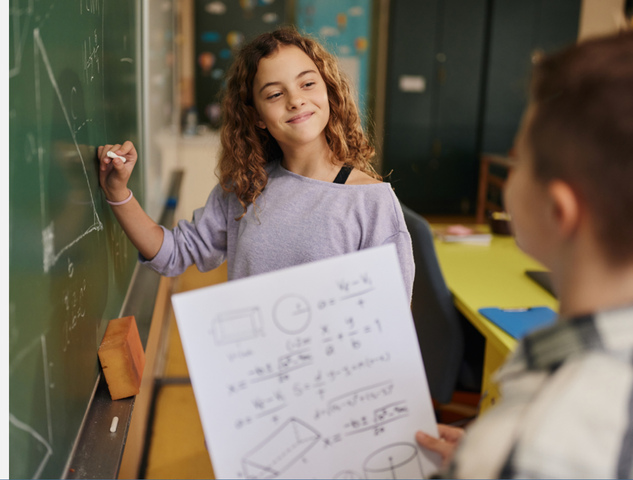
LEARNING POLICY INSTITUTE

JUNE 2025



Positive Conditions for Mathematics Learning

An Overview of the Research

Julie Fitz with Heather Price

Summary

In the United States, stagnating mathematics achievement and persistent racial and socioeconomic disparities in math performance point to a need to understand how math teachers can more effectively support the learning of each and every student. Given a growing body of research that emphasizes the impact of the classroom environment on student learning, this brief synthesizes research findings from the fields of mathematics teaching and learning, educational psychology, and the learning sciences to identify key classroom conditions that matter for K–12 math learning. Evidence suggests that students have better math outcomes when they experience positive relationships with their teachers, feel a sense of belonging in their classroom community and the broader mathematics community, adopt a growth mindset, and engage with high-quality instruction delivered by teachers who hold high expectations and offer strong supports for students' success.

The report on which this brief is based can be found at https://learningpolicyinstitute.org/product/positive-conditions-math-learning.

Introduction

Math achievement for K–12 students in the United States has long lagged behind that of other nations and has been relatively stagnant for 8th graders on national assessments over the past 2 decades.[1] The need to understand how teachers can better support math learning is particularly acute in the wake of pandemic-era learning disruptions, which impacted already low math performance more than other subject areas.[2] According to multiple analyses, the negative effects of disrupted learning hit students hardest in districts and schools serving higher proportions of students from low-income families and historically marginalized racial and ethnic groups.[3] Data from the 2024 National Assessment of Education Progress show that average student achievement has not yet fully rebounded.[4]

The factors contributing to disparate outcomes in math achievement are complex. Systemic barriers abound, including students' inequitable access to well-prepared math teachers, high-quality curriculum and instruction, and advanced coursework.[5] Resolving systemic disparities in student access to quality math instruction will be essential to improving U.S. learning outcomes in math and will require the careful design and implementation of policies that address each of these conditions.

However, educators need not wait for the resolution of systemic issues to begin creating more equitable learning opportunities within their own classrooms. A significant and growing body of research suggests that what happens in the classroom greatly influences student achievement in math, particularly for those historically marginalized or excluded from math. Deepening our shared understanding of the classroom conditions that are most conducive to math learning will help pave the path toward math classrooms in which all students can thrive and achieve their potential.

Why Classroom Conditions Matter

Recent syntheses of research from the fields of neuroscience, psychology, and other developmental and learning sciences—commonly known as the science of learning and development—emphasize the impact of the classroom environment on student learning.[6] This research finds that students learn best in environments in which they feel a sense of physical, emotional, and identity safety; hold positive relationships with adults and peers; and experience belonging, purpose, and affirmation.[7] These positive conditions promote healthy development, supporting students' cognitive growth and their physical, psychological, social, and emotional development.[8] They can also help to counter the negative effects of stress and trauma, which impact the brain in ways that biologically impair learning.[9]

