Using Research in Mathematics Education Technology to Inform Classroom Teaching

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MathTech Research Team

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Technology in the Standards

CCSSM Standards of Practice	MD STEM Standards of Practice	Technical Subjects Literacy Anchor Standards
1. Make sense of problems and persevere in solving them.	4. Engage in Inquiry 6. Collaborate as a STEM Team	2. Determine central ideas or themes. 3. Identify key steps. 4. Interpret words or phrases. 5. Analyze structure. 6. Assess point of view or purpose. 10. Read and comprehend independently and proficiently.
2. Reason abstractly and quantitatively 3. Construct viable arguments and critique the reasoning of others. 8. Look for and express regularity in repeated reasoning.	5. Engage in Logical Reasoning	1. Cite specific textual evidence. 2. Determine central ideas or themes. 3. Identify key steps. 8. Delineate and evaluate arguments and claims. 9. Compare information from two or more sources.
4. Model with mathematics 6. Attend to precision 7. Look for and make use of structure	1, 2, and 3. Learn and Apply, Integrate, Interpret and Communicate… …Rigorous STEM Content	4. Interpret words or phrases. 5. Analyze structure.
5. Use appropriate tools strategically	**7. Apply Technology Strategically**	7. Integrate diverse formats and media.

Questions Guiding the Presentation

1. What does mathematics educational technology research offer teachers to help apply technology strategically?
2. What is the quality of educational technology research literature available for helping teachers use technology strategically?

Technologies Addressed in the Literature

Technology	1960s (n=2)	1970s (n=22)	1980s (n=48)	1990s (n=320)	2000s (n=818)	Technology Total
Technology in General	0	0	0	10	39	**49**
Calculators	0	21	33	181	348	**583**
Computer Software	0	6	17	195	518	**736**
Computers Available	0	2	8	35	33	**78**
Computer Programming	1	0	6	17	6	**30**
Internet	0	0	2	24	202	**228**
Probeware	0	0	0	11	28	**39**
Interactive Whiteboard	0	0	0	0	22	**22**
Video	0	0	0	3	13	**16**
Other Tools	1	0	1	17	100	**119**
Decade Totals	**2**	**29**	**67**	**493**	**1,309**	**1,900**

"Other Tools" were technologies addressed 10 times or less in the literature.

- **Assistive/adaptive technology**
- Authorware
- Blackboard©
- **Chat room/online discussion**
- **Classroom networks**
- **Computer applets**
- **Database software**
- Digital/video cameras
- Digital curriculum materials
- **Document cameras**
- Document software
- Email
- **GPS**
- Graphic design software
- Instant messaging
- Internet technologies in general
- Media players
- **Online Courseware**
- Online Mentoring/Support
- Online Programming
- Personal Digital Assistants
- **Podcasts**
- **Problem Solving Software**
- Remote Desktops
- **Robotics**
- Speech Recognition Software
- Student Response Systems
- System Usage Data Collection Tools
- Television
- **Virtual Reality**
- **Web-based Professional Development**
- **Webcams**

These are the technologies we know the least about in terms of their effect on education outcomes and how to integrate them into mathematics teaching and learning.

Types of Calculators Addressed

Technology	1960s (n=2)	1970s (n=22)	1980s (n=48)	1990s (n=320)	2000s (n=818)	Calc Totals
Non-Scientific Calculator	0	19	18	20	28	85
Scientific Calculator	0	2	5	16	14	37
Graphing Calculator (Type Specified)	0	0	1	41	95	137
Graphing Calculator (Type Not Specified)	0	0	4	61	110	175
Advanced Calculator Features[a]	0	0	1	35	97	133
Calculators Available	0	0	4	8	4	16
Decade Totals	0	21	33	181	348	583

[a]Advanced calculator features included programming, applications, networking, simulation, symbolic calculus, and dynamic geometry.

76% (445/583) of the calculators addressed in the literature were graphing calculators and advanced calculator features

Calculator Usage has Shown Consistently Positive Outcomes

- Hembree and Dessart (1986): 79 studies: using a calculator with traditional instruction **improves students' basic skills** with paper and pencil, both in working exercises and in problem solving (with an exception for Grade 4) and that students at all grade levels and ability levels **improved in self-concept and attitude**.
- Ellington (2003): 54 studies: students' operational skills and problem-solving skills **improved** when calculators were an integral part of testing and instruction. She also found that calculator use **did not hinder** the development of basic mathematical skills and additionally **improved student attitudes toward mathematics**.
- Ellington (2006): 42 studies: graphing calculators helped students understand mathematical concepts. "There were no circumstances under which the students taught without calculators performed better than the students with access to calculators" (p. 24).

