

REL Pacific Ask A REL Response

Math, Curriculum and Instruction
July 2020

Question:

What is the research on designing effective and equitable mathematics instruction?

Response:

Following an established REL Pacific research protocol, we conducted a web-based search for resources related to designing effective and equitable mathematics instruction (see Methods section for search terms and resource selection criteria). We first prioritized studies in the Pacific and other indigenous contexts for greater relevancy to our partners in the Pacific region; however, we included studies with more generalizable findings due to the limited amount of research available in these contexts.

References are listed in alphabetical order, not necessarily in order of relevance. Descriptions of the resources are quoted directly from the publication abstracts. We have not evaluated the quality of references and the resources provided in this response. We offer them only for your reference. Also, our search included the most commonly used research resources, but they are not comprehensive and other relevant references and resources may exist.

Research References

Averill, R., Anderson, D., & Drake, M. (2015). Developing culturally responsive teaching through professional noticing within teacher educator modelling. *Mathematics Teacher Education and Development*, 17(2), 64–83. <https://eric.ed.gov/?id=EJ1085885>

From the abstract: “Much evidence exists that culturally responsive and equitable teaching practices are challenging to develop. Evidence exists that in-the-moment coaching of 'rehearsals' of practice can help foster mathematics teaching strategies, but how such coaching can assist the development of culturally responsive practice is less clear. Drawn from a larger study into rehearsals of practice, this article illustrates how teacher educator modelling of instructional activities with in-the-moment coaching can provide opportunities for professional noticing of culturally responsive teaching practices. Such opportunities were identified across seven videos of rehearsals of practice in which teacher educator pairs modelled and coached mathematics teaching. Examples are discussed in relation to facilitation of professional noticing and two aspects of a framework of 'cultural competencies' for teachers of indigenous Māori learners. Implications include enhanced equity of access to mathematics learning through pre-service teachers being able to notice, discuss, and use culturally responsive teaching practices.”

Beesley, A. D., Clark, T. F., Dempsey, K., & Tweed, A. (2018). Enhancing formative assessment practice and encouraging middle school mathematics engagement and persistence. *School Science & Mathematics, 118*(1/2), 4–16. <https://eric.ed.gov/?id=EJ1167952>

From the abstract: “In the transition to middle school, and during the middle school years, students' motivation for mathematics tends to decline from what it was during elementary school. Formative assessment strategies in mathematics can help support motivation by building confidence for challenging tasks. In this study, the authors developed and piloted a professional development program, Learning to Use Formative Assessment in Mathematics with the Assessment Work Sample Method (AWSM) to build middle school math teachers' understanding of the characteristics of high-quality formative assessment processes and increase their ability to use them in their classrooms. AWSM proved to be feasible to implement in the middle school setting. It improved teachers' practice of formative assessment, especially in their feedback practices, regardless of their pedagogical content knowledge at entry. Results from focus groups suggested that teachers were better able to implement ungraded practice and student self- and peer-assessment after AWSM, and that students were more willing to engage in complex problem solving.”

Boaler, J., & Staples, M. (2008). Creating mathematical futures through an equitable teaching approach: the case of Railside School. *Teachers College Record, 110*(3), 608-645. <https://eric.ed.gov/?id=EJ822226>

From the abstract: “School tracking practices have been documented repeatedly as having negative effects on students' identity development and attainment, particularly for those students placed in lower tracks. Despite this documentation, tracking persists as a normative practice in American high schools, perhaps in part because we have few models of how departments and teachers can successfully organize instruction in heterogeneous, high school mathematics classes. This paper offers one such model through a qualitative and quantitative analysis. Focus of Study: In an effort to better the field's understanding of equitable and successful teaching, we conducted a longitudinal study of three high schools. At one school, Railside, students demonstrated greater gains in achievement than students at the other two schools and higher overall achievement on a number of measures. Furthermore, achievement gaps among various ethnic groups at Railside that were present on incoming assessments disappeared in nearly all cases by the end of the second year. This paper provides an analysis of Railside's success and identifies factors that contributed to this success. Participants: Participants included approximately 700 students as they progressed through three California high schools. Railside was an urban high school with an ethnically, linguistically, and economically diverse student body. Greendale was situated in a coastal community with a more homogeneous, primarily White student body. Hilltop was a rural high school with primarily White and Latino/a students. Research Design: This longitudinal, multiple case study employed mixed methods. Three schools were chosen to offer a range of curricular programs and varied student populations. Student achievement and attitudinal data were evaluated using statistical techniques, whereas teacher and student practices were documented using qualitative analytic techniques such as coding. Findings/Results: One of the findings of the study was the success of Railside school, where the mathematics department taught heterogeneous classes using a reform-oriented approach. Compared with the other two schools in the study, Railside students learned more, enjoyed mathematics more and progressed to higher mathematics levels. This paper presents large-scale evidence of these important achievements and provides detailed analyses of the ways that the Railside teachers brought them about, with a focus on the teaching and learning interactions within the classrooms.”