In the classroom, teachers play a central role in establishing the daily learning conditions that students experience. Through interpersonal relationships, classroom management practices, and instructional strategies, teachers can attend to the social-emotional developmental needs of students. When students' developmental needs for safety, positive relationships, belonging, and meaningful engagement are met, they are better positioned to engage with cognitively demanding learning experiences.[10]

Attending to learning conditions in math classrooms is particularly important due to the prevalent fear and anxiety that students experience related to math. Math-related fear, often referred to as "math anxiety," changes the way children's brains respond to mathematical situations in ways that are counterproductive to learning.[11] Unsurprisingly, researchers have linked the experience of math anxiety with numerous negative outcomes, such as reduced math achievement and a tendency to avoid college math courses and majors or career paths that require math.[12] Creating math classroom environments that are more aligned with students' developmental needs can help to resolve the common experience of math anxiety and thereby enable more positive and productive math learning experiences.

Overview of Brief

This brief synthesizes research findings from the fields of mathematics teaching and learning, educational psychology, and the learning sciences to identify key classroom conditions that matter for K–12 math learning.[13] To organize discussion of the research literature, the brief is divided into four sections, each describing a different environmental condition that emerged as important for student learning. The literature provides evidence that students learn math best when they can do the following:

1. Experience **positive relationships** with their teachers
2. Feel a sense of **belonging** in their classroom community and the broader mathematics community

3. Adopt a **growth mindset**, meaning the belief that their mathematical ability can be cultivated through effort

4. Engage with **high-quality instruction** delivered by teachers who hold high expectations and offer strong supports for their success

The Importance of Positive Relationships

A large body of research has found that students who report positive relationships with their teachers tend to experience other positive academic outcomes, including elevated math achievement.[14] Associations between teacher–student relationships and academic outcomes tend to be stronger for specific student groups—namely, students who identify as members of racial and ethnic minority groups or who came from lower-income families.[15]

A subset of studies has examined how positive teacher–student relationships bolster student math learning and achievement. In general, studies find that positive relationships with teachers increase student self-efficacy, or their belief in their ability to accomplish specific math goals, with higher levels of self-efficacy linked to greater math achievement.[16] A study of middle school students found that, in addition to increased self-efficacy, students who felt more emotionally supported by their teachers reported a greater sense of belonging and academic enjoyment and that these factors were associated with greater self-reported levels of academic effort.[17] Other evidence suggests that when teachers' actions communicate support of all students, student achievement increases with students' level of engagement and as they develop a sense of "mathematics identity."[18] Mathematics identity refers to a student's belief that they can successfully engage and perform in the math classroom and be socially recognized as someone who is mathematically capable.

Further evidence suggests that emotionally supportive teachers create environments in which all students, including those with doubts about their ability to succeed in math, feel safe to participate fully in the learning process. For instance, one study found that students who have low self-efficacy toward math typically report being less engaged in their math classes. However, when taught by emotionally supportive teachers, low-efficacy students reported similar rates of engagement as their more self-efficacious peers.[19] The findings from this study suggest that emotional support from teachers can help to reengage students who initially come to class with lower confidence in their mathematical abilities, potentially by minimizing the feeling of inhibition that may otherwise keep them from participating fully in classroom activities and interacting comfortably with peers. Put differently, in emotionally supportive environments, students can feel safe to take academic risks in their learning and fully engage with classroom learning opportunities.

The Importance of Belonging

For students, the feeling that they are "personally accepted, respected, [and] included by others in the school social environment" helps to establish the classroom as a psychologically safe space for social and cognitive inquiry, experimentation, and growth.[20] Developmentally, this is very important, particularly during adolescence.[21] Numerous studies provide evidence that students who feel a sense of belonging in their school or classroom community tend to experience more positive social-emotional and academic outcomes, including greater engagement, educational motivation and attitude, self-concept, self-efficacy, and academic achievement.[22] One researcher hypothesized that students who feel a sense of social belonging no longer need to exert effort "avoiding the negative appraisals of others or approaching material from a solely competitive framework" and thus can better focus on their learning.[23]

