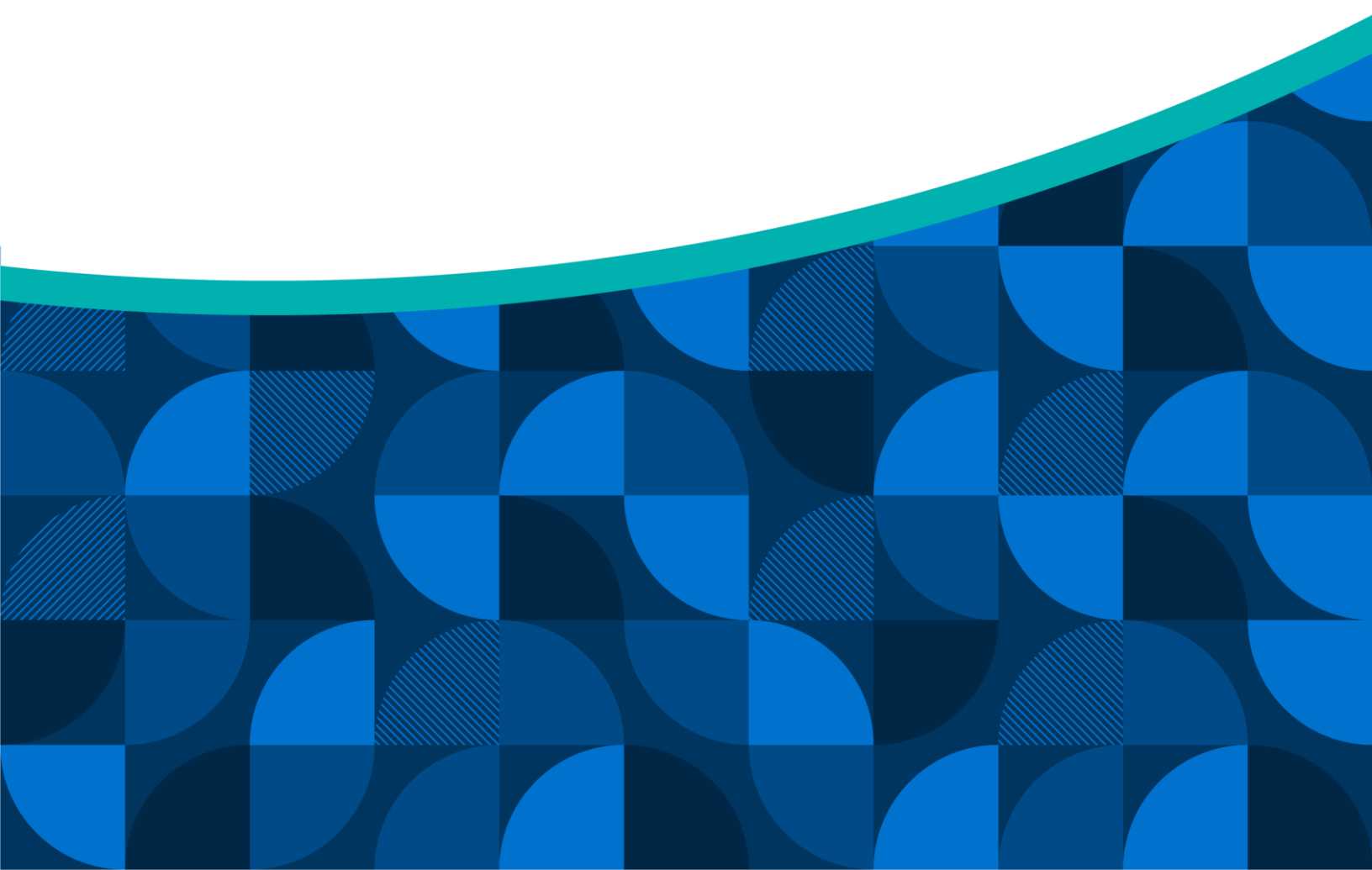




DISTRICT LEADERSHIP FORUM

Middle School Math Instruction

Research-Backed Instruction for the Classroom



District Leadership Forum

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Executive Overview

Key Observations from Our Research

COVID-19 changed the way teachers taught math, and some teachers may continue to depend on highly engaging activities that do not move the needle on test scores. As instruction moved online during the pandemic, teachers were forced to adopt new instructional strategies to make the most of uniquely challenging circumstances. To engage students with online learning, many teachers began using virtual games (e.g., Kahoot, math jeopardy) more frequently.¹ While gamification is a useful tool in math instruction to an extent, these styles of games often function more as worksheet replacement tool, and are less effective at improving test scores than other methods.

Middle school students are at a unique inflection point in their math education: they are moving from math as a practice to math as a concept. Middle school is a pivotal time in a students' math education. For the first time, students must look beyond the arithmetic they used in elementary school and begin thinking conceptually about math, which can be extremely challenging, even for students who have been strong math students in the past.²

Instruction should prioritize exploring the depth of a concept over needless repetition. Frequently, educators place too much emphasis on rote repetition in math learning, asking students to simply repeat a task to ingrain it into memory. While fluency and familiarity with a subject help students succeed in math class, particularly with understanding arithmetic and knowing how to apply it, middle school math teaching should focus on conceptual engagement with material. Strong conceptual engagement helps students apply their knowledge to other topics, making their understanding transferable and increasing their math competence and confidence.

Teachers should set the groundwork for learning by establishing knowledge, but the following activities should be interactive. Explicit instruction is fundamental to student learning, with teacher-led instruction introducing the concept to the class. After a subject is introduced, instruction should transition from being led by the teacher to being structured around student-centered activities that encourage exploration of the content. The most successful students approach new concepts by relating them to concepts they already understand, or by focusing on learning unfamiliar concepts.

Districts need to clearly communicate expectations, work with teachers, and give sufficient time to effectively roll out instructional changes in the classroom. Teachers need support through mediums such as professional development programs and teacher partnership programs from district administrators to prepare them to bring impactful instruction in math class. Districts also need to give their teachers sufficient time to implement the changes in their classrooms, ensuring that teachers are not only prepared to bring change, but can do so sustainably and effectively over the long-term goal of improving middle school students' math scores.

1) [Student engagement during the pandemic: Results of a national survey](#). (2021, October 14). *Education Week*.

2) Wakely, D. S. (2023, February 20). [OPINION: Middle school math is a unique problem that needs more attention](#). The Hechinger Report.

Research Methodology

Our research team spent twelve weeks reviewing literature on impactful math instructional strategies, including improving currently used practices, creating an environment that supports student learning, and incorporating rich learning activities. Our research team also reviewed literature on generating teacher buy-in on math instructional strategies and ways to support teachers as they incorporate these new strategies into their classroom.