Furuto, L.H.I. (2014). Pacific ethnomathematics: Pedagogy and practices in mathematics education. *International Journal for Mathematics Teaching and Learning*. <https://eric.ed.gov/?id=EJ1025672>; full text available at <https://core.ac.uk/reader/32301066>

From the abstract: "In light of the changing ethnic, racial, and cultural demographics in U.S. schools, there is a growing need by scholars and practitioners for teaching practices that are informed by cultural knowledge possessed by students. This comes at a time when standardized testing of student achievement has been given a central role in efforts to improve K-12 education such as the Mathematics Common Core State Standards (CCSS). This article begins with a discussion of ethnomathematics as a conceptual idea, and a practical way of rethinking ideology, content, and pedagogy in a rapidly changing climate of diversity. This is followed by a five year study on the Ethnomathematics Institute which provides strategies for implementing promising practices. In Pacific as well as global communities, it is key to understand the role of experiential, values, and place-based learning. Through ethnomathematics, we endeavor to build capacity and networks across the U.S. and Pacific by creating a database of materials and strategies that are relevant, contextualized, and sustainable."

Hobbs, L. (2018). Developing culturally responsive mathematics teachers: Understanding equity and access in math education [Doctoral thesis, University of Houston]. <https://uh-ir.tdl.org/handle/10657/4081>

From the abstract: "Background: Math is often thought to be one of the few objective, context-free areas of study. Yet, national and state assessment data repeatedly report disparities in mathematics achievement based on race/ethnicity and socioeconomic status. The perceived neutrality of mathematics education combined with persistent gaps in achievement between student groups can mislead educators to believe that some students are inherently incapable of achievement instead of questioning the inequities of students' educational experiences. Culturally Responsive Math Education (CRME) provides a framework through which teachers can critically examine their beliefs about students, their potential for learning mathematics, and the cultural and community-based experiences they bring into the classroom. Purpose: There are often significant cultural, racial, and social gaps between teachers and the diverse student populations they serve, as well as differences in their experiences with learning and using mathematics. Unfortunately, teacher preparation programs rarely provide the time and space needed for teachers to critically consider how their unique experiences contribute to their beliefs and assumptions about students from backgrounds different from their own. Guided by the CRME Framework, this action research study investigated the following questions: (1) How do teachers' sociocultural and mathematical backgrounds and experience influence their understanding and approach to equity and access in math education? and (2) How does professional development for CRME influence participants' understanding and approach to equitable and accessible math education within the context of a mid-sized rural school district? Methods: A qualitative case study design was used to investigate the experiences of nine elementary math teachers within a mid-sized rural school district who recently participated in a five-week PD series designed to increase their understanding of CRME. Qualitative data were collected from participants' responses to pre- and post-PD open-ended questionnaires, math autobiographies, classroom observations, video recordings of PD sessions, and semi structured interviews, then transcribed, coded, and analyzed to identify key themes and patterns as they emerged for individuals, as well as the group as a whole. Results: Teachers' prior experiences as learners of mathematics, as well as sociocultural differences between teachers and their students,

contributed to their beliefs about what counts as mathematical knowledge and who is capable of knowing it. Participants often used deficit-oriented language to describe their students' capabilities for learning mathematics and emphasized a procedural understanding of mathematics with low cognitive demand. However, after participating in a PD for CRME, teachers decreased use of deficit-oriented language while increasing resource-oriented language, placed a higher emphasis on the conceptual understanding of mathematics rather than procedural understanding, and demonstrated a new inclination towards mathematical discourse and student participation as opportunities for learning. Conclusion: A preference for procedural over conceptual understanding of mathematics combined with the notion that some students are mathematically deficient can hinder students' access to equitable learning opportunities. Findings suggest that elementary math teachers, particularly those working with traditionally underserved student populations, can benefit when given time and space to critically reflect and discuss their beliefs about their students and math education, impacting their understanding of equity and access within the math classroom."