A developing research base suggests that, in addition to social belonging, it is also important for students to feel a sense of "mathematics belonging," or a sense that they are socially accepted as an able "doer" of math. Mathematics belonging matters, at least in part, to counter the prevalent gender- and race-based stereotypes about innate math abilities that many students internalize. A recent study of middle school students showed that their competency expectations and sense of mathematics belonging—operationalized as their math-related feelings of acceptance, level of comfort, enjoyment of participation, and trust that their teachers will help them learn—predicted their algebra learning, even when taking into account their prior algebra knowledge and self-concept.[24] A follow-up study found that sense of belonging was the only significant predictor of student learning as measured on a pre/post-test of algebra skills, even when considering students' socioeconomic status, perceptions of the importance of math, incremental view of math ability, and interest in math.[25] Notably, this study also found that Black, Hispanic, and Indigenous students reported lower levels of belonging than their Asian and White peers, even though there were no differences in their prior algebra knowledge. Together, these findings suggest that practices that help students identify themselves as "part of the mathematics community" may help to promote student learning, particularly for students who are members of groups historically stereotyped as mathematically incapable.

The Importance of a Growth Mindset

Students' beliefs about their ability to learn and succeed in math matter for their learning. Researchers and practitioners alike commonly discuss students' beliefs about their ability to learn and succeed through the lens of mindset theory. This theory posits that students either ascribe to a "fixed" mindset, whereby they view ability and intelligence as static and innate, or a "growth" mindset, whereby they view ability and intelligence as malleable and able to be developed over time.[26] The growth mindset perspective aligns with contemporary scientific understandings of how the brain works.[27]

A growth mindset is positively associated with student math learning outcomes. In one large-scale study following students in 4th through 7th grades for a full academic year, researchers found statistically significant relationships between students' growth mindset orientation and their math growth in the following school year. The researchers who ran the study estimated the effect of a strong growth mindset (relative to a fixed mindset) to be the equivalent of 23–31 additional days of learning.[28] A follow-up study longitudinally followed students and found that positive changes in students' self-reported growth mindset–oriented beliefs quickened their rate of growth on standardized math and English language arts achievement.

Among other social-emotional measures—including student self-efficacy, social awareness, and self-management—growth mindset had the strongest effect on student achievement growth in math.[29] The role of growth mindsets may play a more important role for some students than others. Analyses of international data from the Programme for International Student Assessment (PISA) find that the benefits of having a growth mindset were greater for female, immigrant, and socioeconomically disadvantaged students.[30]

Fortunately, research shows that interventions designed to teach students a growth mindset positively impact their math outcomes, with studies finding increases in general classroom motivation;[31] math grades, particularly among lower-achieving students;[32] achievement on math standardized tests, particularly for female students;[33] and enrollment in advanced math courses following participation in growth mindset interventions.[34] While the strength of the relationship between growth mindset interventions and academic achievement continues to be debated,[35] meta-analyses find evidence that economically disadvantaged and academically high-risk students tend to benefit from these interventions, even if the effects on the overall student population are weaker.[36] One recent study also found that the impact of growth mindset interventions on students' math grades is greater when their teacher also has a growth mindset.[37]

The Importance of High-Quality Instruction

Classroom learning conditions that allow students to feel emotionally safe, supported, and able to succeed establish the necessary preconditions for deep engagement in academic learning opportunities. However, these developmentally enabling classroom conditions must be coupled with high-quality math instruction in order for students to achieve their potential and thrive as mathematical thinkers, learners, and doers.

Teacher instructional practices matter for student learning, with multiple studies finding that teacher instructional practices have a stronger relationship with student math achievement than other factors, such as the quality of their relationships with students.[38] High-quality math instruction requires students to move beyond the memorization and reproduction of algorithmic problem-solving methods. Instead, it involves "ambitious learning goals that are grounded in the expectation that all students will develop high-level thinking, reasoning, and problem-solving skills."[39]

