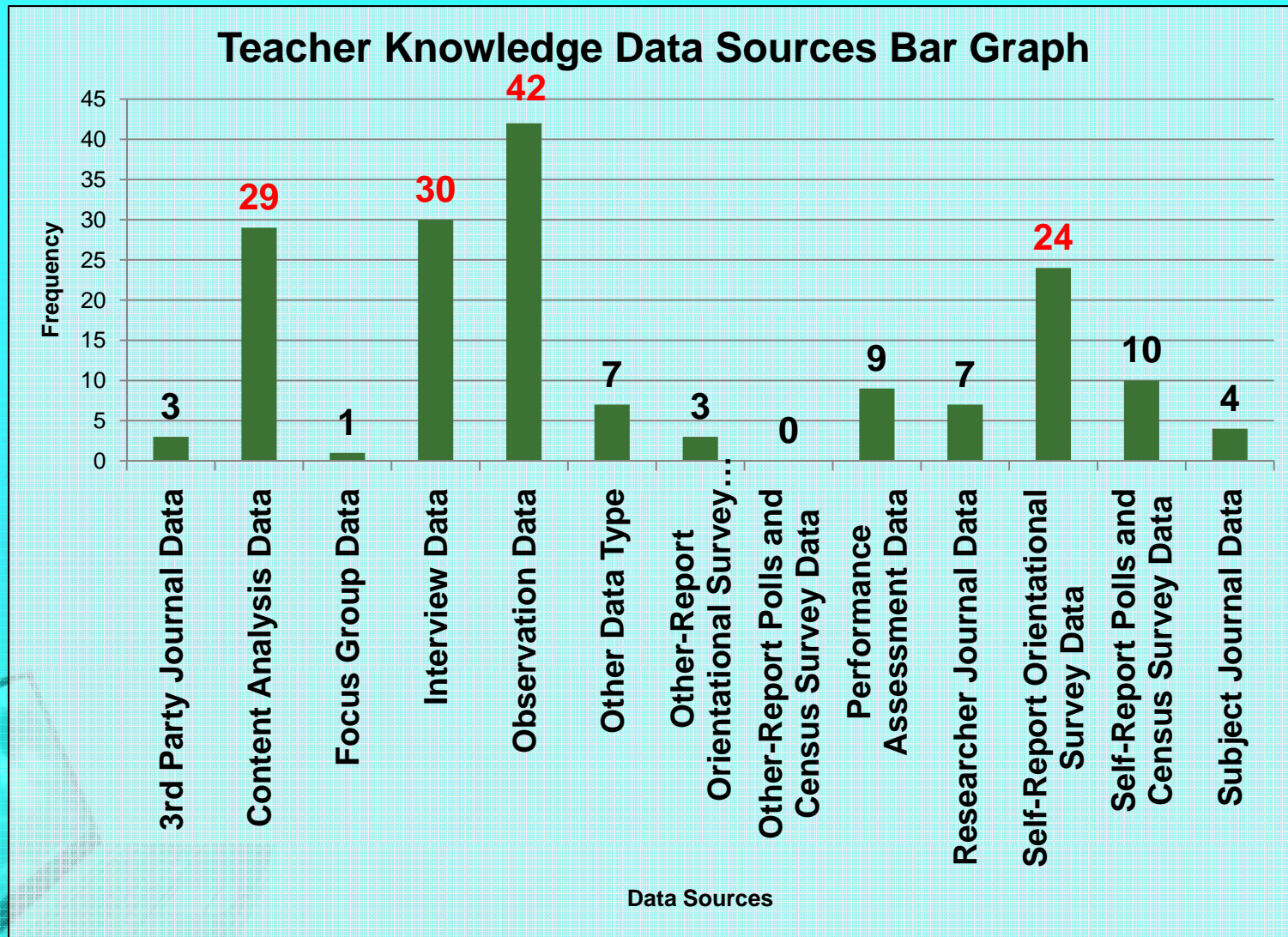


Types of Manuscripts and Research Design

Type of Manuscript by Research Design	Non- Research	Qualitative	Quantitative	Mixed Method	Theory/ Lit Driven	Grand Total
Book Chapter	0	0	0	0	1	1
Conference Paper	0	3	0	0	1	4
Dissertation	0	11	6	9	0	26
Journal	15	20	1	2	1	39
Master's Thesis	0	1	0	0	0	1
Report	0	0	1	0	0	1
Grand Total	15	35	8	11	3	72



Data Sources Used





Technology Examined - Calculators

Calculator Features	Number of Studies (N=72)	
Graphing	22	30.6%
Probeware	5	6.9%
CAS	2	2.8%
Programming	1	1.4%
Scientific	1	1.4%
Symbolic Algebra	1	1.4%
Applications	0	0.0%
Classroom Calculator Networks	0	0.0%
Document Management	0	0.0%
Dynamic Geometry	0	0.0%
Non-Scientific	0	0.0%
Simulation	0	0.0%
Statistics	0	0.0%
Symbolic Calculus	0	0.0%



Technology Examined – Computer Software

Type of Software	Number of Studies (N=72)	
Dynamic Geometry	19	26.4%
Spreadsheets	14	19.4%
Graphing	7	9.7%
Algebraic	5	6.9%
Statistics Instruction	5	6.9%
Tutorials	5	6.9%
Presentation	4	5.6%
SmartBoards	3	4.2%
Games/Puzzles	2	2.8%
Statistics	2	2.8%
Applets	1	1.4%
Testing	1	1.4%



Technology Examined - Internet

Type of Software	Number of Studies (N=126)	
Distance Learning	3	4.2%
Virtual Manipulatives	3	4.2%
Web Sites	3	4.2%
Blogs	2	2.8%
Online Applets	2	2.8%
Online Tutorials	1	1.4%
Video Conferencing	1	1.4%
Document Sharing	0	0.0%
Facebook/MySpace/Twitter	0	0.0%
Online Games/Puzzles	0	0.0%
Online Testing	0	0.0%
Online Video Sharing	0	0.0%
Student Response Systems	0	0.0%
WebQuests	0	0.0%
Wiki Spaces	0	0.0%



NCTM Principles Addressed

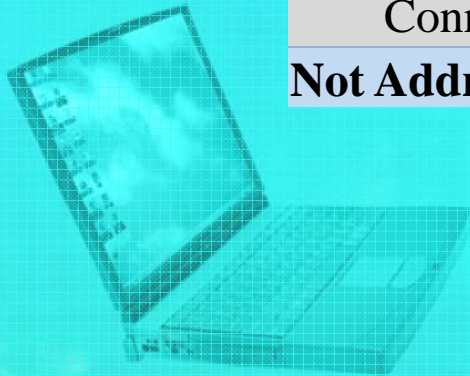
NCTM Principles	Number of Studies Addressing Each Principle	Number Explicit	% Explicit
Total	52 (72%)	28	54%
Technology	48	15	31%
Teaching	17	2	12%
Learning	15	3	20%
Curriculum	13	3	23%
Equity	8	4	50%
Assessment	6	1	17%
Not Addressed	20 (28%)	---	---