The goal of this research is to identify the most high-yield math teaching practices for middle school students. In addition to reviewing literature, our research team spoke to Dr. Jen Munson, Assistant Professor of Learning Sciences at Northwestern University, to discuss rich math instructional practices. While there is no consensus in the literature as to the best math instructional practices (the way there is regarding early reading instruction), our researchers believe we have isolated the math practices with the greatest comparative evidence.³ If you have questions about the research itself or our methodology, please reach out to your dedicated advisor.

We approached our research with the following questions:

1. What are the most impactful/important math teaching strategies?
2. What is the balance between teacher-led and student-centered instruction?
3. Should teaching focus on problem solving or on math fluency?
4. What forms of constructivist/gamification activities are the most valuable?
5. How can district administrators generate teacher buy-in into new instructional practices?
6. How can district administrators support teachers as they implement new instruction practices?

3) Barshay, J. (2023, May 8). [PROOF POINTS: How a debate over the science of math could reignite the math wars](#). The Hechinger Report.

1) Math Instruction in Post-COVID Context

Math Troubles Persist Across the U.S. Following COVID-19

Math Instruction Fundamentally Changed During the COVID-19 Pandemic

Due to the abrupt closures of schools during the COVID-19 pandemic, teachers had to alter their teaching methods, often having to pivot between remote, hybrid, and fully in-person models. Teachers were forced to plan lessons around the uncertainty of learning format, technological accessibility, and attendance of their students.⁴ Students also had to contend with more distractions and uncertainties in their schooling, with many students having to manage distractions at home, with increased responsibilities to their family and siblings, and without a dedicated learning space or stable internet.⁵

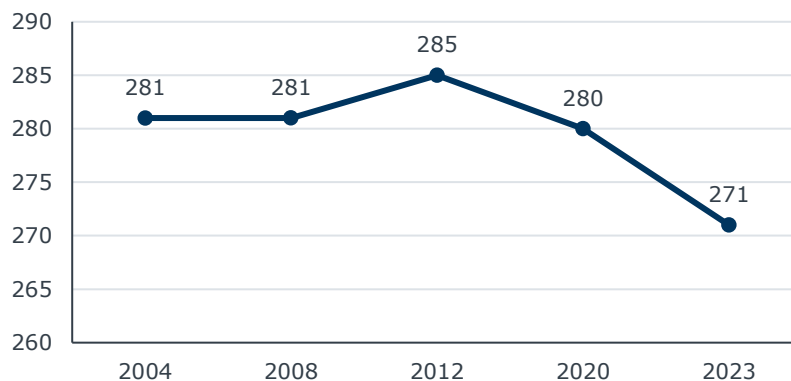
For more information on the link between student engagement and absenteeism, see EAB's [Supporting Chronically Absent Students in Returning to School](#) presentation.

The pandemic also impacted student motivation. In one November 2020 poll, half of students reported that their motivation had declined.⁶ This declining engagement poses a particular threat to student success (including absenteeism) and has forced teachers to try and find new activities that could engage disinterested students.⁷

Math Scores Are Down Nationwide, and Are Not Recovering

Eighth grade math scores are down nationwide following the COVID-19 pandemic. An assessment conducted in 2022 by the National Assessment of Educational Progress (NAEP) of the United States Department of Education found that only 26 percent of eighth grade students were proficient in math, down from 34 percent of eighth grade students in 2019.⁸ The NAEP's Long-Term Trend assessment from 2023 found similar results, with math scores declining significantly from 2019.⁹ While this decline is part of a trend across subjects, it is particularly pronounced in math, with average math scores falling by nine points between 2020 and 2023, in comparison to a four-point drop in English scores during the same time frame.¹⁰

13 Year Olds' Mathematics Average Math Scores (2004-2023)



Source: [National Assessment of Educational Progress](#) (2023)

4) Bombardieri, M. (2021, April 15). [Covid-19 changed education in America—Permanently](#). POLITICO.

5) [Student engagement during the pandemic: Results of a national survey](#). (2021, October 14). Education Week.

6) Ibid.

7) Infantino, Joe. [Preventing chronic absenteeism](#). (2018). EAB.

8) Mervosh, S., & Wu, A. (2022, October 24). [Math scores fell in nearly every state, and reading dipped on national exam](#). The New York Times.

9) [NAEP long-term trend assessment results: Reading and mathematics](#). (n.d.).

10) Collin, B. [Math and reading scores for American 13-year-olds plunge to lowest levels in decades](#). (2023, June 21). AP News.

Math is fundamental to children’s success, both as students and as they begin to navigate the world. Many consider math to be the most important subject students learn in school, with 92 percent of Americans believing that math is somewhat or very useful for K-12 students to learn.¹¹ Math is increasingly important in the workforce: a 2014 study found that 70 percent of all occupations considered mathematical knowledge to be either very important or extremely important,¹² with the Bureau of Labor Statistics also predicting that math-related careers would increase four times over the average job sector rate from 2014 to 2024.¹³

Given math’s importance, many experts are extremely concerned about the post-pandemic decline in math proficiency. But even more concerning than the initial drop in scores is their slow recovery rate. While there is evidence indicating that math scores have begun to increase after the steep decline immediately following the start of the COVID-19 pandemic and the shift in learning formats, with some states reporting small upticks in math scores, math grades have improved at an incredibly slow rate. Experts have warned that recovery will be a multiyear, or even potentially decades-long, process that will require schools to rethink how to best educate their students.¹⁴

But Math Teaching Remains Stuck in the COVID Era

This large-scale learning loss has left teachers with the task of not only teaching students new material, but recovering learning loss and bringing up math grades to pre-pandemic levels. Teachers also must contend with a rise in absenteeism and behavior issues among students following the return to in-person learning. As a result, many teachers began looking for teaching strategies that could be done online or asynchronously, and that were highly engaging for students.

However, while these activities may be more engaging, they are not always effective at encouraging student learning. Many common games and activities are not optimized to support rich learning, often relying on simple repetition or rote memorization. Our researchers share math teaching strategies that value depth, use interactive learning, and make the most of limited class time.

For techniques to address student misbehavior, see our report [Improving Student Behavior in Middle Schools](#).

11) Dumitru, O. (2023, August 31). [Which school subjects do Americans say are most relevant to their lives?](#) YouGov.
12) Anthony P. Carnevale, Smith, N., & Strohl, J. (2013). [Recovery: Job Growth and Education Requirements Through 2020](#). Georgetown Public Policy Institute Center on Education and the Workforce.
13) [The Math Gap: Implications for Investing in America's Workforce](#). (2017). Luminary Labs.
14) Hollingsworth, H., & Thompson, C. (2023, July 11). [Test scores show American students slipping further behind despite recovery efforts](#). AP News.

