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Thank you for your request to our REL Reference Desk regarding reasons for changes in mathematical teaching practices over the last 12 years. Ask A REL is a collaborative reference desk service provided by the ten regional educational laboratories (REL) that, by design, functions much in the same way as a technical reference library. It provides references, referrals, and brief responses in the form of citations on research based education questions.

The information below represents the most rigorous research available. Researchers consider the type of methodology and give priority to research reports that employ well described and thorough methods. The resources were also selected based on the date of the publication with a preference for research from the last ten years. Additional criteria for inclusion include the source and funder of the resource.

**Question:** *How and why have mathematical teaching practices changed over the last 12 years?*

#### **Search Process**

**Key words and search strings used in the search:** *mathematics AND teaching AND practices; mathematics AND pedagogy; mathematics AND standards AND instruction*

#### **Search databases and websites:**

1. ERIC: <http://www.eric.ed.gov/>
2. JSTOR: <http://www.jstor.org/action/showAdvancedSearch>
3. Google Scholar: [www.google.com/scholar](http://www.google.com/scholar)
4. Institute of Education Sciences (IES) Resources: <http://ies.ed.gov>
5. What Works Clearinghouse: <http://ies.ed.gov/ncee/wwc/>

**Sample Citations Retrieved:** *(NOTE: Abstracts and executive summaries are copied directly from the reports when possible to ensure accuracy):*

Askew, Mike. (2012). *Transforming Primary Mathematics*. New York, New York: Routledge, Taylor & Francis Group.

**Abstract/Summary:** What is good mathematics teaching? What is mathematics teaching good for? Who is mathematics teaching for? These are just some of the questions addressed in "Transforming Primary Mathematics", a highly timely new resource for teachers which accessibly sets out the key theories and latest research in primary maths today. Under-pinned by findings from the largest research programme into primary mathematics funded in recent years, it offers a clear, practical approach to implementing fundamental change in curriculum, classroom environment and teaching styles. Written by one of the top experts in mathematics education, it offers an inspiring, sometimes controversial, and often unconventional look at the subject of mathematics, by: (1) Endorsing the use of a "new mathematics"--one based on problem solving, modelling and inquiry, not on abstract rules, memorizing, and regurgitation; (2) Arguing that

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there is more to maths teaching than "death by a thousand worksheets"; (3) Challenging norms, such as the practice of sorting children into sets based on their perceived mathematical ability; (4) Asking whether this mathematical ability is innate or a result of social practices; (5) Upholding the idea that mathematics teaching is an "adaptive" challenge, rather than a "technical" problem; (6) Advocating an environment where teachers are encouraged to take risks; (7) Looking at how best to prepare learners for an unknown future; and (8) Encouraging reflection on teachers' own beliefs and values about mathematics. "Transforming Primary Mathematics" is for all primary school teachers who want to make mathematics welcoming, engaging, inclusive and successful.

Clements, Douglas H., Agodini, Roberto, & Harris, Barbara. (2013). Instructional Practices and Student Math Achievement: Correlations from a Study of Math Curricula. *NCEE Evaluation Brief 2013-4020*. National Center for Education Evaluation and Regional Assistance: Washington, DC. Retrieved from: <http://ies.ed.gov/ncee/pubs/20134020/>

**Abstract/Summary:** This brief is directed to researchers and adds to the research base about instructional practices that are related to student achievement. Additional evidence on these relationships can suggest specific hypotheses for the future study of such instructional practices, which, in turn, will provide research evidence that could inform professional development of teachers and the writing of instructional materials. The results of this study revealed a pattern of relationships largely consistent with earlier research, but not in every case. Results that are consistent with previous research include increased student achievement associated with teachers dedicating more time to whole-class instruction, suggesting specific practices in response to students' work (1st grade only), using more representations of mathematical ideas, asking the class if it agrees with a student's answer, directing students to help one another understand mathematics, and differentiating curriculum for students above grade level (2nd grade only). Less consistent results were found in three 2nd-grade results, and include lower achievement associated with teachers' higher frequency of eliciting multiple strategies and solutions; prompting a student to lead the class in a routine; and with students more frequently asking each other questions. These findings suggest that practices associated with higher achievement gains include both student-centered and teacher-directed practices; however, some student-centered practices were associated with lower achievement gains. (Contains 11 endnotes and 6 tables.)