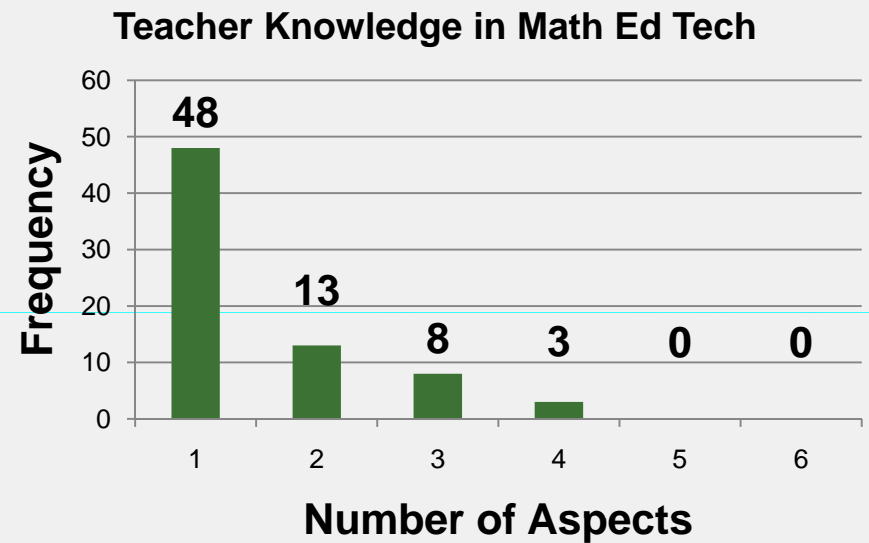
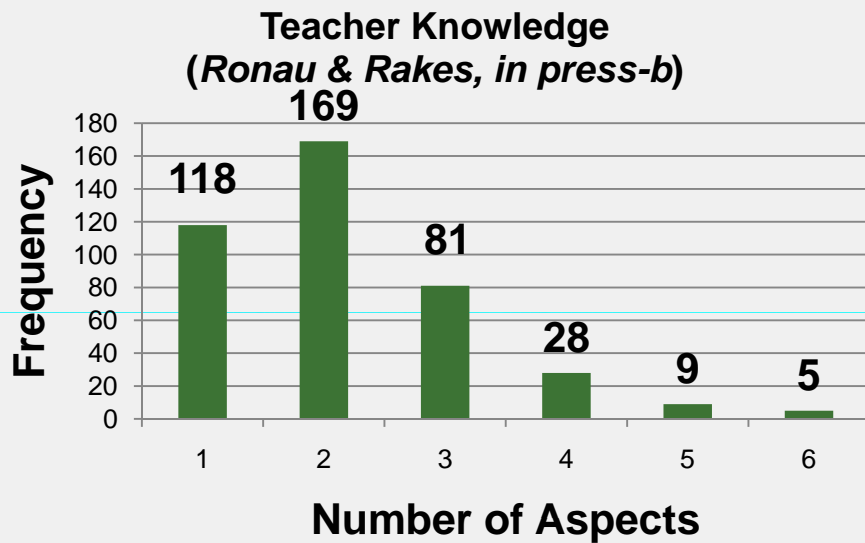


NCTM Standards Addressed

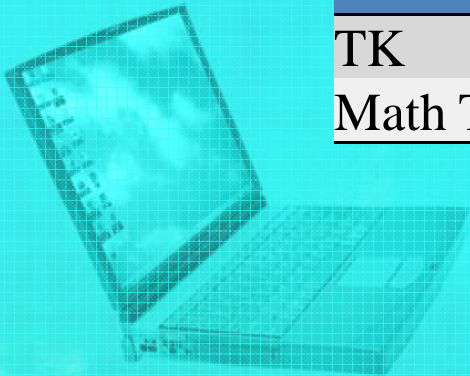
NCTM Standards	No. of Studies Addressing Standard (N=72)	
Total	39	54%
Algebra	20	51%
Geometry	12	31%
Problem Solving	11	28%
Number	10	26%
Communication	6	15%
Reasoning/Proof	5	13%
Representations	5	13%
Data/Probability	4	10%
Measurement	2	5%
Connections	1	3%
Not Addressed	33	46%



Number of Aspects Considered



	Mean	SE	t(df=71)
TK	2.16	0.119	3.74
Math Tech	1.53	0.207	





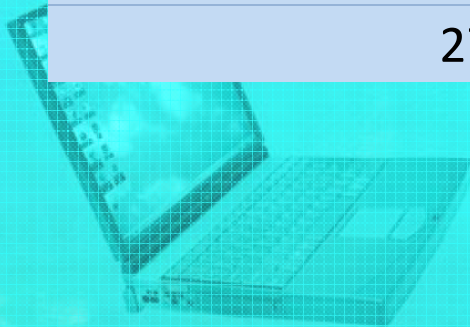
The Use of TPACK to Guide Educational Technology Research





Types of Publications for TPACK

Type of Manuscript by Research Design	Non- Research	Qualitative	Quantitative	Mixed Method	Meta- Analysis/ Syst Review	Theory/ Lit Driven	Grand Total	
Book Chapter	1	2	0	0	0	1	4	1.8%
Conference Paper	3	3	1	0	0	1	8	3.7%
Dissertation	0	16	43	22	4	0	85	38.8%
Journal	54	26	14	4	1	3	102	46.6%
Master's Thesis	1	1	11	0	0	0	13	5.9%
Report	2	0	3	1	1	0	7	3.2%
Grand Total	61	48	72	27	6	5	219	
	27.9%	21.9%	32.9%	12.3%	2.7%	2.3%		





TPACK: Standards and Stages

Stages	Standards Addressed															Total	
	Can't Tell	None	PD	A	I	L	A- PD	I- PD	I- A	L- PD	L- A	L -I	L- I- PD	L- I- A	L- I- PD		
Recognizing	1	1	1	1	5	7	0	1	0	2	0	3	0	1	0	23	10.5%
Accepting	0	0	2	0	1	0	0	0	0	0	0	1	0	0	1	5	2.3%
Exploring	0	0	0	1	0	1	0	0	1	0	1	1	0	15	1	21	9.6%
Adapting	0	0	0	1	1	4	0	0	1	0	1	3	0	16	1	28	12.8%
Advancing	1	0	0	0	0	3	0	0	0	0	0	7	1	9	0	21	9.6%
None	0	0	3	35	8	22	1	0	7	0	4	15	0	22	3	120	54.8%
Can't Tell	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.5%
Grand Total	2	1	6	38	15	37	1	1	10	2	6	30	1	63	6	219	