This means that, in addition to procedural fluency, math instruction should support all learners in developing deep conceptual understanding that enables them to draw connections between different areas of math, model their mathematical thinking, strategically select methods that suit different contexts, and reason adaptively to solve challenging and authentic problems.[40] It should also give students opportunities to grapple with mathematically challenging content,[41] allow for well-structured collaboration,[42] support the flexibility of students' mathematical thinking and problem-solving,[43] leverage students' culture and experience as assets for learning,[44] and include timely evidence-based intervention when needed.[45] These practices bring students' classroom activities more in line with the actual practices of working mathematicians and communicate the expectation that all students can engage with math at a high level. Indeed, students show greater growth in math achievement when they view their teacher as academically challenging, with an especially strong relationship between challenge and academic growth in classrooms with more African American students.[46]

Conclusion

Both developmentally and cognitively, students benefit from learning math in classrooms that provide them with supportive relationships, a strong sense of belonging within the classroom and broader mathematics community, and a firm conviction in their capacity to grow their mathematical abilities through experience and practice. In such classrooms, students are better situated to benefit from high-quality math instruction. When experienced together, these positive classroom conditions set the foundation to promote math learning experiences that are characterized not by fear, but instead by the excitement of discovering mathematical relationships and grappling with challenging and meaningful problems in the context of a supportive classroom community. Positive learning conditions show promise for helping all students achieve their full potential in math. Notably, student groups that have been historically marginalized in math education—namely, female students, students of color, and students experiencing poverty—may stand to benefit most from a transition toward more developmentally nurturing classroom environments.[47] Continued investigation into how positive K–12 classroom conditions impact student math learning and how teachers can cultivate these productive environmental conditions will be an important part of developing math teaching practices that help more students find success in and beyond their math classrooms.

Endnotes

1. National Center for Education Statistics. (2023). *Condition of education: Mathematics performance*. U.S. Department of Education, Institute of Education Sciences. https://nces.ed.gov/programs/coe/indicator/cnc; Organization for Economic Co-operation and Development. (2023). *PISA 2022 Results (Volume I and II) – Country notes: United States*. https://www.oecd.org/en/publications/pisa-2022-results-volume-i-and-ii-country-notes_ed6fbcc5-en/united-states_a78ba65a-en.html

2. Lewis, K., & Kuhfeld, M. (2023). *Education's long COVID: 2022–23 achievement data reveal stalled progress toward pandemic recovery* [Brief]. Center for School and Student Progress. https://files.eric.ed.gov/fulltext/ED630208.pdf

3. Fahle, E. M., Kane, T. J., Patterson, T., Reardon, S. F., Staiger, D. O., & Stuart, E. A. (2023). *School district and community factors associated with learning loss during the COVID-19 pandemic*. Harvard University Center for Education Policy Research. https://cepr.harvard.edu/sites/hwpi.harvard.edu/files/cepr/files/explaining_covid_losses_5.23.pdf; Kuhfeld, M., Soland, J., & Lewis, K. (2022). *Test score patterns across three COVID-19-impacted school years* [EdWorkingPaper No. 22–521]. Annenberg Institute at Brown University. https://doi.org/10.26300/ga82-6v47

4. National Center for Education Statistics, National Assessment of Educational Progress (NAEP). (2024). *NAEP report card: Mathematics: Performance trends for states and districts.* U.S. Department of Education, Institute of Education Sciences. https://www.nationsreportcard.gov/reports/mathematics/2024/g4_8/state-district-trends/?grade=8

5. Gamoran, A. (2010). Tracking and inequality: New directions for research and practice. In M. W. Apple, S. J. Ball, & L. A. Gandin (Eds.), *The Routledge international handbook of the sociology of education* (pp. 213–228). Routledge; Kaufman, J. H., Steiner, E. D., & Woo, A. (2023). *The American mathematics educator study: Unraveling the formula for equitable and excellent mathematics teaching and learning*. RAND Corporation. https://www.rand.org/pubs/perspectives/PEA2836-1.html; Wolfe, R. L., Steiner, E. D., & Schweig, J. (2023). *Getting students to and through advanced math: Which students have access and how state and district leaders can help address challenges* [Research brief]. RAND Corporation. https://www.rand.org/pubs/research_briefs/RBA827-1.html