2) The Value of Depth

Building Understanding, Not Just Memorization

Middle Schoolers Are in a Unique Place in their Mathematical Education

Middle school is a time of unique changes and challenges for students. In addition to the rapid cognitive changes that early adolescents experience, which present new social and emotional challenges, students are faced with increasingly complicated school subjects, particularly in math.¹⁵ Students need to not only master certain concepts, such as fractions and decimals,¹⁶ but also tackle more complex equations and functions over time.¹⁷ Additionally, many students see a reduction in support in learning math at home, as their parents and guardians feel less confident with the more complex concepts and unable to support their children, meaning that a student's success will almost completely rely on teaching they receive while in the classroom.¹⁸

Algebraic thinking is an entirely new way to conceptualize math. While numbers in arithmetic appear naturally in the world around us and are familiar to students, algebra requires students to think qualitatively about numbers, rather than quantitatively with numbers ([source](#)).

A student's success in middle school math class determines their success in every math class they will take down the line.¹⁹ If middle schoolers do not have a full grasp of basic arithmetic, they will struggle to build knowledge and to succeed in later math classes.²⁰ In addition to demonstrating technical mastery over arithmetic, students must simultaneously begin thinking about math conceptually, building the logic, reasoning, and problem-solving skills that are essential for success in high school math.²¹

Prioritize Teaching that Encourages Conceptual Engagement

There is a common misconception that mathematics learning is solely based on the basic memorization of facts.²² While memorization does play a role in mathematics learning, contributing to students working memory and their "ability to temporarily store and manipulate information" that allows students to quickly recall numerical information,²³ full math fluency depends on the students' ability to develop number sense.

International testing has long shown that countries which focus on developing a number sense achieve better outcomes than those that focus on memorization. The 2012 Program for International Student Assessment (PISA) categorized students approach to math in three learning styles, with some students reporting that they primarily relied on memorization to learn math, explaining that they learn new topics by repeating problems over and over. These memorizing-based learners scored lowest on the assessment in all participating countries.²⁴

In addition to performing worse on assessments, memorization-based approaches such as timed tests and flash card learning have been found to increase anxiety in students. Despite this, American schools routinely present mathematics as series of steps that students need to memorize and apply.²⁵

15) Yoder, S. (2023, January 6). [Inside the new middle school math crisis](#). *Washington Post*.

16) Wakelyn, D. S. (2023, February 20). [OPINION: Middle school math is a unique problem that needs more attention](#). The Hechinger Report.

17) Yoder, S. (2023, January 6). [Inside the new middle school math crisis](#). *Washington Post*.

18) Ibid.

19) Wakelyn, D. S. (2023, February 20). [OPINION: Middle school math is a unique problem that needs more attention](#). The Hechinger Report.

20) Ibid.

21) Ibid.

22) Boaler, J., Munson, J., & Williams, C. (2019). [Mindset mathematics: Visualizing and investigating big ideas, grade 7](#). John Wiley & Sons.

23) Barnes, K. (2020). [Effectiveness of Number Sense Instruction and Memorization of Math Facts](#).

24) Zoido, J. B., Pablo. (2016, November 1). [Why math education in the U.S. Doesn't add up](#). *Scientific American*.

25) Ibid.

The PISA analysis included two other categories: students approached new concepts by relating them to concepts they already understand, and “self-monitoring” students who routinely evaluated their own understanding and focused on concepts they had not yet learned. Students who used these two approaches significantly outscored the memorizers, showing understanding of concepts six months to one year ahead of memorizers.²⁶

Use Tasks that Emphasize Deep Understanding Over Task Repetition

During our research, our team concluded that a deep dive into a single, complicated question can be more impactful than the repetition of a high number of simple questions. Spending more time on a single problem allows students to work through each step of finding the solution and develop a stronger comprehension of each phase.²⁷ In contrast, drill-like worksheets with lots of short questions can increase stress and math anxiety in students,²⁸ which prevents students from accessing the skills they need to solve a problem in the short term, and later reduces the likelihood of finishing graduate school or entering science, technology, engineering, and math careers.²⁹

To help students gain a deeper understanding of mathematical concepts, teachers should avoid needless repetition. Instead of asking students to solve 40 questions during a class period, teachers should instead dedicate the class time to a small selection of questions, or even just one single question.

Example Exercise: Complex Fractions³⁰



Have students work through one complex fraction instead of a worksheet of many simple fractions. Work through sample problems as a class until students show understanding, then ask students to work on problems in groups or as a class.

Example:

$$\frac{\frac{3}{4}}{\frac{1}{2}}$$

Incorporating Classroom Activities that Lead to Deep Learning

Use Rich, Interactive Activities to Encourage Deep Understanding of Mathematical Concepts

Good mathematics learning should involve deep, rich tasks. These tasks should engage students and stimulate discussion between the teacher and their students. The goal of rich activities is to be interesting enough that students will continue to try to solve it, even if it feels difficult.³¹ Highly engaging activities have positive impacts

26) Zoido, J. B., Pablo. (2016, November 1). [Why math education in the U.S. Doesn't add up](#). Scientific American.

27) Munson, J. (2023, November 29). Interview With Jen Munson, Assistant Professor, Learning Sciences (C. Rock & K. View, Interviewers) [Zoom].

28) Ibid.

29) Kirsten, W. (2023, August 15). [How to help kids manage math anxiety](#). American Psychological Association.

30) Munson, J. (2023, November 29). Interview With Jen Munson, Assistant Professor, Learning Sciences (C. Rock & K. View, Interviewers) [Zoom].

31) Gojak, L. (n.d.). [A Key to Deep Understanding: The Importance of Rich Tasks in K-12 Mathematics](#).

One theory behind students' lack of engagement is technology. Sixty-five percent of students reported experiencing distraction from digital devices during math lessons on the 2022 PISA ([source](#)).

on student achievement and have been shown to keep students interested in learning. Teachers across the various subjects know that it is challenging to keep students motivated, engaged, and concentrated over a long class period. This lack of interest and engagement often results in reduced learning outcomes, with students scoring lower on major tests.³²

Rich, open-ended tasks help develop a students' "growth mindset," which inspires students to believe that their intelligence develops as they learn more. Students who developed their growth mindset tend to outperform their peers with a "fixed mindset" who believe that their intelligence is at a fixed level.³³ Students with a growth mindset had a more significant gain in achievement than their peers.³⁴

While rich activities should be challenging, they should also be accessible to all students in the class. Rich tasks can be made achievable by offering various "entry points," or different angles or methods of approaching the problem and can be scaled up or down depending on the students' grasp of the material.³⁵ Tasks should also be able to be stretched to allow for higher levels of exploration for students who quickly grasp the concepts. These "low floor, high ceiling" tasks allow students of all knowledge levels to participate.³⁶

Preparing for rich activities:³⁷



Do the task yourself before using it in class.