PD = Professional Development

A = Assessment

I = Facilitates Instruction

L = Learning Environment

Quantitative Studies: TPACK



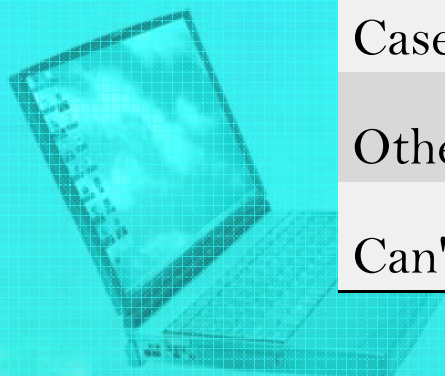
Quantitative Studies (N=72)		
Reliability Types	Y	N
Internal Consistency	31	41
Alternate Forms	2	70
Split Half	4	68
Test-Retest	6	66
Can't Tell	2	70
None Given	35	37

Number of Types Described per Study	
Reliability Types Described	Studies
Two Reliability Types	10
One Reliability Types	22
Zero Reliability Types	37
Blank	3



Qualitative Studies (N=48)

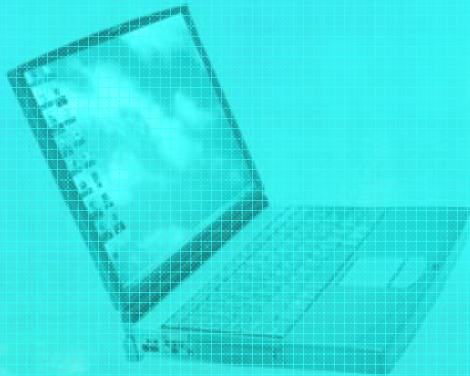
Study Type	Number
Narrative/Historical	0
Biography	1
Design Study	0
Phenomenology	3
Ethnography	2
Grounded Theory	4
Case Study	33
Other	2
Can't Tell	5



Qualitative Studies (N=48)

Method	n
Covert Observation	0
Overt Observation	33
Interview	29
Document Analysis	34
Focus Group	2
Subject Dialog	18

Trustworthiness	n
Persistent Observation	8
Triangulation	27
Peer Debriefing	7
Negative Case Analysis	1
Referential Adequacy	1
Member Checks	5
Thick Description	8
Dependability Audit	1
Confirmability Audit	4
Reflective Journal	5
Not Addressed	31





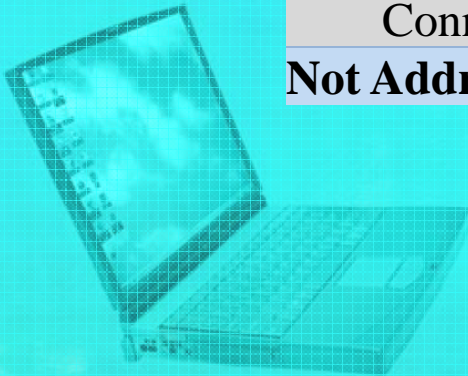
Sources of Data Used: TPACK

Sources of Data	Number of Studies (N=219)	
Performance Assessment	86	39.3%
Self-Report Orientation Survey	77	35.2%
Observation	61	27.9%
Content Analysis	46	21.0%
Interview	45	20.5%
None	21	9.6%
Self-Report Polls and Census Survey	14	6.4%
Researcher Journal	10	4.6%
Subject Journal	6	2.7%
Subject Dialog	5	2.3%
3rd Party Journal	3	1.4%
Other-Report Orientation Survey	3	1.4%
Other-Report Polls and Census Survey	2	0.9%
Focus Group	1	0.5%



NCTM Standards Addressed: TPACK

NCTM Standards	No. of Studies Addressing Standard (N=219)	
Total	138	63.0%
Algebra	67	30.6%
Geometry	45	20.5%
Number	37	16.9%
Problem Solving	35	16.0%
Representations	16	7.3%
Data/Probability	13	5.9%
Reasoning/Proof	11	5.0%
Communication	8	3.7%
Measurement	6	2.7%
Connections	4	1.8%
Not Addressed	81	37.0%





