# REL Appalachia Ask A REL Response

Math
May 2020

## Question:

How do math attitudes and/or a growth mindset relate to elementary math achievement? Are there instructional practices or interventions that support development of positive math attitudes and/or a growth mindset?

## Response:

Thank you for your request to our REL Reference Desk regarding evidence-based information about how math attitudes and/or a growth mindset relate to elementary math achievement. Ask A REL is a collaborative reference desk service provided by the 10 Regional Educational Laboratories (RELs) that, by design, functions much in the same way as a technical reference library. Ask A REL provides references, referrals, and brief responses in the form of citations in response to questions about available education research.

Following an established REL Appalachia research protocol, we searched for peer-reviewed articles and other research reports on math attitudes, growth mindset, elementary math achievement, and practices supporting positive math attitudes and/or growth mindset. We focused on identifying resources that specifically addressed the effects of math attitudes on elementary student achievement. The sources included ERIC and other federally funded databases and organizations, research institutions, academic research databases, and general Internet search engines. For more details, please see the methods section at the end of this document.

The research team did not evaluate the quality of the resources provided in this response; we offer them only for your reference. Also, the search included the most commonly used research databases and search engines to produce the references presented here, but the references are not necessarily comprehensive, and other relevant references and resources may exist. References are listed in alphabetical order, not necessarily in order of relevance.

### *References*

Blazer, C. (2011). Strategies for reducing math anxiety. *Information Capsule, 1102*, 1–8. Retrieved from https://eric.ed.gov/?id=ED536509

*From the abstract:* "Approximately 93 percent of Americans indicate that they experience some level of math anxiety. Math anxiety is defined as negative emotions that interfere with the solving of mathematical problems. Studies have found that some students who perform

poorly on math assessments actually have a full understanding of the concepts being tested; however, their anxiety interferes with their ability to solve mathematical problems. Researchers believe that implementation of strategies to prevent or reduce math anxiety will improve the math achievement of many students. This Information Capsule summarizes strategies that teachers, parents, and students can use to prevent or reduce math anxiety."

Boaler, J. (2013). Ability and mathematics: The mindset revolution that is reshaping education. *Forum*, *55*(1), 143–152. Abstract retrieved from https://eric.ed.gov/?id=EJ1016613; full text available at http://www.youcubed.org/wp-content/uploads/14_Boaler_FORUM_55_1_web.pdf

*From the abstract:* "Recent scientific evidence demonstrates both the incredible potential of the brain to grow and change and the powerful impact of growth mindset messages upon students' attainment. Schooling practices, however, particularly in England, are based upon notions of fixed ability thinking which limits students' attainment and increases inequality. This article reviews evidence for brain plasticity, the importance of mindset and the ways that mindset messages may be communicated through classroom and grouping practices."

Dweck, C. S. (2008). *Mindsets and math/science achievement*. New York: Carnegie Corporation of New York, Institute for Advanced Study, Commission on Mathematics and Science Education. Retrieved from http://www.growthmindsetmaths.com/uploads/2/3/7/7/23776169/mindset_and_math_science_achievement_-_nov_2013.pdf

*From the abstract:* "There is a growing body of evidence that students' mindsets play a key role in their math and science achievement. Students who believe that intelligence or math and science ability is simply a fixed trait (a fixed mindset) are at a significant disadvantage compared to students who believe that their abilities can be developed (a growth mindset). Moreover, research is showing that these mindsets can play an important role in the relative underachievement of women and minorities in math and science. Below, I will present research showing that a) mindsets can predict math/science achievement over time; b) mindsets can contribute to math/science achievement discrepancies for women and minorities; c) interventions that change mindsets can boost achievement and reduce achievement discrepancies; and d) educators play a key role in shaping students' mindsets."

Gunderson, E. A., Park, D., Maloney, E. A., Beilock, S. L., & Levine, S. C. (2018). Reciprocal relations among motivational frameworks, math anxiety, and math achievement in early elementary school. *Journal of Cognition and Development*, *19*(1), 21–46. Abstract retrieved from https://eric.ed.gov/?id=EJ1168313; full text available at https://cpb-us-w2.wpmucdn.com/voices.uchicago.edu/dist/5/1727/files/2019/04/Gunderson-et-al-2018-2jbbqzb.pdf