Identify questions and statements you can ask or say to the class to help guide students who are stuck.



Identify supplies and tools students will need to complete the activity.

Rich activities should accommodate different methods and allow for multiple paths to the solution. This allows students to approach and complete the problem in their own way, encouraging deeper thinking.³⁸ These tasks transform math from a series of procedures to a more complex "whole," making math more interesting for students. Rich math activities help students figure out how to apply practices to a wider range of situations.³⁹

32) Alf Inge Wang & Rabail Tahir. (2020). [The effect of using Kahoot! for learning – A literature review](#). Computers & Education.

33) Boaler, J., Dieckmann, J. A., LaMar, T., Leshin, M., Selbach-Allen, M., & Pérez-Núñez, G. (2021). [The transformative impact of a mathematical mindset experience taught at scale](#). *Frontiers in Education*, 6.

34) Ibid.

35) Gojak, L. (n.d.). [A Key to Deep Understanding: The Importance of Rich Tasks in K-12 Mathematics](#).

36) Boaler, J., Munson, J., & Williams, C. (2019). [Mindset mathematics: Visualizing and investigating big ideas, grade 7](#). John Wiley & Sons.

37) [Low Floor High Ceiling Tasks](#). (n.d.).

38) Munson, J. (2023, November 29). Interview With Jen Munson, Assistant Professor, Learning Sciences (C. Rock & K. View, Interviewers) [Zoom].

39) Hewson, S. (2011). [What is a mathematically rich task?](#) University of Cambridge.



Example Rich Activity: 1492 Challenge

Have students find an equation that gives the numbers 1 to 100 as the answer using each of the digits 1, 4, 9, and 2 only once.

Students may use any of the following operations: square root, factorials, exponents, decimals, parentheses, negative numbers, addition, multiplication, subtraction, division.

Teachers may share examples to get the ball rolling.

Examples:

$$1 = 9 - (2 * 4 * 1), \text{ or } (9 - 1) / (4 * 2)$$

$$2 = 9 - (4 * 2) + 1, \text{ or } (-2 * 4) + 9 + 1$$

$$3 = 1 * (9 - 4 - 2), \text{ or } 9 / (4 - 1^2)$$

Students may work separately or in groups. Have students share their equations and compile all of the different paths found.

Activities should be based in worlds that are relevant and understandable to students. Remember that activities that are relevant to the teachers' world may not be relevant to the students: while problems using miles per gallon are related to real world activities, the concept may still seem intangible to students who cannot drive. Choose problems and activities that are tied to regular experiences for the students' ages, such as snack grocery store prices or video game probabilities.



Example Rich Activity: Grocery Store Calculations

Take students on a "grocery store trip" to teach calculations like fractions. Ask students to find the best value for an item by comparing the weight, cost, and cost per weight.

Chips Bag A: \$5.49, 12oz

Chips Bag B: \$4.29, 8oz

Chips Bag C: \$4.79, 10oz

Rich activities can also include hands-on activities. Hands-on learning activities that are built on other forms of instruction deepen students' understanding of the course material. The use of physical manipulatives in math creates concrete representations of the concepts being learned, making the concept easier to grasp.⁴⁰ Hands-on activities can be particularly helpful for middle school students, as math becomes increasingly abstract as students move into Algebra I.⁴¹

Hands-on learning activities may include creating visual representations of data in charts or graphs, building out physical shapes using blocks or paper, using physical

40) Salifu, A. S. (2022). [The Effects of Balance Model and Algebra Tiles Manipulative in Solving Linear Equations in One Variable](#). *Contemporary Science and Mathematics Education*.

41) Forrest, F., & Herring-Watson, J. (2023, July 13). [Offering hands-on learning experiences in middle school math](#). Edutopia.

measuring tools to compare different objects, or using puzzles. Teachers can also use digital programs to help students visualize concepts.

While digital apps can be used to teach probability, teachers should use physical examples as much as possible to ground the concept in something tangible ([source](#)).

Example Hands-on Activity: Dice Probability⁴²



What is the likelihood that a certain number will be shown when a single dice is rolled?

Have students guess how many times they'll get the number 4. What fraction of the total rolls will that number be? Ask students why.

Next, set the students in pairs or groups and have the students roll the die and track how many times each number is rolled. Did each number appear equally? If not, why?

Next, combine the totals for all of the teams. Among all teams, how many times did each number appear? What fraction of the total rolls did each number appear?

⁴²) [Probability with Dice](#). (n.d.). PBS LearningMedia.

3) Interactive Learning

Bringing Students into the Learning Process by Doing, Not Just Telling

Use Explicit Instruction to Introduce Key Topics, But Avoid a Lecture-only Format

In explicit instruction (also known as systematic instruction) teachers lead students with modeling, guided practice, and independent practice, sharing feedback with students regularly throughout the process.⁴³ Teachers also regularly pose questions to individuals and the group, asking students to demonstrate their understanding of the topic being discussed.⁴⁴ Explicit instruction includes three key components: clear and concise teacher demonstrations, regular opportunities for students to practice, and timely academic feedback from teachers.⁴⁵

Teachers should use explicit instruction to establish goals and introduce models and activities. The duration of direct instruction should vary depending on the activity at hand. This time can be used to introduce new mathematics vocabulary and concepts, to reconnect with previously learned relevant knowledge, and to model activities or sample math problems. Information should be presented material in small, digestible steps to avoid overwhelming students,⁴⁶ and to make sure that the lesson's information is thoroughly shared.

Good, thorough instruction takes time. One study found that the most effective math teachers spent about 23 minutes of their 40-minute class period on lecture, demonstration, and working through example questions.⁴⁷ The increased time spent on initial explanation and answering questions reduces the likelihood that teachers will have to reexplain and rework through the problem at later stages of the class, allowing students to make continuous progress.

However, explicit instruction should not be just a lecture.⁴⁸ While it should be led by the teacher, instruction should not only involve the teacher. Teachers should regularly pause to take questions from students, as well as to pose their own questions to their students to evaluate understanding of the lesson.⁴⁹ The teacher should not just perform problems step by step and expect students to follow their exact process.⁵⁰ Instead, teachers should encourage students to approach the problem their own way. This ensures that students can "discover" the process that leads to the solution themselves rather than having it handed to them by their teacher.

Support 'Productive Struggle' to Encourage Students' Thorough Understanding of a Concept

Learning math is not just about students getting the solution, but about them figuring out the process of getting to that solution. Teachers can support learning by encouraging "productive struggle" and supporting their students as they work to try and understand the problem. Instead of learning passively, as they would during a lecture, students become actively involved in the learning process.