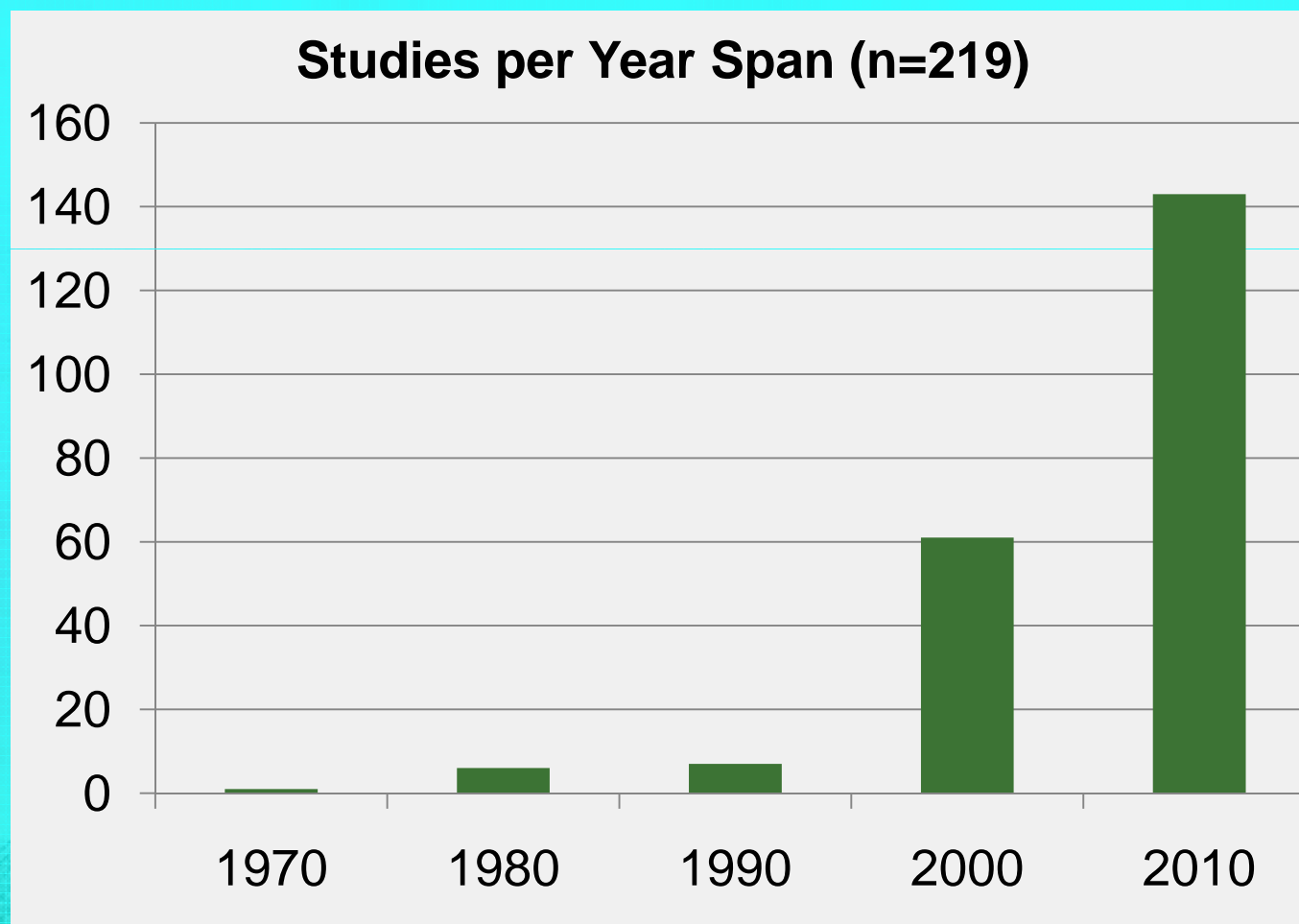
NCTM Principles Addressed: TPACK

NCTM Principles	Number of Studies Addressing Each Principle	Number Explicit	% Explicit
Total	191 (87%)	69	36.1%
Technology	184	42	22.8%
Learning	47	7	14.9%
Equity	41	7	17.1%
Teaching	36	4	11.1%
Curriculum	24	5	20.8%
Assessment	13	4	30.8%
Not Addressed	28 (13%)	---	---





Years Spanned





Technology Examined - TPACK

<i>Number of Studies Using N Types of Technology</i>						
Technology	Number of Technologies					
	0	1	2	3	4	>4
Calculator	139	43	26	10	0	1*
Probeware	214	5	0	0	0	0
Computer Software	115	81	16	4	2	1**
Smartboards	219	0	0	0	0	0
virtual Manipulatives	192	18	4	3	2	0
Distance Ed	211	8	0	0	0	0
SRS	217	2	0	0	0	0

*5 different types of technology used in one study

**7 different types of technology used in one study



Technology Examined - Calculators

Calculator Features	Number of Studies (N=219)	
Graphing	54	24.7%
Non-Scientific	17	7.8%
CAS	9	4.1%
Scientific	7	3.2%
Probeware	5	2.3%
Programming	1	0.5%
Applications	0	0.0%
Document Management	0	0.0%
Dynamic Geometry	0	0.0%
Classroom Calculator Networks	0	0.0%
Simulation	0	0.0%
Statistics	0	0.0%
Symbolic Algebra	0	0.0%
Symbolic Calculus	0	0.0%



Technology Examined – Computer Software

Type of Software	Number of Studies (N=219)	
Dynamic Geometry	49	22.4%
Spreadsheets	25	11.4%
Tutorials	22	10.0%
Algebra	16	7.3%
Graphing	8	3.7%
Statistics Instruction	8	3.7%
SmartBoards	6	2.7%
Statistics	6	2.7%
Games/Puzzles	5	2.3%
Presentation	5	2.3%
Testing	3	1.4%
Applets	1	0.5%



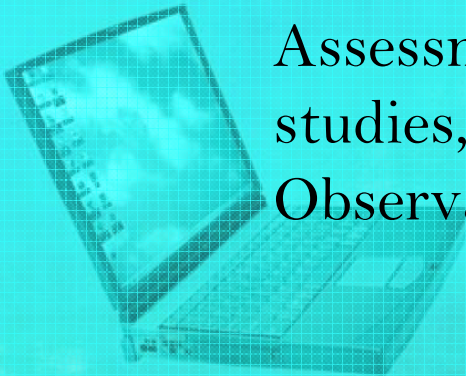
Technology Examined - Internet

Type of Software	Number of Studies (N=219)	
Online Applets	10	4.6%
Virtual Manipulatives	9	4.1%
Distance Learning	6	2.7%
Web Sites	6	2.7%
Document Sharing	3	1.4%
Online Tutorials	3	1.4%
Blogs	2	0.9%
Online Games/Puzzles	2	0.9%
Student Response Systems	2	0.9%
Video Conferencing	2	0.9%
Facebook/MySpace/Twitter	0	0.0%
Online Testing	0	0.0%
Online Video Sharing	0	0.0%
WebQuests	0	0.0%
Wiki Spaces	0	0.0%

Findings: TPACK



- There is some balance between Quantitative, & Qualitative studies at 33% and 22%. Mixed methods & Meta Analysis much lower. Non research papers at 28%
- Case Studies make up more than 2/3 of the Qualitative Studies
- More than 1/3 of the qualitative studies (including mixed methods studies) have no validity process such as triangulation
- Across all methodologies in 219 studies, Performance Assessment (e.g. tests) were used on 40% of the studies, followed by Self report surveys (35%), Observation(28%), and Interviews (21%).