Computer Software

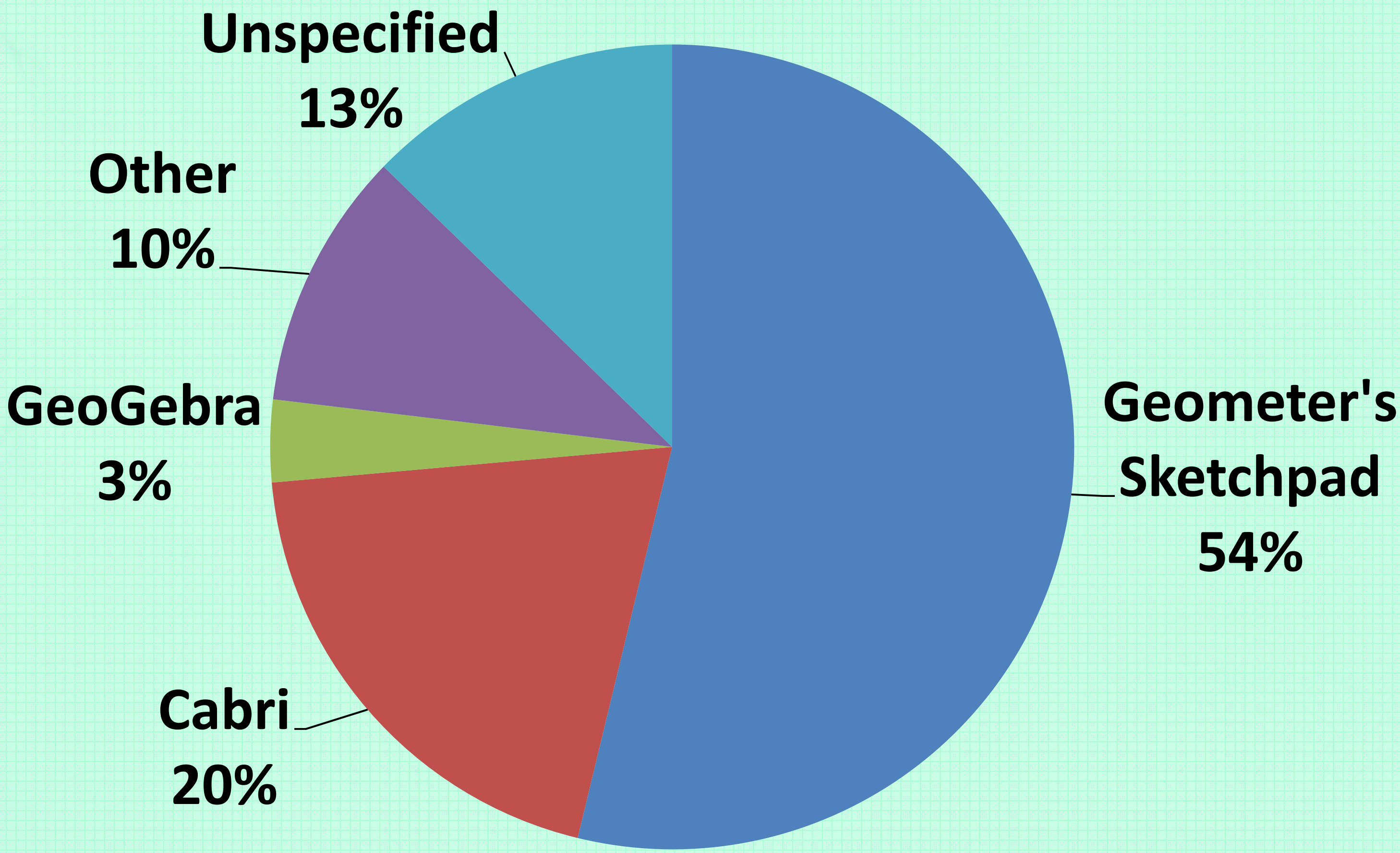
Technology	1960s (n=2)	1970s (n=22)	1980s (n=48)	1990s (n=320)	2000s (n=818)	Comp Totals
Dynamic Geometry	0	0	2	35	160	197
Tutorials	0	2	5	53	122	182
Spreadsheets	0	0	1	17	82	100
CAS	0	0	2	28	48	78
Graphing	0	0	5	25	19	49
Statistics and Statistics Instruction	0	2	0	15	38	55
Games and Puzzles	0	2	0	14	16	32
Presentation	0	0	0	6	21	27
Testing	0	0	2	2	12	16
Decade Software Totals	**0**	**6**	**17**	**195**	**518**	**736**
Computer Availability	**0**	**2**	**8**	**35**	**33**	**78**
Computer Programming	**1**	**0**	**6**	**17**	**6**	**30**