43) *Direct Instruction: Math*. (n.d.). University of Kansas.

44) Doabler Ph.D., C. T., Baker, Ph.D., S. K., Kosty, B.S., D. B., Smolkowski, Ph.D., K., Clarke, Ph.D., B., Miller, Ph.D., S. J., & Fien, Ph.D., H. (2015). *Examining the Association Between Explicit Mathematics Instruction and Student Mathematics Achievement*. *The Elementary School Journal*.

45) Ibid.

46) Rosenshine, B. (2012). *Principles of Instruction: Research-Based Strategies That All Teachers Should Know*. *American Educator*.

47) Ibid.

48) *High-Impact Instructional Practices in Mathematics*. (2020). Queen's Printer for Ontario.

49) Rosenshine, B. (2012). *Principles of Instruction: Research-Based Strategies That All Teachers Should Know*. *American Educator*.

50) Andrews University. (n.d.). *The Effective Mathematics Classroom*. *Algebra Readiness, Cycle 1*.

This active involvement supports deeper understanding of a concept. Real deep learning does not happen by watching others do the work, but by the students doing the work themselves. Learning happens during the struggle.⁵¹ Struggling through finding the solution and being more actively involved gives students more responsibility, encourages more interaction, and allows them to receive more feedback that helps thorough learning.⁵²

Tasks that support productive struggle should be relevant, engaging, and should not be overly scaffolded. Tasks should also be highly cognitively demanding and allow for different ways of thinking. Tasks should also not be timed so as not to rush students as they work through tricky problems.⁵³

Ways to Support Productive Struggle in the Classroom⁵⁴

Use these methods in the classroom to encourage perseverance and thinking:

- 1 Call on students who may not have the correct answer and guide them by questioning their thinking.
- 2 Give students descriptive feedback and provide context to help students navigate towards the solution.
- 3 Praise students for persevering through problem solving, not just for being smart.
- 4 Share examples of students' work that shows creative problem solving.

Guiding Students to Learning

Support Knowledge Retention by Starting the Period with Review

Beginning the day's math class with a review of previous learning is a fundamental component of instruction. Classes should begin with five to eight minutes of review of previous material, with a particular emphasis on the review of concepts that are relevant to the day's lesson.⁵⁵ This helps students refamiliarize themselves with previous material and freshen understanding before they tackle problems of.

Teachers can use this time to check over homework and discuss problems that were difficult for students, and to review newly acquired knowledge that needs continued practice.⁵⁶ Regular review helps students become more comfortable with the content at hand, and make recollection of the material more automatic, with students in classrooms that regularly begin with review scoring higher achievement scores than students in other classrooms.⁵⁷

Use Guided Math to Teach to Every Student's Level

There will always be some variation in student instructional level in mathematics, making teaching to the larger class difficult. Educators can section classes into smaller, flexible groups, enabling the teacher to teach to each group's instructional

51) Boaler, J., Munson, J., & Williams, C. (2019). *Mindset mathematics: Visualizing and investigating big ideas, grade 7*. John Wiley & Sons.

52) *Flipped classroom*. (n.d.). The University of Texas at Austin Center for Teaching and Learning.

53) *Teaching with rich math tasks*. (n.d.). San Francisco Unified School District Mathematics.

54) Valentine, K. D., & Bolyard, J. (2018). *Creating a Classroom Culture that Supports Productive Struggle: Pre-service Teachers' Reflections on Teaching Mathematics*.

55) Rosenshine, B. (2012). *Principles of Instruction: Research-Based Strategies That All Teachers Should Know*. *American Educator*.

56) Ibid.

57) Ibid.

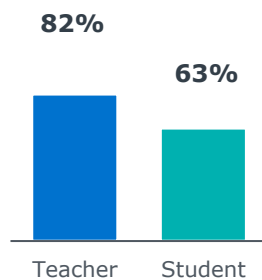
level. These smaller groups allow for more personalized and individualized help for students,⁵⁸ even as classroom sizes continue to grow.⁵⁹

Students who learn with the guided math instructional model tend to perform better on assessments than their peers in a whole-group (i.e., traditional teacher-directed) instructional model. In a series of controlled studies, students who participated in guided math had their post-test results increase more than the students in the traditional group.⁶⁰

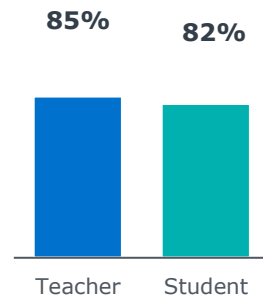
Teacher and Student Perceptions of Guided Math

*From Guided Math in the Classroom*⁶¹

Guided math instruction has given me a deeper understanding of the content.

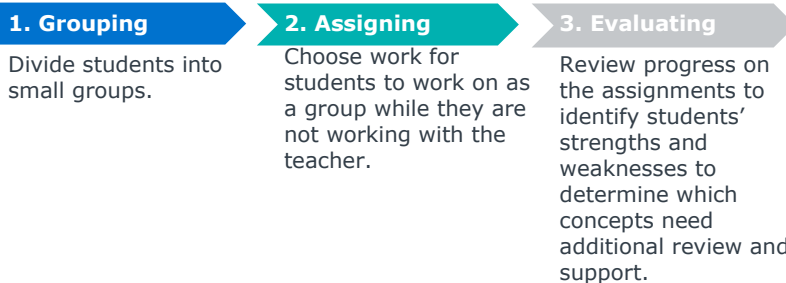


Guided math instruction is better, more effective than traditional instruction.



The exact form of guided math changes with the type of task being conducted during the class session. Guided math generally avoids basic worksheets and instead favors interactive exploration of material.⁶²

The Steps to Implementing Guided Math Learning⁶³



Determining Small Groups for Guided Learning to Maximize Learning

For more information on creating effective small groups, see EAB's [Skills-Based Grouping Toolkit](#).

Teachers can use small groups in guided math to stimulate active learning by creating opportunities for interaction and conversation between students. When grouping students, teachers may choose to group students "homogeneously," in which students work with others of similar achievement levels, or "heterogeneously," in which students work with others of mixed achievement levels.⁶⁴

58) Hollas, Ph.D., T., Coyne, Ph.D., J., Lane, Ph.D., M., & Nickson, Ph.D., L. (2018). [Guided Math in the Classroom](#). *Journal of Education and Social Development*, 2(2), 36–39.

59) Newton, N. (n.d.). [Guided Math in Action: Six Components to Making It Work](#). McGraw Hill Education.