Findings: TPACK (cont'd)

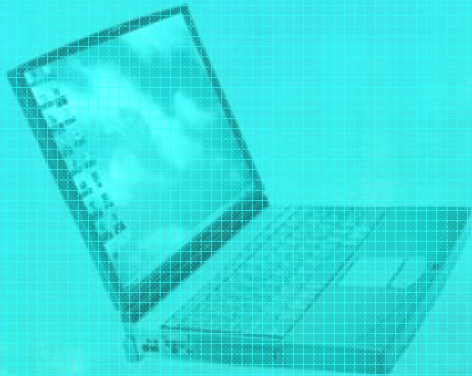


- NCTM standards Measurement, Connections, and Communication and the NCTM Principles, Assessment and Equity were addressed by less than 10% of the studies
- An overwhelming number of studies were found between Years 2000 and 2010 than in any other time period
- Studies focused on three large categories of technology: Calculators(20%);Computer Software(37%); & virtual Manipulatives(8%)





Conclusions/Final Thoughts

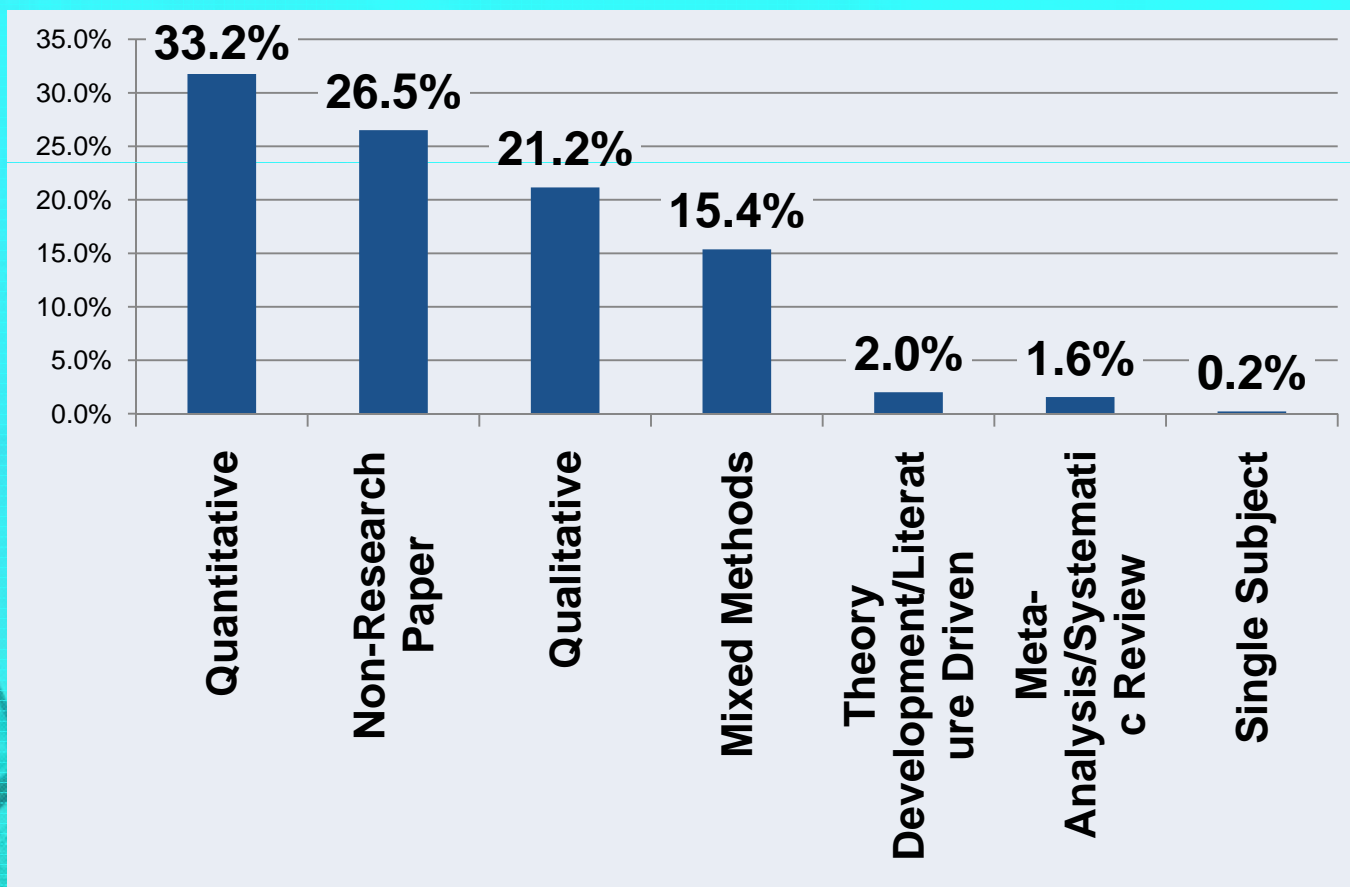


What does our work tell us (or not tell us)?

- Issues of reliability, validity, and trustworthiness are thorny: Not being addressed
- It isn't always explicit what constructs are being measured by selected instruments (domain of performance instruments)
- The teacher knowledge studies in mathematics education technology research appear to address fewer aspects and interactions than other teacher knowledge studies.
- We know little about the effects of newer technologies (e.g., online tools)

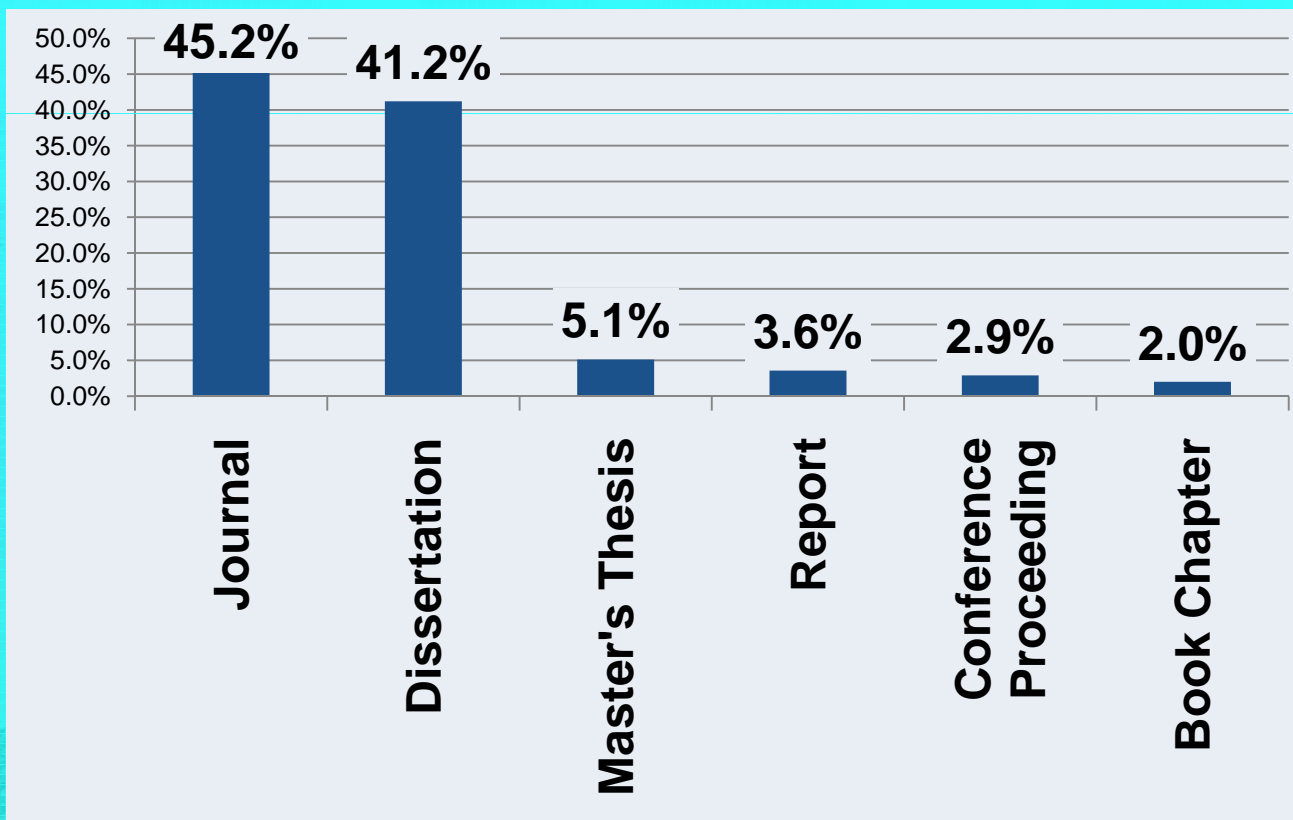
What types of research is needed?