26% (197/736) of the computer software addressed in the literature was dynamic geometry

Conclusions about Dynamic Geometry

- 72 out of 197 (36.5%) conclusions reported positive outcomes from using dynamic geometry.
- 8 out of 197 (4.1%) conclusions reported negative effects or difficulties with implementation.
- 19 out of 197 (9.6%) conclusions discussed issues about how best to implement dynamic geometry software.
- 98 out of 197 (49.7%) conclusions reported no conclusions about the dynamic geometry (discussed other aspects of the paper) or only described an activity using dynamic geometry.

Dynamic Geometry Software Addressed



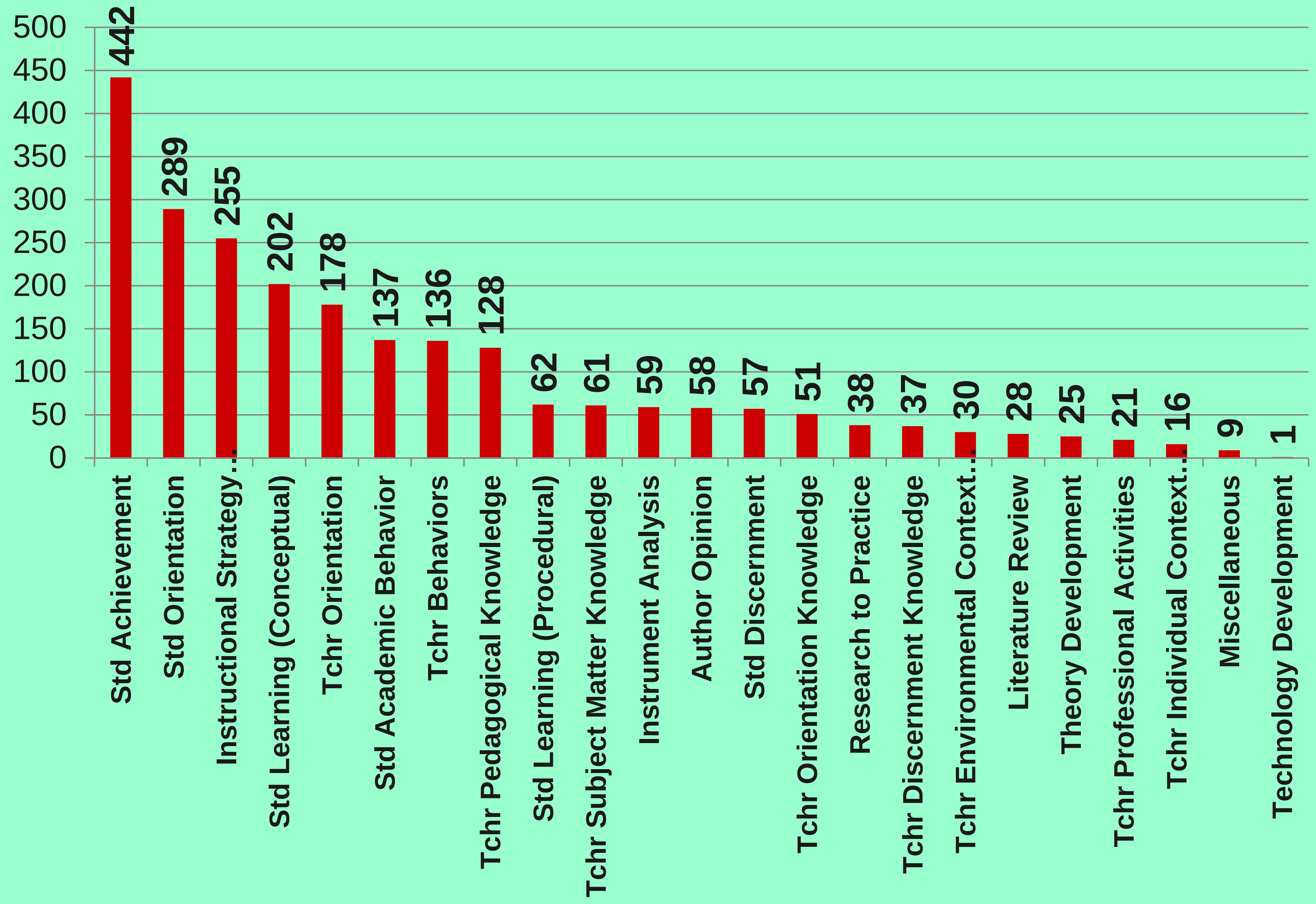
Internet Technologies Addressed

Technology	1960s (n=2)	1970s (n=22)	1980s (n=48)	1990s (n=320)	2000s (n=818)	Web Totals
Distance Learning	0	0	2	11	51	**64**
WebQuests, Websites, Wikis	0	0	0	5	45	**50**
Virtual Manipulatives	0	0	0	2	31	**33**
Social Networking	0	0	0	1	30	**31**
Testing/ Tutorials/ Puzzles	0	0	0	2	25	**27**
Applets (Internet-Based)	0	0	0	3	20	**23**