60) Hollas, Ph.D., T., Coyne, Ph.D., J., Lane, Ph.D., M., & Nickson, Ph.D., L. (2018). [Guided Math in the Classroom](#). *Journal of Education and Social Development*, 2(2), 36–39.

61) Ibid.

62) Newton, N. (n.d.). [Guided Math in Action: Six Components to Making It Work](#). McGraw Hill Education.

63) Cloyd, K. (2020). [Guided Math: Best Practice for the General Education Classrooms](#) [Master's Theses & Capstone Projects, Northwestern College, Iowa].

64) Thomas, E., & Feng, J. (2014, October). [Effects of Ability Grouping on Math Achievement of Third Grade Students](#). Georgia Educational Research Association Annual Conference, Savannah, Georgia.

Both homogeneous and heterogeneous groupings have advantages: with homogeneous groups teachers may give students harder stretch tasks that challenge them, and with heterogeneous groups students who have a stronger grasp on the material may be given leadership roles to assist their classmates with the topic, and in turn assess their own understanding of the material.⁶⁵ Research is divided on whether one form of grouping is better, with some studies finding that heterogeneous groups perform better on assessments, others that homogeneous groups perform better, and others finding that there is no noteworthy statistical difference at all.⁶⁶

As each type of grouping has its advantages, teachers may use heterogeneous and homogeneous grouping to achieve a specific goal. If the teacher needs to give specific students additional support, they may use homogeneous skill-based grouping to spend more time with struggling students, while simultaneously allowing other students work at an appropriate instructional level and allows the students to learn at a pace that works for them.⁶⁷ Additionally, these small groups allow teachers to tailor math instruction to students at different levels.

Build Scaffolding to Support Continuous Learning

Scaffolds are instructional supports that are specifically built into a lesson and designed to provide students with support that is “just right” and “just in time.”⁶⁸ When used correctly, scaffolding boosts students’ understanding of and confidence in the course material. In general, scaffolding is a support that both leads to a students’ immediate construction of knowledge, and provides a foundation of knowledge that will the act as the basis of future independent learning.⁶⁹ Teachers should build scaffolding by asking questions that prompt student thinking or help them work through their understanding of the material.⁷⁰

Scaffolding should not simply provide the answer to the question. Instead, scaffolding should allow the student to solve a problem that would otherwise be too challenging to complete on their own.⁷¹ Scaffolding may include models or examples of similar problems that students can reference when solving other problems, or steps that can be used to solve the problem.

Scaffolding can also be structured in a way that the teacher does not have to be present with the student – in both individual and group work. A study conducted in 2014 found that scaffolding in group work can be particularly helpful for students, with comparisons of results from groups of students that use scaffolding to those that do not show that scaffolding can significantly improve student achievement. Students in the study also shared that they could more effectively start problems and gained more confidence when working with others.⁷²

65) Thomas, E., & Feng, J. (2014, October). [Effects of Ability Grouping on Math Achievement of Third Grade Students](#). Georgia Educational Research Association Annual Conference, Savannah, Georgia.

66) Černilec, B., Cotić, M., Felda, D., & Doz, D. (2023). [Differences in students’ mathematics knowledge in homogeneous and heterogeneous groups](#). *European Journal of Science and Mathematics Education*.

67) Cloyd, K. (2020). [Guided Math: Best Practice for the General Education Classrooms](#) [Master’s Theses & Capstone Projects, Northwestern College, Iowa].

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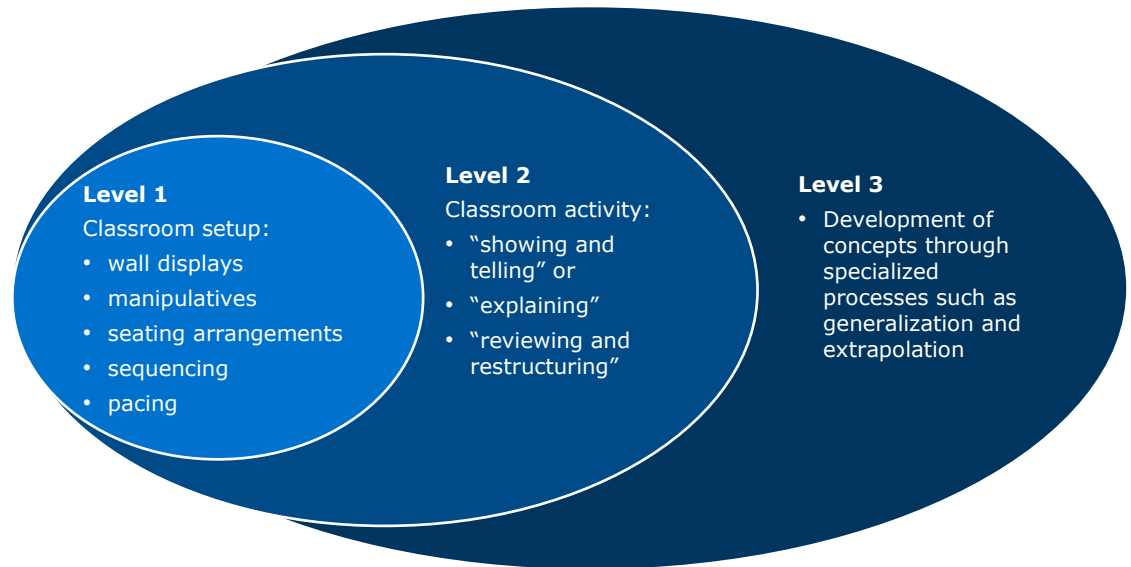
70) McCosker, N., & Diezmann, C. (2009). [Scaffolding Students’ Thinking in Mathematical Investigations](#). *Australian Primary Mathematics Classroom*, 14(3).

71) Ibid.

72) Frederick, M. L., Courtney, S., & Caniglia, J. (2014). [With a Little Help from My Friends: Scaffolding Techniques in Problem Solving](#).

Levels of Scaffolding

From *Investigations in Mathematics Learning*⁷³



Reinforce Learning with Practice to Solidify Understanding

Practice helps students work on their “fluency” of the topic, helping them become more familiar and more comfortable with the material.⁷⁴ Fluency from practice makes processes more automatic, and is key for basic operations such as fractions. Practice also significantly increases students’ retention of knowledge.⁷⁵ This automaticity is particularly important in middle school: middle school math is a transitional period, with students transitioning from learning basic arithmetic to learning more conceptual algebra.

In class, teachers can follow guided learning with independent practice, where they supervise and engage with students working alone on pre-set problems. During in-class practice, teachers should circulate throughout the classroom and check on student work. Teachers should not have to spend extensive time with students during independent practice. Necessary reexplanations of entire processes to the student likely indicates that the material was not discussed thoroughly enough during guided learning.