- What implications does this raise for future work?





What types of research are needed?





What types of research are needed?

All types of evidence are not considered equal

(e.g., NCLB, 2001; Shavelson & Towne, 2002; Whitehurst, 2003)

**Most
Compelling**

1. Randomized trial (true experiment)
2. Comparison groups (quasi-experiment)
3. Pre-post comparison
4. Correlational studies
5. Case studies
6. Anecdotes

*Least
Compelling*

*Lowest
Emphasis in
Math Ed Tech*

**Highest
Emphasis in
Math Ed Tech**





Future directions of Teacher Knowledge Research in Math Ed Tech

- Relationship of TPACK to CFTK.
- Develop measures/instruments that yield similar results to observation rubrics (i.e., attention to psychometrics, especially convergent validity)
- Can inventories be used effectively (i.e., self report, student perceptions, administrator perceptions)?





Questions or Comments?

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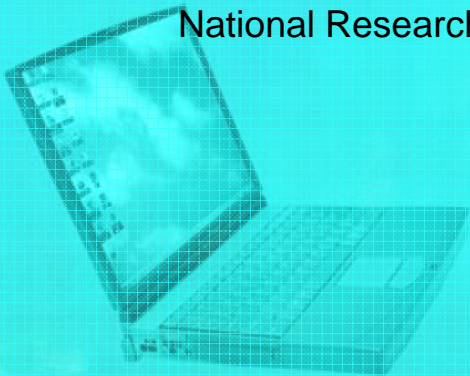
References

No Child Left Behind Act of 2001, 20 U.S.C. § 6301 et seq. (West, 2002). Retrieved on February 1, 2009, from <http://www.ed.gov/policy/elsec/leg/esea02/107-110.pdf>

Ronau, R. N., & Rakes, C. R. (in press, 2011a). Making the grade: Reporting educational technology and teacher knowledge research. 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*. Hershey, PA: IGI Global.

Ronau, R. N., & Rakes, C. R. (in press, 2011b). Aspects of teacher knowledge and their interactions: A comprehensive framework for research. 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*. Hershey, PA: IGI Global.

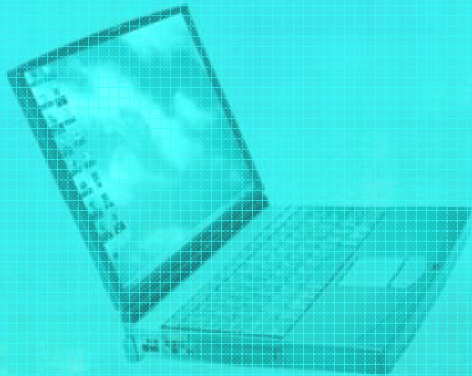
Shavelson, R. J., & Towne, L. (Eds.). (2002). *Scientific research in education*. Washington, D.C.: National Research Council, National Academy Press.





Appendix A

Additional Slides for Student Achievement and Learning





Types of Graphing Calculators

Types of Graphing Calculators	Number of Studies (N=24)
TI-73/73+	
TI-80/81/82	
TI-83/83+	
TI-84/84+/84+SE	
TI-85/86	
TI-89	
TI-92/92+/Voyage 200	
TI-NSpire	
Casio FX-9860G/GII/GSlim	
Casio ClassPad 300/330	
Casio FX-9750GII/GAPlus	
Casio FX-7400G/GPlus	
HP 10s/33s/35s/39gs/40gs/48gII/50g	
HP SmartCalc 300s	
Brand & Type Not Specified	



Appendix B

Additional Slides for Student Orientation,
Discernment, & Learning Behavior





Types of Graphing Calculators

Types of Graphing Calculators	Number of Studies (N=24)	
TI-73/73+	0	0%
TI-80/81/82	7	29%
TI-83/83+	5	21%
TI-84/84+/84+SE	0	0%
TI-85/86	2	8%
TI-89	1	4%
TI-92/92+/Voyage 200	6	25%
TI-NSpire	1	4%
Casio FX-9860G/GII/GSlim	0	0%
Casio ClassPad 300/330	0	0%
Casio FX-9750GII/GAPlus	0	0%
Casio FX-7400G/GPlus	0	0%
HP 10s/33s/35s/39gs/40gs/48gII/50g	0	0%
HP SmartCalc 300s	0	0%
Brand & Type Not Specified	2	8%



Studies Examining One Outcome Orientation

Validity Reliability Trustworthiness Addressed	Non e	T T	T T	TTT TT	TTT TT	R R	T T	RTTT	R R	RRR T	V V	VR R	VRTTT T	VR R	V V	VV R	VVRT T	VVR R	Reliable/ Valid	Total	
Meta- Analysis/Systemat ic Review	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mixed Methods	3	4	1	0	0	0	1		1	1	1	1	1		1	1	0	0	2	16	
Non-Research Paper	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Qualitative	2	1	5	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	10	12	
Quantitative	27	0	0	0	0	10	0	0	3	0	4	8	0	0	1	1	1	0	1	10	56
Total	35	5	6	2	1	10	1	1	4	1	5	8	1	1	1	2	1	1	22	87	

(25%)





One Outcome (cont'd)