Kaufman, Julia H., Karam, Rita, Pane, John F., & Junker, Brian. (2012). How Curriculum and Classroom Achievement Predict Teacher Time on Lecture- and Inquiry-based Mathematics Activities. *Journal of Mathematics Education at Teachers College*, 3(2), 56-62.

**Abstract/Summary:** This study drew on data from a large, randomized trial of Cognitive Tutor Algebra (CTA) in high-poverty settings to investigate how mathematics curricula and classroom achievement related to teacher reports of time spent on inquiry-based and lecture-based mathematics activities. We found that teachers using the CTA curriculum reported more time on

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inquiry-based activities and less time on teacher lecture activities overall compared to non-CTA teachers. However, both CTA and non-CTA teachers of the highest-achieving students spent more time on inquiry-based activities compared to teachers of lower-achieving students. Additionally, CTA teachers in classrooms with the most low-achieving and non-gifted students reported almost as much time on lecture-based activities as their non-CTA counterparts. Qualitative findings suggest that CTA teachers engaged in more traditional lecture-based activities and fewer inquiry-based activities when they thought their lower-achieving students could not tackle the reading open-ended activities in the curriculum without explicit demonstration and traditional practice problems. CTA thus appeared to increase inquiry-based activities in teachers' classrooms overall. However, lower-achieving students may have had needs unaddressed by the CTA curriculum. These findings thus imply that districts should think carefully about how to implement CTA and—potentially—other inquiry-based curricula in order to support teachers of students with the highest needs and least preparation.

National Mathematics Advisory Panel. (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. U.S. Department of Education: Washington, DC. Retrieved from: <http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf>

**Abstract/Summary:** This Panel, diverse in experience, expertise, and philosophy, agrees broadly that the delivery system in mathematics education—the system that translates mathematical knowledge into value and ability for the next generation—is broken and must be fixed. On the basis of its deliberation and research, the Panel can report that America has genuine opportunities for improvement in mathematics education. The panel identified six elements for improvement: 1) The mathematics curriculum in Grades PreK–8 should be streamlined and should emphasize a well-defined set of the most critical topics in the early grades; 2) Use should be made of what is clearly known from rigorous research about how children learn, especially by recognizing a) the advantages for children in having a strong start; b) the mutually reinforcing benefits of conceptual understanding, procedural fluency, and automatic (i.e., quick and effortless) recall of facts; and c) that effort, not just inherent talent, counts in mathematical achievement; 3) Our citizens and their educational leadership should recognize mathematically knowledgeable classroom teachers as having a central role in mathematics education and should encourage rigorously evaluated initiatives for attracting and appropriately preparing prospective teachers, and for evaluating and retaining effective teachers; 4) Instructional practice should be informed by high-quality research, when available, and by the best professional judgment and experience of accomplished classroom teachers. High-quality research does not support the contention that instruction should be either entirely “student centered” or “teacher directed.” Research indicates that some forms of particular instructional practices can have a positive impact under specified conditions; 5) NAEP and state assessments should be improved in quality and should carry increased emphasis on the most critical knowledge and skills leading to Algebra; and 6) The nation must continue to build capacity for more rigorous research in education so that it can inform policy and practice more effectively.

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Ni, Yujing, & Cai, Jinfa. (2011). Searching for Evidence of Curricular Effect on the Teaching and Learning of Mathematics: Lessons Learned from the Two Projects. *International Journal of Educational Research*, 50(2), 137-143. doi:10.1016/j.ijer.2011.06.005

**Abstract/Summary:** The two research projects described and discussed in the special issue provided much needed longitudinal empirical data to show the curricular influence on classroom instruction and student learning outcomes. The findings have helped to advance our understanding of whether the reform curricula can bring about positive changes in classroom instruction and student learning outcomes and how such changes might be sustained. In this article we synthesize the results from the two studies and discuss several lessons learned from the projects about investigating and understanding curricular effects on the teaching and learning of mathematics.

Sackes, Mesut, Flevares, Lucia M., Gonya, Jennifer, & Trundle, Kathy Cabe. (2012). Preservice Early Childhood Teachers' Sense of Efficacy for Integrating Mathematics and Science: Impact of a Methods Course. *Journal of Early Childhood Teacher Education*, 33(4), 349-364. doi: 10.1080/10901027.2012.732666

**Abstract/Summary:** The purpose of this study was to explore the impact of an integrated science and mathematics methods course on preservice early childhood teachers' efficacy beliefs for integrating these content areas. Thirty-four preservice teachers participated in this study, which utilized a quasi-experimental design with two treatment groups. Participants in two cohorts were tested to assess their efficacy beliefs for teaching science, mathematics, and integrated science and mathematics before and immediately after instruction that lasted 8 weeks. Results indicated a statistically significant change in preservice teachers' efficacy beliefs scores from pre- to posttest measures. These results provide evidence that the methods course utilized in the present study was effective in enhancing preservice teachers' efficacy beliefs for integrating science and mathematics. (Contains 2 tables.)