⁷³Frederick, M. L., Courtney, S., & Caniglia, J. (2014). [With a Little Help from My Friends: Scaffolding Techniques in Problem Solving](#).

⁷⁴Rosenshine, B. (2012). [Principles of Instruction: Research-Based Strategies That All Teachers Should Know](#). *American Educator*.

⁷⁵Brabeck, PhD, M., Jeffrey, PhD, J., & Fry, MA, S. (n.d.). [Practice for knowledge acquisition \(Not drill and kill\)](#). American Psychological Association.

4) Making the Most of Class Time

Rich Interaction Over “Worksheet Replacement”

Construct an Interactive Learning Environment that Encourages Participation

A good math classroom is a loud classroom. As with other subjects, interaction and discourse are fundamental to learning. Students should rarely sit silently, but instead ask questions and participate, and discuss tasks and approaches with their peers.⁷⁶

Good math classrooms create opportunities for students to participate in math discussions. These math “conversations” encourage students to engage in meaningful discussions that deepen understanding of a topic. Students can discuss ideas with a partner, with a small group, or with the larger classroom.⁷⁷

Teachers should consistently engage with students, creating ongoing conversation and interaction. From an outside perspective, the teacher should be almost imperceptible, interacting so much with the students that they blend into the classroom.⁷⁸ This creates a classroom environment that fosters innovative thinking and makes students feel open to asking questions when they need help.

Promoting participation in the classroom⁷⁹



Warm Ups

Start class with a warm-up question that students can discuss with a partner or in small groups.



Explanation

Ask students to explain their thinking and reasoning.



Reflection

Ask students to think about what they have learned.



Interactive Activities

Use activities that require students to collaborate and communicate with each other.

76) Munson, J. (2023, November 29). Interview With Jen Munson, Assistant Professor, Learning Sciences (C. Rock & K. View, Interviewers) [Zoom].

77) [High-Impact Instructional Practices in Mathematics](#). (2020). Queen's Printer for Ontario.

78) Munson, J. (2023, November 29). Interview With Jen Munson, Assistant Professor, Learning Sciences (C. Rock & K. View, Interviewers) [Zoom].

79) Jones, T. (2023, May 1). [3 simple ideas to encourage math talk](#). SMART Technologies.

Avoid Overreliance on Games to Encourage New Learning

Math games are one of the most common teaching techniques, with 56% of teachers reporting regularly using math games ([source](#)).

When used effectively, math games positively impact student performance. The gamified approach to math has been proven to have positive impacts on in-classroom behavior.⁸⁰ Gamification creates opportunities for students with different math abilities to participate and encourages peer collaboration in team-based activities.⁸¹ Students in classrooms that regularly utilize games have reported less anxiety and ask more questions than peer students in traditional classrooms.⁸²

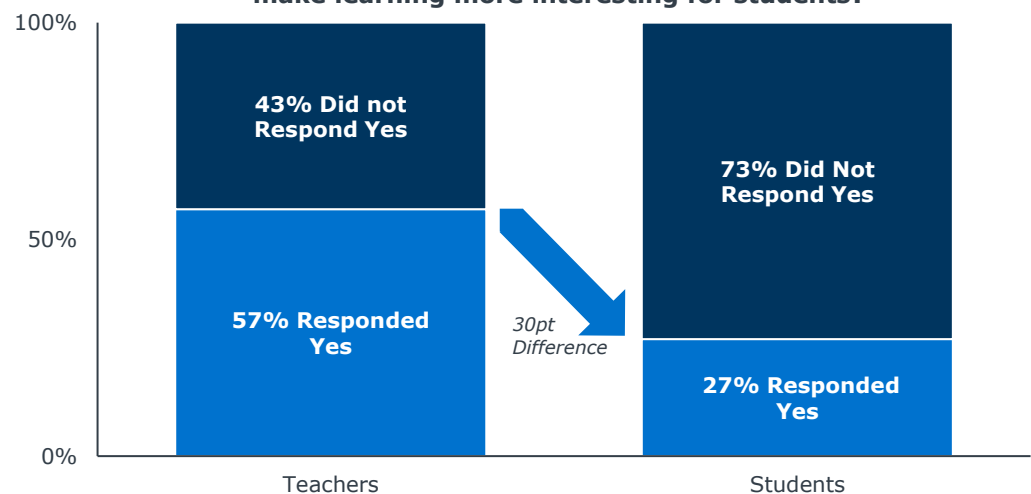
The Positive Impact of the Gamified Approach⁸³

- ✓ Increased class attendance
- ✓ Increased timeliness
- ✓ Improved classroom dynamics
- ✓ Higher final grades

However, while games may immediately increase interaction, engagement declines as the novelty of the game wears off. If overused, the games that seem exciting at first, such as Kahoot or Math Jeopardy, become mundane.⁸⁴ In reality, these games are most similar to a worksheet, with the same memorization-based task being repeated.⁸⁵ This repetition of the activity may ultimately lead to student boredom, which is associated with poorer learning and problem behavior.⁸⁶

There is also a potential misalignment in the perception of how the use of games can increase engagement and interest in students. During the pandemic, more than half of teachers who increased their use of digital games said that games made learning more interesting for their students. But only 27 percent of students reported that an increase in the use of games made learning more interesting.⁸⁷

Did including more digital games during remote learning make learning more interesting for students?



Source: [Education Week Research Center](#) (2021)

80) [5 benefits of gamification](#). (2015, September 18). Smithsonian Science Education Center.

81) Onder, K., & Aslihan Kuyumcu, V. (2021). [The effect of gamification on young mathematics learners' achievements and attitudes](#). *Journal of Educational Technology & Online Learning*, 4(2).

82) Alf Inge Wang & Rabail Tahir. (2020). [The effect of using Kahoot! for learning – A literature review](#). *Computers & Education*.

83) Ibid.

84) Munson, J. (2023, November 29). Interview With Jen Munson, Assistant Professor, Learning Sciences (C. Rock & K. View, Interviewers) [Zoom].

85) Lai, A. (n.d.). [A Study of Gamification Techniques in Mathematics Education](#). Harvard University.

86) Wang, A. I. (2015). [The wear out effect of a game-based student response system](#). *Computers & Education*, 82, 217–227.

87) [Student engagement during the pandemic: Results of a national survey](#). (2021, October 14). *Education Week*.

Additionally, many math games are based on the use of previously learned concepts rather than new ideas. While these review-based games can be useful in familiarizing students with the concept, they can stall the progress of learning. These sorts of activities can be used to reinforce learning, but should be avoided as a method of teaching.