Discernment

Validity Reliability Trustworthiness Addressed	Discernment				Reliable/Valid	Total
	None	T	TT	RT		
Meta-Analysis/Systematic Review	1	0	0	0	0	1
Mixed Methods	0	2	0	1	0	3
Non-Research Paper	1	0	0	0	0	1
Qualitative	3	1	1	0	2	5
Theory Development/Literature Driven	1	0	0	0	0	1
Grand Total	6	3	1	1	2	11

(18%)

Learning Behavior

Validity Reliability Trustworthiness Addressed	Learning Behavior					Reliable/Valid	Total
	None	T	T ⁹	R	VVR		
Mixed Methods	1	1	0	0	0	0	2
Qualitative	0	4	1	0	0	5	5
Quantitative	1	0	0	1	1	1	3
Theory Development/Literature Driven	1	0	0	0	0	0	1
Grand Total	3	5	1	1	1	6	11

(55%)

Studies Examining Two Outcomes

Orientation and Discernment

Validity Reliability Trustworthiness Addressed	T	T ⁶	VRR	Reliable/ Valid	Total
Mixed Methods	1	0	0	0	1
Qualitative	0	1	0	1	1
Quantitative	0	0	1	1	1
Grand Total	1	1	1	(67%)	3

Orientation and Learning Behavior

Validity Reliability Trustworthiness Addressed	None	T	TT	TTT	Reliable/ Valid	Total
Meta-Analysis/Systematic Review	1	0	0	0	0	1
Mixed Methods	0	3	0	1	0	4
Qualitative	0	0	1	0	1	1
Grand Total	1	3	1	1	1	6

(17%)



Two and Three Outcomes

Discernment and Learning Behavior

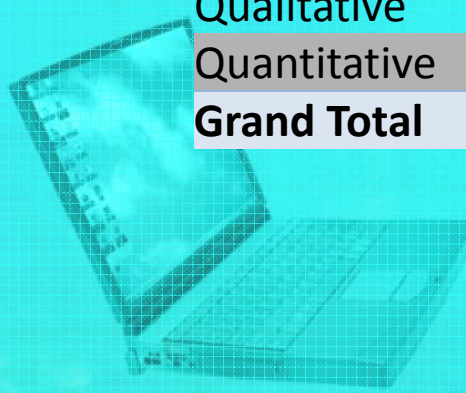
Validity Reliability Trustworthiness Addressed	None	T	TT	Reliable/ Valid	Total
Mixed Methods	1	0	0	0	1
Qualitative	1	1	1	2	3
Quantitative	1	0	0	0	1
Theory Development/Literature Driven	1	0	0	0	1
Grand Total	4	1	1	2	6

(33%)

Orientation, Discernment, and Behavior

Validity Reliability Trustworthiness Addressed	None	VR	Reliable/ Valid	Total
Qualitative	1	0	0	1
Quantitative	0	1	1	1
Grand Total	1	1	1	2

(50%)





Quality of Evidence – Detail Table

	None	T	T ²	T ³	T ⁵	T ⁶	T ⁹	RRT	RT ³	R ²	R ³ T	V	VR	VRT	VRT ⁴	VR ²	V ²	V ² R	V ² RT ²	V ² R ²	Valid/ Reliable	Total	% Valid/ Reliable	% Grand Total	
1 Outcome																						34	109	31%	87%
Systematic Review	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0%	
Mixed Methods	4	7	1	0	0	0	0	0	2	0	1	1	1	0	1	1	0	0	1	1	0	4	21	19%	
Non-Research Paper	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0%	
Qualitative	5	6	6	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	17	22	77%	
Quantitative	28	0	0	0	0	0	0	11	0	0	3	0	4	8	0	0	1	1	2	0	1	13	59	22%	
Theory Development	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0%	
Orientation	35	5	6	2	1	0	0	10	1	1	4	1	5	8	1	1	1	1	2	1	1	22	87	25%	
Discernment	6	3	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	11	18%	
Learning Behavior	3	5	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	6	11	55%	
2 Outcomes																						4	15	27%	12%
Systematic Review	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0%	
Mixed Methods	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0%	
Qualitative	1	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	60%	
Quantitative	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	2	50%	
Theory Development	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0%	
Orientation & Discernment	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	3	67%	
Orientation & Learning Behavior	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	17%	
Discernment & Learning Behavior	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	33%	
3 Outcomes																						1	2	50%	2%
Qualitative	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0%	
Quantitative	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	100%	
Grand Total	50	18	9	3	1	1	1	11	2	1	4	1	5	9	1	1	2	1	3	1	1	39	126	31%	



Technology Impact Claims

“The students who used graphing calculators in these studies while learning mathematics had more positive attitudes toward mathematics at the conclusion of instruction when compared to their noncalculator counterparts.”

“Allowing students to use calculators in mathematics may result in better attitudes toward mathematics. In this study, attitudes showed the most improvement after 9 or more weeks of calculator use. Students' self-concept in mathematics and attitude toward the use of calculators in mathematics were not hindered by calculator use.”



Quantitative Studies

Research Design	Can't Tell	Quasi-Experimental	Randomized Experiment	Single Subject	Grand Total
Sampling Method					
Can't Tell	1	3	0	0	4
Cluster Random	0	0	1	0	1
Convenience	1	39	3	1	44
Other Non-Random	0	2	0	0	2
Purposive	1	6	1	1	9
Stratified Random	0	2	0	0	2
Grand Total	3	52	5	2	62

Sampling Method	No Comparison Group	Group Comparison		Group Comparison Total
	Quasi-Experimental	Quasi-Experimental	Randomized Experiment	
Can't Tell	1	2	0	2
Cluster Random	0	0	1	1
Convenience	7	32	3	35
Other Non-Random	0	2	0	2
Purposive	2	4	1	5
Stratified Random	0	2	0	2
Grand Total	10	42	5	47



Quantitative (cont'd)

	Quasi-Experimental								Randomized Experiment		Validity and Reliability Total
	None	V	VV	R	RV	RR	RRV	RRVV	None	V	
Can't Tell	1	0	0	0	0	1	0	0	0	0	0
Cluster Random	0	0	0	0	0	0	0	0	1	0	0
Convenience	12	1	1	7	6	2	2	1	2	1	9
Other Non-Random	0	1	0	1	0	0	0	0	0	0	0
Purposive	1	1	0	1	1	0	0	0	1	0	1
Stratified Random	1	0	0	1	0	0	0	0	0	0	0
Grand Total	15	3	1	10	7	3	2	1	4	1	10

Internal Validity Threats	No	No	No	Yes	Yes	Yes	
External Validity Threats	No	No	Yes	No	No	Yes	
Construct Validity Threats	No	Yes	No	No	Yes	Yes	
Statistical Conclusion Validity Threats	No	Yes	Yes	No	Yes	Yes	Total
Convenience	4		1	1	1	2	9
Purposive		1					1
Grand Total	4	1	1	1	1	2	10