*From the abstract:* "School-entry math achievement is a strong predictor of math achievement through high school. We asked whether reciprocal relations among math achievement, math anxiety, and entity motivational frameworks (believing that ability is fixed and a focus on performance) can help explain these persistent individual differences. We assessed 1st and 2nd graders' ($N$ = 634) math achievement, motivational frameworks,

and math anxiety 2 times, 6 months apart. Cross-lagged path analyses showed reciprocal relations between math anxiety and math achievement and between motivational frameworks and math achievement. Entity motivational frameworks predicted higher math anxiety. High math achievement was a particularly strong predictor of lower math anxiety and less entity-oriented motivational frameworks. We concluded that reciprocal effects are already present in the first 2 years of formal schooling, with math achievement and attitudes feeding off one another to produce either a vicious or virtuous cycle. Improving both math performance and math attitudes may set children onto a long-lasting, positive trajectory in math."

Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *Journal of Experimental Child Psychology, 141*, 83–100. Retrieved from https://cpb-us-w2.wpmucdn.com/voices.uchicago.edu/dist/8/1250/files/2018/07/Ramirez-et-al-2016-MathAnxietyStrategies-1htur11.pdf

*From the abstract:* "Even at young ages, children self-report experiencing math anxiety, which negatively relates to their math achievement. Leveraging a large dataset of first and second grade students' math achievement scores, math problem solving strategies, and math attitudes, we explored the possibility that children's math anxiety (i.e., a fear or apprehension about math) negatively relates to their use of more advanced problem solving strategies, which in turn relates to their math achievement. Our results confirm our hypothesis and, moreover, demonstrate that the relation between math anxiety and math problem solving strategies is strongest in children with the highest working memory capacity. Ironically, children who have the highest cognitive capacity avoid using advanced problem solving strategies when they are high in math anxiety and, as a result, underperform in math compared with their lower working memory peers."

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development, 14*(2), 187–202. Abstract retrieved from https://eric.ed.gov/?id=EJ1011797; full text available at http://mrbartonmaths.com/resourcesnew/8.%20Research/Anxiety/Math%20Anxiety,%20Working%20Memory,%20and%20Math%20Acheivement.pdf

*From the abstract:* "Although math anxiety is associated with poor mathematical knowledge and low course grades (Ashcraft & Krause, 2007), research establishing a connection between math anxiety and math achievement has generally been conducted with young adults, ignoring the emergence of math anxiety in young children. In the current study, we explored whether math anxiety relates to young children's math achievement. One hundred and fifty-four first- and second-grade children (69 boys, 85 girls) were given a measure of math achievement and working memory (WM). Several days later, children's math anxiety was assessed using a newly developed scale. Paralleling work with adults (Beilock, 2008), we found a negative relation between math anxiety and math achievement for children who were higher but not lower in WM. High-WM individuals tend to rely on WM-intensive solution strategies, and these strategies are likely disrupted when WM capacity is co-opted by

math anxiety. We argue that early identification and treatment of math anxieties is important because these early anxieties may snowball and eventually lead students with the highest potential (i.e., those with higher WM) to avoid math courses and math-related career choices."

Savelsbergh, E. R., Prins, G. T., Rietbergen, C., Fechner, S., Vaessen, B. E., Draijer, J. M., & Bakker, A. (2016). Effects of innovative science and mathematics teaching on student attitudes and achievement: A meta-analytic study. *Educational Research Review*, *19*, 158–172. Retrieved from https://doi.org/10.1016/j.edurev.2016.07.003

*From the abstract:* "Many teaching approaches have been tried to improve student attitudes and achievement in science and mathematics education. Achievement effects have been synthesized, but a systematic overview of attitude effects is missing. This study provides a meta analytic review based on 56 publications (1988–2014), reporting 65 independent experiments that investigated the effects of teaching approaches on student attitudes in primary or secondary science or mathematics education. Five types of teaching approaches were distinguished: inquiry-based, context-based, computer-based, collaborative learning strategies, and extra-curricular activities. Since many different attitude outcomes were distinguished and attitudes were assessed at different levels of granularity, we did separate analyses for specific and more global outcomes. Outcomes were not significantly different for different educational approaches. When taking all interventions together, significant effects were found for General Attitude ($n$ = 60; $d$ = 0.35), General Interest ($n$ = 20; $d$ = 0.22), and Career Interest in Science ($n$ = 4; $d$ = 0.40). The effects were significantly weaker for studies with older students. Analysis of achievement outcomes yielded a significant and large overall effect ($n$ = 40; $d$ = 0.78), again with no significant differences between teaching approaches. Although the positive effects might be partly due to novelty, the current findings do counter skepticism about the learning outcomes of interest-oriented teaching approaches."