Decade Totals	**0**	**0**	**2**	**24**	**202**	**228**

Internet Technologies

- A lot of exploratory studies (i.e., the technology showed promise for helping with some classroom procedures)
- Results were often not about the effectiveness of the Internet technologies. They were about other characteristics of the study (e.g., student ability levels, special needs, time spent on campus).
- Mostly positive outcomes (i.e., increased learning, achievement, self efficacy, teacher pedagogy)

Outcomes



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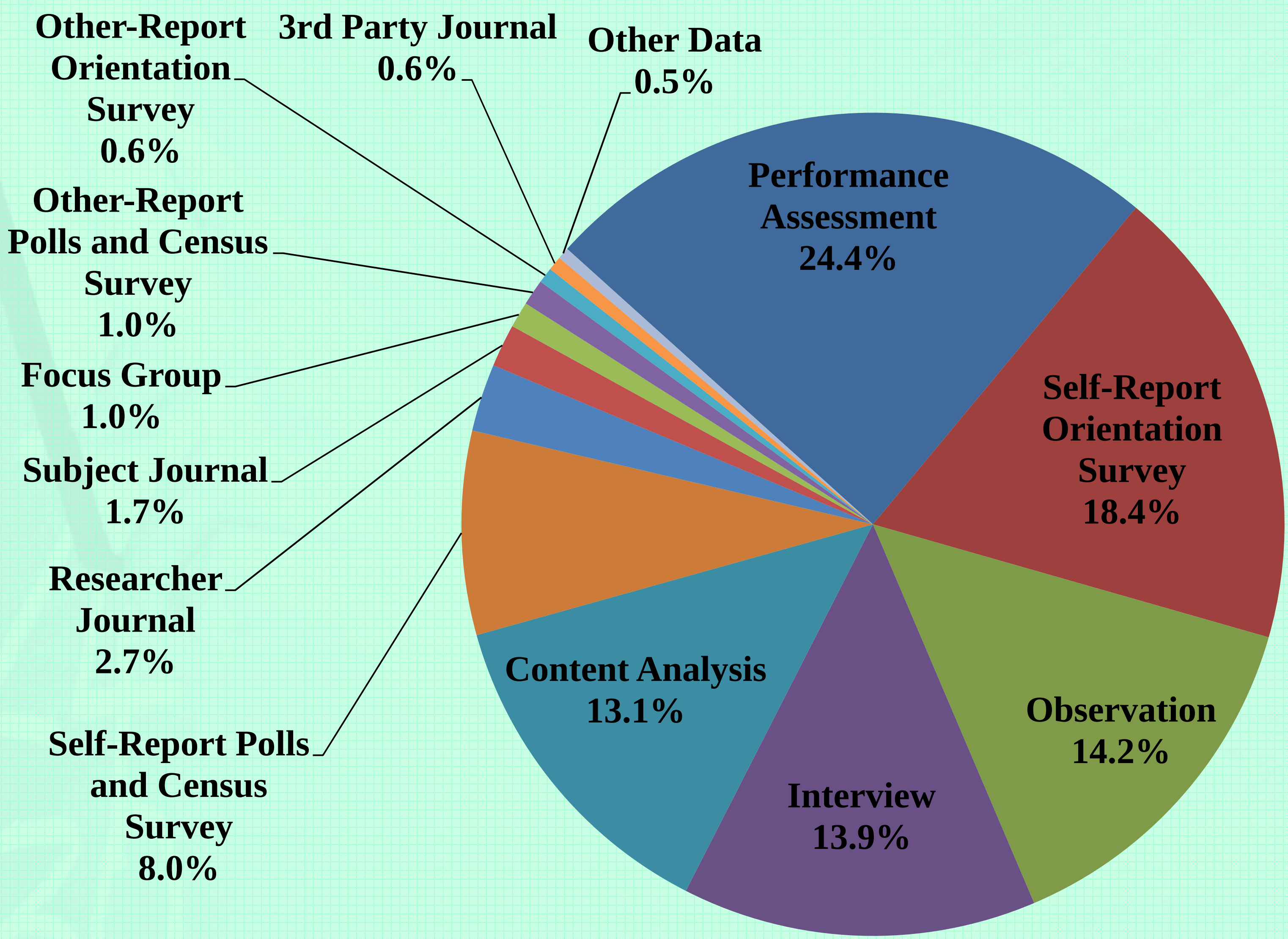
Std Achievement
Std Orientation
Instructional Strategy…
Std Learning (Conceptual)
Tchr Orientation
Std Academic Behavior
Tchr Behaviors
Tchr Pedagogical Knowledge
Std Learning (Procedural)
Tchr Subject Matter Knowledge
Instrument Analysis
Author Opinion
Std Discernment
Tchr Orientation Knowledge
Research to Practice
Tchr Discernment Knowledge
Tchr Environmental Context…
Literature Review
Theory Development
Tchr Professional Activities
Tchr Individual Context…
Miscellaneous
Technology Development