6. Cantor, P., Osher, D., Berg, J., Steyer, L., & Rose, T. (2019). Malleability, plasticity, and individuality: How children learn and develop in context. *Applied Developmental Science*, *23*(4), 307–337. https://doi.org/10.1080/10888691.2017.1398649

7. Darling-Hammond, L., Flook, L., Schachner, A., & Wojcikiewicz, S. (with Cantor, P., & Osher, D.). (2022). *Educator learning to enact the science of learning and development*. Learning Policy Institute. https://doi.org/10.54300/859.776; Osher, D., & Kendziora, K. (2010). Building conditions for learning and healthy adolescent development: Strategic approaches. In B. Doll, W. Pfohl, & J. Yoon (Eds.), *Handbook of youth prevention science* (pp. 121–140). Routledge.

8. Darling-Hammond, L., & Cook-Harvey, C. M. (2018). *Educating the whole child: Improving school climate to support student success* [Report]. Learning Policy Institute. https://doi.org/10.54300/145.655

9. Osher, D., Cantor, P., Berg, J., Steyer, L., & Rose, T. (2020). Drivers of human development: How relationships and context shape learning and development. *Applied Developmental Science*, *24*(1), 6–36. https://doi.org/10.1080/10888691.2017.1398650

10. Darling-Hammond, L., Flook, L., Schachner, A., & Wojcikiewicz, S. (with Cantor, P., & Osher, D.). (2022). *Educator learning to enact the science of learning and development*. Learning Policy Institute. https://doi.org/10.54300/859.776; Osher, D., & Kendziora, K. (2010). Building conditions for learning and healthy adolescent development: Strategic approaches. In B. Doll, W. Pfohl, & J. Yoon (Eds.), *Handbook of youth prevention science* (pp. 121–140). Routledge.

11. Young, C. B., Wu, S. S., & Menon, V. (2012). The neurodevelopmental basis of math anxiety. *Psychological Science*, *23*(5), 492–501. https://doi.org/10.1177/0956797611429134

12. Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin*, *147*(2), 134–168. https://doi.org/10.1037/bul0000307; Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33–46. https://doi.org/10.2307/749455; LeFevre, J. A., Kulak, A. G., & Heymans, S. L. (1992). Factors influencing the selection of university majors varying in mathematical content. *Canadian Journal of Behavioural Science*, *24*(3), 276–289. https://doi.org/10.1037/h0078742; Organization for Economic Co-operation and Development. (2015, February). *PISA in focus: Does math make you anxious?* [Brief]. https://www.oecd-ilibrary.org/docserver/5js6b2579tnx-en.pdf?expires=1733257016&id=id&accname=guest&checksum=E58085AC46283638034A2DEEBACE4620

13. See the report for a full description of the methods used in this literature synthesis.

14. See, for example, Fernández, L. M., Nguyen, U., & Callahan, R. (2024). Learners' mathematics identity and achievement: Where does the teacher come in? *International Journal of Mathematical Education in Science and Technology*, *55*(8), 1999–2024. https://doi.org/10.1080/0020739X.2022.2117657; Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology*, *104*(3), 700–712. https://doi.org/10.1037/a0027268; Roorda, D. L., Koomen, H. M., Spilt, J. L., & Oort, F. J. (2011). The influence of affective teacher–student relationships on students' school engagement and achievement: A meta-analytic approach. *Review of Educational Research*, *81*(4), 493–529. https://doi.org/10.3102/0034654311421793

15. Roorda, D. L., Koomen, H. M., Spilt, J. L., & Oort, F. J. (2011). The influence of affective teacher–student relationships on students' school engagement and achievement: A meta-analytic approach. *Review of Educational Research*, *81*(4), 493–529. https://doi.org/10.3102/0034654311421793

16. Fan, W., & Williams, C. (2018). The mediating role of student motivation in the linking of perceived school climate and achievement in reading and mathematics. *Frontiers in Education*, *3*, 1–12. https://doi.org/10.3389/feduc.2018.00050; Lewis, J. L., Ream, R. K., Bocian, K. M., Cardullo, R. A., Hammond, K. A., & Fast, L. A. (2012). Con cariño: Teacher caring, math self-efficacy, and math achievement among Hispanic English learners. *Teachers College Record*, *114*(7), 1–42. https://doi.org/10.1177/016146811211400701