White, K., & McCoy, L. P. (2019). Effects of game-based learning on attitude and achievement in elementary mathematics. *Networks: An Online Journal for Teacher Research*, *21*(1), 1–17. Retrieved from https://eric.ed.gov/?id=EJ1206814

*From the abstract:* "Games-based learning involves instruction with realistic game experiences (Cicchino, 2015). This action research study explored game-based learning as fifth grade mathematics students completed a brief unit on ordered pairs utilizing game-based lessons. Attitude and achievement data were collected mainly by surveys, content tests, student interviews, and field notes. Additional information included in the teacher-researcher analysis consisted of classroom photographs, videos, and student work samples. Results revealed that student attitudes improved both toward the lessons and toward math in general. Similarly, achievement improved for all students across the unit. Analysis of the narrative data produced three themes. First, the students acquired a growth mindset (Boaler, 2016) that fostered a positive work ethic. Second, student partner work helped them to develop problem solving skills. And third, the games engaged the students. In summary, students showed significant improvements both in their attitudes about math and their achievement in ordered pairs."

### *Additional Ask A REL Responses to Consult*

Ask A REL Appalachia at SRI International. (2019). *How does a STEM (science, technology, engineering, and mathematics) or STEAM (science, technology, engineering, art, and mathematics) approach to gifted programs affect students' math or science outcomes and their attitudes about math and science?* Retrieved from https://ies.ed.gov/ncee/edlabs/regions/appalachia/askarel/aar65.asp

### *Additional Organizations to Consult*

The Mindset Scholars Network: https://mindsetscholarsnetwork.org/

> *From the website:* "The Mindset Scholars Network's mission is to advance our scientific understanding of learning mindsets in order to improve student outcomes and expand educational opportunity. It conducts original interdisciplinary research, builds capacity for high quality mindset scholarship, and disseminates the latest scientific knowledge through outreach to education stakeholders. The Network serves as an authoritative resource for reliable, research-based information about learning mindsets, including: Growth Mindset, Belonging, and Purpose & Relevance."

National Math and Science Initiative: https://www.nms.org/

> *From the website:* "Our mission is to advance STEM education to ensure all students, especially those furthest from opportunity, thrive and reach their highest potential as problem solvers and lifelong learners who pursue their passions and tackle the world's toughest challenges."

## Methods

### *Keywords and Search Strings*

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

- math* AND elementary AND (attitude* OR mindset* OR metacogniti* OR "self-efficacy" OR "motivation* framework") AND (outcome* OR achievement)
- math* AND elementary AND (strateg* OR intervention* OR practice*) AND (mindset* OR attitude* OR metacogniti*)

### *Databases and Resources*

We searched ERIC, a free online library of more than 1.6 million citations of education research sponsored by the Institute of Education Sciences (IES), for relevant resources. Additionally, we searched the academic database ProQuest, Google Scholar, and the commercial search engine Google.

## *Reference Search and Selection Criteria*

In reviewing resources, Reference Desk researchers consider—among other things—these four factors:

- Date of the publication: Searches cover information available within the last 10 years, except in the case of nationally known seminal resources.
- Reference sources: IES, nationally funded, and certain other vetted sources known for strict attention to research protocols receive highest priority. Applicable resources must be publicly available online and in English.
- Methodology: The following methodological priorities/considerations guide the review and selection of the references: (a) study types—randomized controlled trials, quasi experiments, surveys, descriptive data analyses, literature reviews, policy briefs, etc., generally in this order; (b) target population, samples (representativeness of the target population, sample size, volunteered or randomly selected), study duration, etc.; (c) limitations, generalizability of the findings and conclusions, etc.
- Existing knowledge base: Vetted resources (e.g., peer-reviewed research journals) are the primary focus, but the research base is occasionally slim or nonexistent. In those cases, the best resources available may include, for example, reports, white papers, guides, reviews in non-peer-reviewed journals, newspaper articles, interviews with content specialists, and organization websites.

Resources included in this document were last accessed on May 4, 2020. URLs, descriptions, and content included here were current at that time.

This memorandum is one in a series of quick-turnaround responses to specific questions posed by education stakeholders in the Appalachia region (Kentucky, Tennessee, Virginia, and West Virginia), which is served by the Regional Educational Laboratory Appalachia (REL AP) at SRI International. This Ask A REL response was developed by REL AP under Contract ED-IES-17-C-0004 from the U.S. Department of Education, Institute of Education Sciences, administered by SRI International. The 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.