Data Sources



A Framework for Measuring Quality

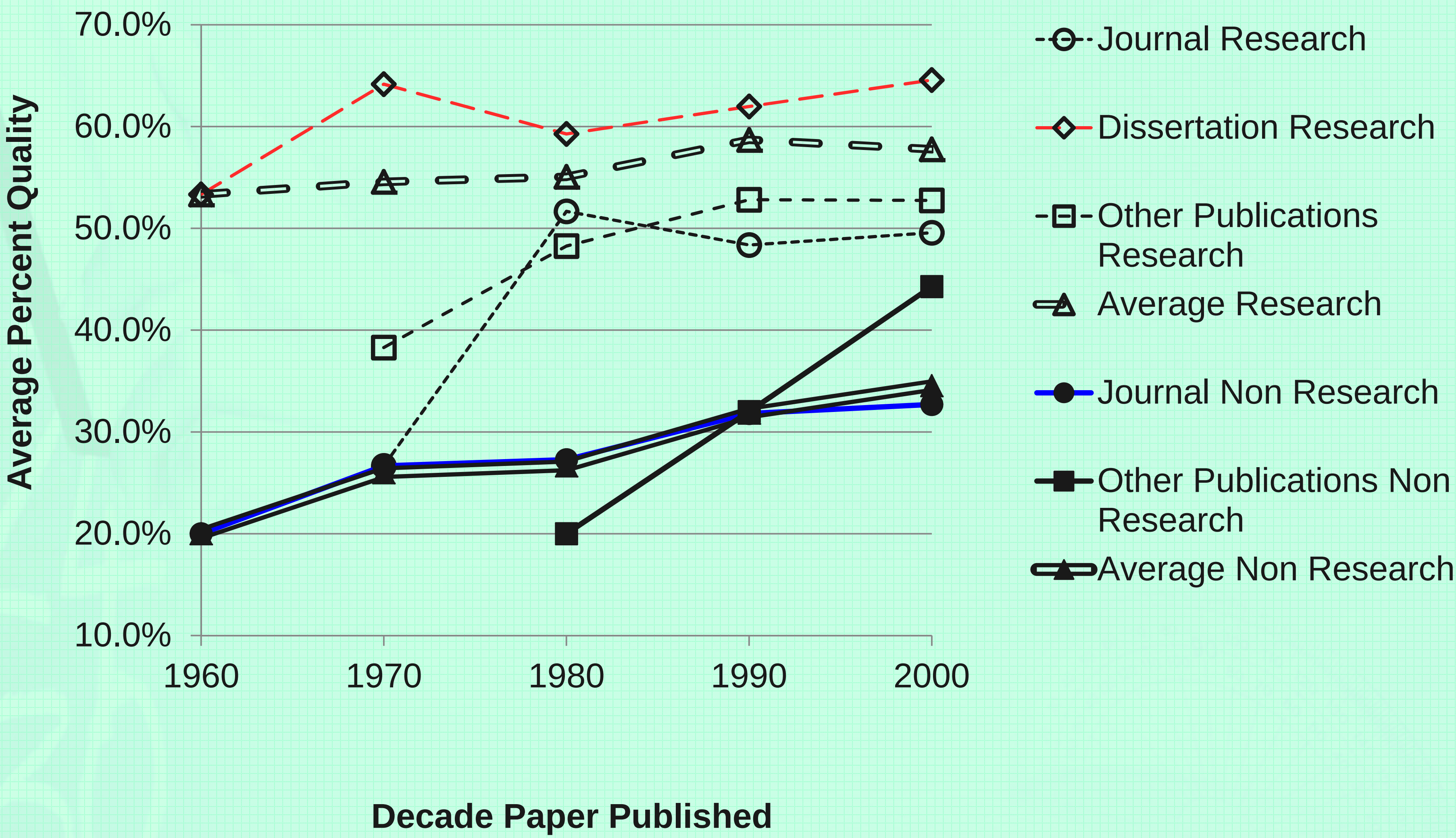
- Developed to capture how well papers identified important information for determining the credibility and usefulness of findings.