17. Sakiz, G., Pape, S. J., & Hoy, A. W. (2012). Does perceived teacher affective support matter for middle school students in mathematics classrooms? *Journal of School Psychology*, *50*(2), 235–255. https://doi.org/10.1016/j.jsp.2011.10.005

18. Aguirre, J. M., Mayfield-Ingram, K., & Martin, D. B. (2013). Identities, agency, and mathematical proficiency: What teachers need to know to support student learning. In J. M. Aguirre, K. Mayfield-Ingram, & D. B. Martin (Eds.), *The impact of identity in K–8 mathematics learning and teaching: Rethinking equity-based practices* (p. 14). The National Council of Teachers of Mathematics; Fernández, L. M., Nguyen, U., & Callahan, R. (2024). Learners' mathematics identity and achievement: Where does the teacher come in? *International Journal of Mathematical Education in Science and Technology*, *55*(8), 1999–2024. https://doi.org/10.1080/0020739X.2022.2117657; Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology, 104*(3), 700–712. https://doi.org/10.1037/a0027268

19. Rimm-Kaufman, S. E., Baroody, A. E., Larsen, R. A. A., Curby, T. W., & Abry, T. (2015). To what extent do teacher–student interaction quality and student gender contribute to fifth graders' engagement in mathematics learning? *Journal of Educational Psychology*, *107*(1), 3. http://dx.doi.org/10.1037/a0037252

20. Goodenow, C., & Grady, K. E. (1993). The relationship of school belonging and friends' values to academic motivation among urban adolescent students. *Journal of Experimental Education*, *62*(1), 61. https://psycnet.apa.org/doi/10.1080/00220973.1993.9943831

21. Osher, D., Cantor, P., Berg, J., Steyer, L., & Rose, T. (2020). Drivers of human development: How relationships and context shape learning and development. *Applied Developmental Science*, *24*(1), 6–36. https://doi.org/10.1080/10888691.2017.1398650

22. Korpersoek, H., Canrinus, E. T., Fokkens-Bruinsma, M., & de Boer, H. (2020). The relationships between school belonging and students' motivational, social-emotional, behavioural, and academic outcomes in secondary education. *Research Papers in Education*, *35*(6), 641–680. https://doi.org/10.1080/02671522.2019.1615116

23. Walker, C. O. (2012). Student perceptions of classroom achievement goals as predictors of belonging and content instrumentality. *Social Psychology of Education*, *15*, 99. https://doi.org/10.1007/s11218-011-9165-z

24. Barbieri, C., & Booth, J. L. (2016). Support for struggling students in algebra: Contributions of incorrect worked examples. *Learning and Individual Differences*, *48*, 36–44. https://doi.org/10.1016/j.lindif.2016.04.001

25. Barbieri, C. A., & Miller-Cotto, D. (2021). The importance of adolescents' sense of belonging to mathematics for algebra learning. *Learning and Individual Differences*, *87*, 1–11. https://doi.org/10.1016/j.lindif.2021.101993

26. Dweck, C. S. (2017). *Mindset* (2nd ed.). Little, Brown Book Group.

27. See, for a review of the literature, Menon, V., & Chang, H. (2021). Emerging neurodevelopmental perspectives on mathematical learning. *Developmental Review*, *60*, 10. https://doi.org/10.1016/j.dr.2021.100964

28. Claro, S., & Loeb, S. (2024). Students with growth mindset learn more in school: Evidence from California's CORE school districts. *Educational Researcher*, *53*(7), 1–14. https://doi.org/10.3102/0013189X241242393

29. Kanopka, K., Claro, S., Loeb, S., West, M., & Fricke, H. (2024). Are changes in reported social-emotional skills just noise? The predictive power of longitudinal differences in self-reports. *AERA Open*, *10*(1), 1–21. https://journals.sagepub.com/doi/10.1177/23328584241233277