Polly, D., Wang, C., Lambert, R., Martin, C., McGee, J. R., Pugalee, D., & Lehew, A. (2017). Supporting kindergarten teachers' mathematics instruction and student achievement through a curriculum-based professional development program. *Early Childhood Education Journal*, 45(1), 121–131. <https://eric.ed.gov/?id=EJ1125190>; full text available at <https://www.researchgate.net/publication/257557055>

From the abstract: "This study investigates the impacts of a year-long professional development program on Kindergarten teachers' beliefs and practices and the association of these changes with student achievement in mathematics measured by curriculum-based instruments. Although teacher content knowledge was not statistically significantly different before and after participation in the program, changes in teachers' beliefs and practices were both noticed: a trend towards discovery/connectionist orientation and student-centered practices. Teachers' gain scores on a measure of mathematics content knowledge was positively related to the linear growth rate of student achievement."

Additional Resources to Consult

Coe, K. (2019). *Mathematics: Menu of best practices and strategies*. Washington Office of Public Instruction. <https://www.k12.wa.us/student-success/support-programs/learning-assistance-program-lap/menus-best-practices-strategies/mathematics-menu-best-practices-strategies>

From the abstract: "This report contains not only the menu of best practices, but also foundational content describing Washington state's mathematics landscape and other initiatives designed to improve mathematics concepts and skills for all students. It describes how a Multi-Tiered System of Supports (MTSS) framework is critical for implementing a high-achieving educational system. It also explains how assessment data and reporting serve to continuously improve LAP and student outcomes. We have included a rich set of resources and references for those who wish to further explore the identified best practices."

Pellegrini, M., Lake, C., Inns, A., & Slavin, R. E. (2018). *Effective programs in elementary mathematics: A best evidence synthesis*. Best Evidence Encyclopedia.
http://www.bestevidence.org/word/elem_math_Oct_8_2018.pdf

From the abstract: "This article reviews research on the mathematics achievement outcomes of all programs with at least one study meeting inclusion criteria. 78 studies evaluated 61 programs in grades K-5. The studies were very high in quality, with 65 (83%) randomized and 13 (17%) quasi-experimental evaluations. Programs were organized in 8 categories. Particularly positive outcomes were found for tutoring programs. One-to-one and one-to-small group models had equal impacts, as did teachers and paraprofessionals as tutors. Technology programs showed modest positive impacts. Professional development approaches focused on helping teachers gain in understanding of math content and pedagogy had no impact on student achievement, but more promising outcomes were seen in studies focused on instructional processes, such as cooperative learning. Whole-school reform, social-emotional approaches, math curricula, and benchmark assessment programs found few positive effects, although there were one or more effective individual approaches in most categories. The findings suggest that programs emphasizing personalization, engagement, and motivation are most impactful in elementary mathematics instruction, while strategies focused on textbooks, professional development for math knowledge or pedagogy, and other strategies that do not substantially impact students' daily experiences have little impact."

Star, J. R., Caronongan, P., Foegen, A., Furgeson, J., Keating, B., Larson, M. R., Lyskawa, J., McCallum, W. G., Porath, J., & Zbiek, R. M. (2015, Revised 2019). *Teaching strategies for improving algebra knowledge in middle and high school students* (NCEE 2014-4333). Washington, DC: National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education. <https://ies.ed.gov/ncee/wwc/PracticeGuide/20>

From the abstract: "Mastering algebra is important for future math and postsecondary success. Educators will find practical recommendations for how to improve algebra instruction in the What Works Clearinghouse (WWC) practice guide, 'Teaching Strategies for Improving Algebra Knowledge in Middle and High School Students'. The methods and examples included in the guide focus on helping students analyze solved problems, recognize structure, and utilize alternative approaches to solving algebra problems. Each recommendation includes the level of supporting research evidence behind it, examples to use in class, and solutions to potential implementation roadblocks. Teachers can implement these strategies in conjunction with existing standards or curricula. In addition, these strategies can be utilized for all students learning algebra in grades 6-12 and in diverse contexts, including during both formative and summative assessment. Administrators and professional development providers can use the guide to implement evidence-based instruction and align instruction with state standards or to prompt teacher discussion in professional learning communities. Appended are: (1) Postscript from the Institute of Education Sciences; (2) About the Authors; (3) Disclosure of Potential Conflicts of Interest; and (4) Rationale for Evidence Ratings. A Glossary is included."