Schmidt, William H. (2012). At the Precipice: The Story of Mathematics Education in the United States. *Peabody Journal of Education*, 87(1), 133-156. doi: 10.1080/0161956X.2012.642280

**Abstract/Summary:** According to a variety of metrics (NAEP, PISA, TIMMS, college completion, etc.), the mathematics knowledge of U.S. students can be described, at best, as mediocre. In light of the growing importance of mathematics for both individual and national economic competitiveness, this weak performance has rightfully alarmed policymakers and the public. The results of decades of research on improving mathematics curricula, most notably the TIMSS, TEDS, and PROM/SE studies, points convincingly to the possibilities of more rigorous, more focused, and most of all, more coherent mathematics standards. The data clearly demonstrate that, compared with higher performing countries, the United States intended curriculum is highly fragmented and the implemented curriculum exceptionally variable across

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and even within local education agencies. Although the recently adopted Common Core Standards in Mathematics present a major opportunity for overcoming these defects, the weak preparation of U.S. mathematics teachers, particularly primary and early secondary teachers, poses a significant obstacle. The author concludes by calling for a major effort to strengthen the recruitment and preparation of future mathematics teachers and for more aggressively engaging the public in the task of implementing strong mathematics standards.

Spillane, James P. & Zeuli, John S. (1999). Reform and Teaching: Exploring Patterns of Practice in the Context of National and State Mathematics Reforms. *Educational Evaluation and Policy Analysis*, 21(1), 1-27. doi: 10.3102/01623737021001001

**Abstract/Summary:** This article investigates teachers' mathematics practice in the context of recent national and state efforts to reform mathematics education. The authors develop a conceptual frame for examining reformers' proposals for mathematics education in classroom teaching in terms of the intersection of classroom tasks and discourse patterns with principled and procedural mathematical knowledge. Applying this framework to examine mathematics instruction in 25 classrooms, classrooms where teachers reported practices consistent with the reforms as well as familiarity and agreement with either national or state mathematics standards, the authors identify distinctly different patterns of practice in response to the reforms. Based on this analysis, the authors identify some dimensions of practice that appear more responsive to reform than others. In light of their analysis, the authors consider issues for policy analysis, policy research, and the design of policy.

Wachira, Patrick, Pourdavood, Roland G., & Skitzki, Raymond. (2013). Mathematics Teacher's Role in Promoting Classroom Discourse. *International Journal for Mathematics Teaching and Learning*.

**Abstract/Summary:** Recent mathematics education reform calls for efforts to create collaborative and student-centered environments, where students have opportunities to reason and construct their understanding as part of a community of learners. Mathematics instruction should provide students opportunities to engage in mathematical inquiry and meaning making through discourse. While there have been successes to this end, traditional models of instruction still dominate mathematics education especially at the high school level. This can be attributed, in part to the teachers' role and their ability to successfully organize and facilitate collaborative classroom practices as called for by the reform movement. This qualitative study illustrates how one high school mathematics teacher engaged his students in classroom discourse and promoted in them the use of appropriate mathematics language to communicate their thinking and make sense of mathematics concepts. The study also shares students' perceptions of the teaching approach. The findings of the study suggest that while the mathematical dispositions of students depend significantly on their prior experiences they can be transformed over time by a teacher's pedagogical practices. This research recommends that high school mathematics teachers adopt

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some of the more recent reform-based instructional strategies that have been underutilized in these classrooms.

### **Referrals**

#### **Organizations:**

- National Council of Teachers of Mathematics: <http://www.nctm.org>

#### **Federally Funded Resources:**

- Institute of Education Sciences (IES), public search engine available at: <http://ies.ed.gov/pubsearch/>
- What Works Clearinghouse: <http://ies.ed.gov/ncee/wwc/>
- Center for Improving Learning of Fractions: <http://www.udel.edu/soe/fractions>
- National Research & Development Center on Cognition & Mathematics Instruction: <http://www.iesmathcenter.org/>

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