30. Organization for Economic Co-operation and Development. (2021, April). *Sky's the limit: Growth mindset, students, and schools in PISA*. https://www.oecd.org/content/dam/oecd/en/about/programmes/edu/pisa/publications/national-reports/pisa-2018/brochures/Sky-s-the-limit-pisa-growth-mindset.pdf

31. Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development*, *78*(1), 246–263. https://doi.org/10.1111/j.1467-8624.2007.00995.x

32. Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development*, *78*(1), 246–263. https://doi.org/10.1111/j.1467-8624.2007.00995.x; Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., Tipton, E., Schneider, B., Hulleman, C. S., Hinojosa, C. P., Paunesku, D., Romero, C., Flint, K., Roberts, A., Trott, J., Iachan, R., Buontempo, J., Yang, S. M., Carvalho, C. M., … Dweck, C. S. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature*, *573*(7774), 364–369. https://doi.org/10.1038/s41586-019-1466-y

33. Good, C., Aronson, J., & Inzlicht, M. (2003). Improving adolescent standardized test performance: An intervention to reduce the effects of stereotype threat. *Applied Developmental Psychology*, *24*, 645–662. https://doi.org/10.1016/j.appdev.2003.09.002

34. Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., Tipton, E., Schneider, B., Hulleman, C. S., Hinojosa, C. P., Paunesku, D., Romero, C., Flint, K., Roberts, A., Trott, J., Iachan, R., Buontempo, J., Yang, S. M., Carvalho, C. M., … Dweck, C. S. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature*, *573*(7774), 364–369. https://doi.org/10.1038/s41586-019-1466-y

35. Macnamara, B. N., & Burgoyne, A. P. (2023). Do growth mindset interventions impact students' academic achievement? A systematic review and meta-analysis with recommendations for best practices. *Psychological Bulletin*, *149*(3–4), 133–173. https://doi.org/10.1037/bul0000352; Tipton, E., Bryan, C., Murray, J., McDaniel, M., Schneider, B., & Yeager, D. S. (2023). Why meta-analyses of growth mindset and other interventions should follow best practices for examining heterogeneity: Commentary on Macnamara and Burgoyne (2023) and Burnette et al. (2023). *Psychological Bulletin*, *149*(3–4), 229–241. https://doi.org/10.1037/bul0000384

36. Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychological science*, *29*(4), 549–571. https://doi.org/10.1177/0956797617739704

37. Yeager, D. S., Carroll, J. M., Buontempo, J., Cimpian, A., Woody, S., Crosnoe, R., Muller, C., Murray, J., Mhatre, P., Kersting, N., Hulleman, C., Kudym, M., Murphy, M., Duckworth, A. L., Walton, G. M., & Dweck, C. S. (2022). Teacher mindsets help explain where a growth-mindset intervention does and doesn't work. *Psychological Science*, *33*(1), 18–32. https://doi.org/10.1177/09567976211028984

38. Blazar, D. (2015). Effective teaching in elementary mathematics: Identifying classroom practices that support student achievement. *Economics of Education Review*, *48*, 16–29. https://doi.org/10.1016/j.econedurev.2015.05.005; Fernández, L. M., Nguyen, U., & Callahan, R. (2024). Learners' mathematics identity and achievement: Where does the teacher come in? *International Journal of Mathematical Education in Science and Technology*, *55*(8), 1999–2024. https://doi.org/10.1080/0020739X.2022.2117657

39. Forzani, F. M. (2014). Understanding "core practices" and "practice-based" teacher education: Learning from the past. *Journal of Teacher Education*, *65*(4), 359. https://doi.org/10.1177/0022487114533800

40. See Lampert, M., Beasley, H., Ghousseini, H., Kazemi, E., & Franke, M. (2010). Using designed instructional activities to enable novices to manage ambitious mathematics teaching. In M. Stein & L. Kucan (Eds.), *Instructional explanations in the disciplines* (pp. 129–141). Springer. https://doi.org/10.1007/978-1-4419-0594-9_9; Lampert, M., & Graziani, F. (2009). Instructional activities as a tool for teachers' and teacher educators' learning. *Elementary School Journal*, *109*(5), 491–509. https://doi.org/10.1086/596998

41. Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester Jr. (Ed.), *Second handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 371–404). Information Age Publishing; Warshauer, H. K. (2014). Productive struggle in middle school mathematics. *Journal of Mathematics Teacher Education*, *18*, 376. https://doi.org/10.1007/s10857-014-9286-3

42. Boaler, J. (1998). Open and closed mathematics: Student experiences and understandings. *Journal for Research in Mathematics Education*, *29*, 41–62. https://psycnet.apa.org/doi/10.2307/749717; 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://doi.org/10.1177/016146810811000302; Lubienski, S. T. (2006). Examining instruction, achievement, and equity with NAEP mathematics data. *Education Policy Analysis Archives*, *14*(14), 1–30. https://doi.org/10.14507/epaa.v14n14.2006

43. Stein, M. K., Gover, B. W., & Henningsen, M. (1996). Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal*, *33*(2), 455–488. https://doi.org/10.2307/1163292

44. See, for a review of relevant literature, Abdulrahim, N. A., & Orosco, M. J. (2020). Culturally responsive mathematics teaching: A research synthesis. *The Urban Review*, *52*, 1–25. https://doi.org/10.1007/s11256-019-00509-2

45. What Works Clearinghouse. (2021). *Assisting students struggling with mathematics: Intervention in the elementary grades*. Institute of Education Sciences. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/WWC2021006-Math-PG.pdf

46. Sandilos, L. E., Rimm-Kaufman, S. E., & Cohen, J. J. (2017). Warmth and demand: The relation between students' perception of classroom environment and achievement growth. *Child Development*, *88*(4), 1321–1337. https://doi.org/10.1111/cdev.12685

47. Barbieri, C. A., & Miller-Cotto, D. (2021). The importance of adolescents' sense of belonging to mathematics for algebra learning. *Learning and Individual Differences*, *87*, 1–11. https://doi.org/10.1016/j.lindif.2021.101993; Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology*, *102*(4), 700–717. https://doi.org/10.1037/a0026659; Lewis, J. L., Ream, R. K., Bocian, K. M., Cardullo, R. A., Hammond, K. A., & Fast, L. A. (2012). Con cariño: Teacher caring, math self-efficacy, and math achievement among Hispanic English learners. *Teachers College Record*, *114*(7), 1–42. https://doi.org/10.1177/016146811211400701; Nasir, N. S., & Niral, S. (2011). On defense: African American males making sense of racialized narratives in mathematics education. *Journal of African American Males in Education*, *2*(1), 25–45; Organization for Economic Co-operation and Development. (2021, April). *Sky's the limit: Growth mindset, students, and schools in PISA*. https://www.oecd.org/content/dam/oecd/en/about/programmes/edu/pisa/publications/national-reports/pisa-2018/brochures/Sky-s-the-limit-pisa-growth-mindset.pdf; Roorda, D. L., Koomen, H. M., Spilt, J. L., & Oort, F. J. (2011). The influence of affective teacher–student relationships on students' school engagement and achievement: A meta-analytic approach. *Review of Educational Research*, *81*(4), 493–529. https://doi.org/10.3102/0034654311421793

Acknowledgments

The report on which this brief is based benefited from review by Christina Barbieri, Associate Professor of Education at the University of Delaware, and Sara Rimm-Kaufman, Commonwealth Professor of Education at the University of Virginia.

This research was supported by the Gates Foundation. Core operating support for the Learning Policy Institute is provided by the Carnegie Corporation of New York, Heising-Simons Foundation, William and Flora Hewlett Foundation, Raikes Foundation, Sandler Foundation, Skyline Foundation, and MacKenzie Scott. The ideas voiced here are those of the author and not those of our funders.

Suggested citation: Fitz, J. (with Price, H.). (2025). *Positive conditions for mathematics learning: An overview of the research* [Brief]. Learning Policy Institute. https://learningpolicyinstitute.org/product/positive-conditions-math-learning-brief

Document last revised June 16, 2025