Woodward, J., Beckmann, S., Driscoll, M., Franke, M., Herzig, P., Jitendra, A., Koedinger, K. R., & Ogbuehi, P. (2012, Revised 2018.). *Improving mathematical problem solving in grades 4 through 8: A practice guide* (NCEE 2012-4055). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. <https://ies.ed.gov/ncee/wwc/PracticeGuide/16>

From the abstract: “Instructional tips help educators carry out recommendations contained in IES Educator’s Practice Guides. This summary describes the research evidence that supports the use of the instructional tips in classrooms and is based on a practice guide authored by Sybilla Beckmann, Mark Driscoll, Megan Franke, Patricia Herzig, Asha Jitendra, Kenneth R. Koedinger, Philip Ogbuehi, and John Woodward. Provided is a summary of evidence on instructional tips for: (1) Assisting Students in Monitoring and Reflecting on the Problem-Solving Process; (2) Teaching Students to Use Visual Representations to Solve Problems; and (3) Helping Students Make Sense of Algebraic Notation. The evidence supporting the three mathematical problem solving instructional tips is drawn from research that meets What Works Clearinghouse (WWC) design standards and is summarized here.”

Additional Organizations to Consult

Center for Education Equity: <https://cee-maec.org/>

From the website: “MAEC established the Center for Education Equity (CEE) to address problems in public schools caused by segregation and inequities. As the Region I equity assistance center, CEE works to improve and sustain the systemic capacity of public education to increase outcomes for students regardless of race, gender, religion, and national origin. CEE is funded by the US Department of Education under Title IV of the Civil Rights Act of 1964.”

The Equity Project: <https://www.air.org/project/equity-project>

From the website: “The Equity Project at AIR is committed to building an inclusive and vibrant future through education. The project's mission is to use the breadth and depth of AIR's education research, policy, and practice experience to increase educational opportunities for all American children, especially minority children and children from low-income households.”

Methods

Keywords and Search Strings

The following keywords and search strings were used to search the reference databases and other sources:

- “equity” AND “math instruction”
- “math” AND “minority”
- “math instruction” AND “best practices” AND “equity”
- “ethnomathematics” AND “Pacific Islanders”

Databases and Resources

We searched ERIC, a free online library of over 1.6 million citations of education research sponsored by the Institute of Education Sciences, for relevant resources. We also used the academic databases Google Scholar and ProQuest. In some cases, we used resource harvesting to find additional related studies.

Reference Search and Selection Criteria

REL Pacific searched ERIC and other academic journal databases for studies that were published in English-language peer-reviewed research journals within the last 10 years, apart from Boaler & Staples (2008) for its relevancy to the topic. Sources included in this document were last accessed in July 2020.

REL Pacific prioritized documents that are accessible online and publicly available, and prioritized references that provide practical information based on peer-reviewed research for the education system stakeholders who requested this Ask A REL.¹ For questions with small or nonexistent research bases, we may rely on, for example, white papers, guides, reviews in non-peer-reviewed journals, interviews with content specialists, and organization websites. Additional methodological priorities/considerations given in the review and selection of the references were:

- Study types—randomized control trials, quasi experiments, surveys, descriptive data analyses, literature reviews, etc.
- Target population, sample size, study duration, etc.
- Limitations, generalizability of the findings and conclusions, etc.

¹ This memorandum is one in a series of quick-turnaround responses to specific questions posed by educational stakeholders in the Pacific Region (American Samoa, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, Guam, Hawai'i, the Republic of the Marshall Islands, and the Republic of Palau), which is served by the Regional Educational Laboratory (REL Pacific) at McREL International. This memorandum was prepared by REL Pacific under a contract with the U.S. Department of Education's Institute of Education Sciences (IES), Contract ED-IES-17-C-0010, administered by McREL International. Its content does not necessarily reflect the views or policies of IES or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.