Author	Year	Internal Validity Threats		External Validity Threats		Construct Validity Threats		Statistical Conclusion Validity Threats	
A	2000	TRUE	Implicit	TRUE	Implicit	TRUE	Implicit	TRUE	Implicit
B	1991	TRUE	Implicit	TRUE	Implicit	TRUE	Implicit	TRUE	Explicit
C	2008	TRUE	Implicit	FALSE	---	TRUE	Implicit	TRUE	Explicit

Qualitative Studies

No. of Trustworthiness Strategies Addressed	Conference Paper	Dissertation	Journal Article	Grand Total
0	0	2	5	7
1	0	3	4	7
2	1	6	1	8
3	0	3	0	3
5	0	1	0	1
6	0	1	0	1
9	0	1	0	1
Grand Total	1	17	10	28

No. of Trustworthiness Strategies Addressed	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	5	6	9	Total
Design Study																									X		1
Phenomenology	X										X						X				X					X	5
Ethnography														X													1
Grnded Theory																									X	X	5
Case Study	X		X	X	X	X																					16



Mixed Methods, Quantitative

Sampling Method	No Comparison Group				Group Comparison	
	Can't Tell	Counterbalanced Within-Subject	Quasi-Experimental	Randomized Experiment	Quasi-Experimental	Total
Can't Tell	0	0	1	0	3	4
Convenience	1	0	6	1	9	17
Purposive	1	0	3	0	1	5
Stratified Random	0	1	0	0	0	1
Grand Total	2	1	10	1	13	27

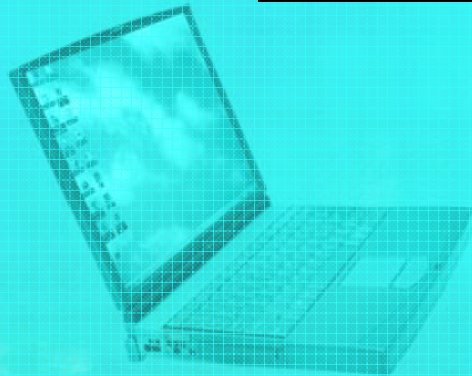
Sampling	None	V	R	RV ²	R ³	Validity and Reliability Total
Can't Tell	2	0	0	0	1	0
Convenience	6	1	1	1	0	1
Purposive	1	0	0	0	0	0
Grand Total	9	1	1	1	1	1



Mixed Methods, Qualitative

Number of Trustworthiness Strategies Used	Conference Paper	Dissertation	Journal Article	Grand Total
0	1	5	2	8
1	0	13	2	15
2	0	2	0	2
3	0	1	0	1
4	0	1	0	1
Grand Total	1	22	4	27

Number of Trustworthiness Strategies Used	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	4	Total	
Phenomenology																								4	
Grounded Theory																									2
Case Study																									14
Can't Tell																									8





Appendix C

Additional Slides for Teacher Knowledge





Types of Graphing Calculators

Types of Graphing Calculators	Number of Studies (N=24)	
TI-73/73+	0	0.0%
TI-80/81/82	3	13.6%
TI-83/83+	4	18.2%
TI-84/84+/84+SE	0	0.0%
TI-85/86	0	0.0%
TI-89	0	0.0%
TI-92/92+/Voyage 200	2	9.1%
TI-NSpire	1	4.5%
Casio FX-9860G/GII/GSlim	0	0.0%
Casio ClassPad 300/330	0	0.0%
Casio FX-9750GII/GAPlus	0	0.0%
Casio FX-7400G/GPlus	0	0.0%
HP 10s/33s/35s/39gs/40gs/48gII/50g	1	4.5%
HP SmartCalc 300s	0	0.0%
Brand & Type Not Specified	11	50.0%



Aspects	Number of Studies - Tchr Knwldge	Number of Studies - Math Ed Tech	Aspects	Number of Studies - Tchr Knwldge	Number of Studies - Math Ed Tech	Aspects	Number of Studies - Tchr Knwldge	Number of Studies - Math Ed Tech
S	36	7	S-P-D	23	1	S-P-D-I	7	0
P	35	36	S-P-I	11	0	S-P-D-E	4	0
O	6	2	S-P-E	16	2	S-P-I-E	8	0
D	23	3	S-O-D	0	0	S-O-D-I	0	0
I	9	0	S-O-I	0	0	S-O-D-E	0	0
E	9	0	S-O-E	1	0	S-O-I-E	1	0
S-P	74	9	S-D-I	0	0	S-D-I-E	0	0
S-O	2	0	S-D-E	0	0	P-O-D-I	1	0
S-D	5	0	S-I-E	0	0	P-O-D-E	1	0
S-I	5	0	P-O-D	3	1	P-O-I-E	0	1
S-E	1	0	P-O-I	2	0	P-D-I-E	1	0
P-O	12	2	P-O-E	2	1	O-D-I-E	0	0
P-D	23	2	P-D-I	5	0	S-P-O-D-I	2	0
P-I	9	0	P-D-E	7	0	S-P-O-D-E	1	0
P-E	13	0	P-I-E	1	0	S-P-O-I-E	2	0
O-D	8	0	O-D-I	0	0	S-P-D-I-E	4	0
O-I	0	0	O-D-E	0	0	S-O-D-I-E	0	0
O-E	4	0	O-I-E	1	0	P-O-D-I-E	0	0
D-I	5	0	D-I-E	0	0	S-P-O-D-I-E	5	0
D-E	1	0	S-P-O-D	3	2			
I-E	7	0	S-P-O-I	1	0			
S-P-O	9	3	S-P-O-E	1	0			



Appendix D

Additional Slides for TPACK





Types of Graphing Calculators

Types of Graphing Calculators	Number of Studies (N=54)	
TI-73/73+	1	1.9%
TI-80/81/82	10	18.5%
TI-83/83+	11	20.4%
TI-84/84+/84+SE	1	1.9%
TI-85/86	3	5.6%
TI-89	1	1.9%
TI-92/92+/Voyage 200	10	18.5%
TI-NSpire	4	7.4%
Casio FX-9860G/GII/GSlim	0	0.0%
Casio ClassPad 300/330	1	1.9%
Casio FX-9750GII/GAPlus	0	0.0%
Casio FX-7400G/GPlus	0	0.0%
HP 10s/33s/35s/39gs/40gs/48gII/50g	0	0.0%
HP SmartCalc 300s	0	0.0%
Brand & Type Not Specified	12	22.2%