- This framework examines non-research papers (Congdon & Dunham, 1999) 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).

Other (up to 5 pts)	Mixed Methods (up to 16 pts)	
	Quantitative (up to 15 pts)	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) • **Conceptual Framework 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)**	**Theoretical Connections (up to 4 pts)** • **Literature Support (up to 2 pts)** ➢ Well Grounded (2 pts) ➢ Partially Grounded (1 pt) ➢ Not Grounded (0 pts) • **Conceptual Framework 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 ➢ Inter-Rater ➢Test-Retest ➢ Alternate Forms • **Validity (1 point)** ➢ Content ➢Construct ➢ Concurrent Criterion ➢Discriminant ➢ Predictive Criterion ➢Convergent	**Theoretical Connections (up to 4 pts)** • **Literature Support (up to 2 pts)** ➢ Well Grounded (2 pts) ➢ Partially Grounded (1 pt) ➢ Not Grounded (0 pts) • **Conceptual Framework 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

Percentage of Quality Points Earned



Conclusion 1:Journal articles offering tips for technology inclusion offer little research-based evidence.

Sources of Research-Based Practices

- NCTM Journals (TCM, MTMS, MT)
- NCTM Research Briefs http://www.nctm.org/news/content.aspx?id=8468
- State and/or Federal Reports, e.g., Practice Guides: http://ies.ed.gov/ncee/wwc/publications_reviews.aspx
- Other research-to-practice journals
- Professional Development Sessions?
- District or State Materials?
- Textbooks?
- Other Commercial Products?
- Internet?
- Peers?

Two More Conclusions

- Technology is here to stay and offers the potential of enormous benefits for student learning.
- How technology is incorporated is critical to whether the technology integration successfully improves student learning.

Principles of Effective Implementation
(Pape et al., 2011)

Effective implementation is dependent upon:

1. mathematical tasks that support examination of patterns leading to generalizations and conceptual development.
2. classroom interactions that focus mathematical thinking within students and the collective class.
3. formative assessment instructional practices that lead to teachers’ and students’ increased knowledge of students’ present understandings.
4. sustained engagement in mathematical thinking.

Discussion

- What technologies are used in my classroom?
- How are these technologies used?
- How can technology integration be improved in my classroom?
  - What support do I need to improve it?
  - What changes need to happen in terms of planning to improve technology integration?

Thank You!

- Questions? Contact

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- This presentation will be available on the Web at

http://csrakes.yolasite.com

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