Provide Feedback to Outline a Path for Learning Growth

Use Feedback to Guide and Correct Students

Teachers should regularly provide feedback to students during lessons and activities to update students on their progress. This immediate feedback should be given as soon as the student makes the mistake, and with time allowed for the student to fix the mistake.⁸⁸ Immediate feedback improves students' acquisition and retention of material and helps prevent unproductive struggling that delays learning without deepening the learning process.⁸⁹ Students who receive immediate corrective feedback on homework score higher on later assessments than students who received delayed feedback.⁹⁰ Feedback that is given too late may also be difficult for the student to connect to the original task.⁹¹

Feedback should go beyond telling a student whether an answer is right or wrong. Good feedback is corrective and descriptive, offering an explanation as to why something is right or wrong.⁹² Descriptive feedback should generally be framed positively, and should offer specific information about what the student needs to work on and steps they should take to improve.⁹³

Use Formative Assessments to Gauge Student Progress

Teachers can use formative assessments, such as regular tests and quizzes, observations, and notes on student discussions and comments to gauge student progress. Unlike standard assessments, formative assessments should not be counted towards a student's grade and should only be used to evaluate material students may need to be retaught.⁹⁴ Teachers may then review results, either independently or collaboratively with peer teachers, to track student and classroom progress. Formative assessments are especially useful in identifying and addressing learning loss.



Avoid Timed Tests to Avoid Increasing Anxiety

While assessments are an effective tool for measuring student progress, teachers should forgo timed tests. Timed tests increase stress, which reduces the brain's capacity for working memory. The use of timed tests, particularly in the younger years, often contributes to math anxiety among students ([source](#)).

88) Vanderbeek, G. (2007). [Improving the Effectiveness of Independent Practice with Corrective Feedback](#) [Action Research Projects, University of Nebraska - Lincoln].

89) Ibid.

90) Johnston, K. (2015). [The Effects of Immediate Correctness Feedback on Student Learning, Understanding, and Achievement](#) [University of Wisconsin - Superior].

91) [Importance of providing meaningful student feedback](#). (n.d.). University of South Carolina Center for Teacher Excellence.

92) Barry, V. J. (2008). [Using Descriptive Feedback in a Sixth Grade Mathematics Classroom](#) [Action Research Partnerships, University of Nebraska-Lincoln].

93) [Communicating student learning: Information for parents and caregivers](#). (n.d.). British Columbia Ministry of Education and Child Care.

94) Barry, V. J. (2008). [Using Descriptive Feedback in a Sixth Grade Mathematics Classroom](#) [Action Research Partnerships, University of Nebraska-Lincoln].

5) Generating Teacher Buy-In

Communicating Goals with Teachers

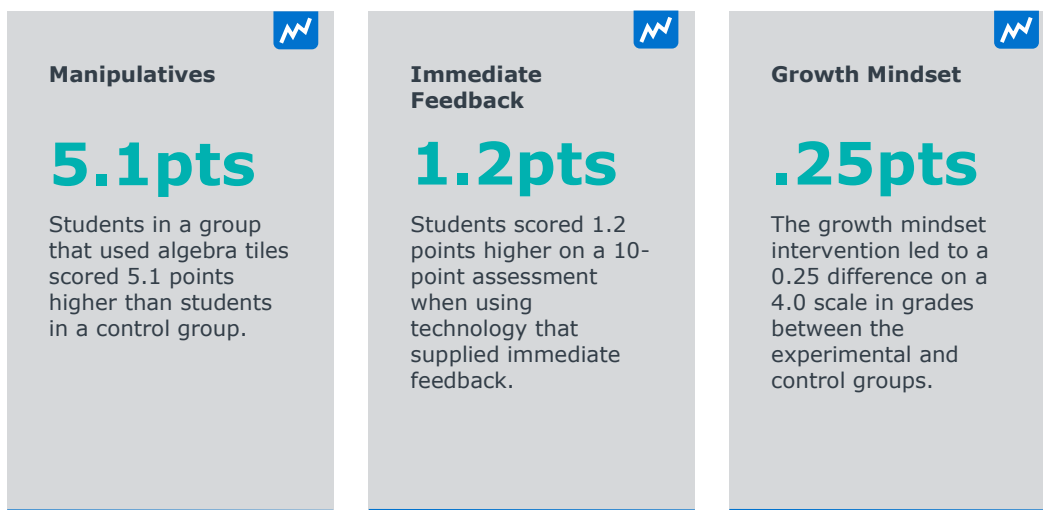
Communicate to Teachers Why New Teaching Practices Are Necessary

Teachers are sometimes hesitant to get on board with new changes and innovations in education, such as curriculum updates, revised protocols, or classroom environment expectations. It is not enough for teachers to simply comply with these changes; ideally, they should be invested in implementing them effectively.⁹⁵ To ensure successful implementation, administrators must first make sure that the new innovations are researched-back and knowledge-based. It is essential for teachers to perceive the changes as beneficial and necessary for student learning.

To gain teacher buy-in, administrators should highlight the limitations of the current approach to teaching and use specific examples when proposing changes. By discussing the issues with the current system with full transparency, administrators can help teachers understand the need for improvements and rally behind the new initiative, increasing the likelihood of acceptance of the proposal by teachers.⁹⁶

Administrators can ensure successful implementation of new innovations by evaluating their necessity, explaining the flaws of the current system, and involving teachers in decision-making processes. By doing so, they can encourage teachers to embrace and implement changes effectively by moving beyond a culture of mere compliance.⁹⁷

Impact of Moving Toward High-Impact Instruction



Create an Open Dialogue Between Teachers and Administrators

An open dialogue between teachers and administrators gives teachers the opportunity to pose questions, as well as giving administrators the chance to address any

⁹⁵Ayres, A. T. (2023, January 26). [3 ways to ensure teacher buy-in for big changes](#). Edutopia.
⁹⁶Miller, K. (2020, March 19). [5 critical steps in the change management process](#). Harvard Business School.
⁹⁷Lee, L. (2019, October 5). [For leaders, getting real buy-in for school initiatives](#). Edutopia.

apprehension that teachers may have. Administrators can foster a sense of empowerment among teachers by involving teachers in the decision-making process.

Offering teachers some level of choice and control over the changes encourages them to take on the new challenge. This approach is particularly useful when selecting new curricula, as even limited input from teachers strengthens the chances of successful implementation.⁹⁸

Providing Support for Teachers

Provide Professional Development to Support Teachers as They Adopt New Approaches

Once educators have been presented with new teaching techniques, districts will need to train their teachers to use them in the classroom. Teachers may initially struggle with new approaches and will need time to familiarize themselves with the techniques and practices. Offering consistent professional development should help teachers feel more supported and confident in what their teaching. Structured professional development focused on bringing new mathematics teaching activities into the classroom will support teachers as they become more comfortable with new teaching practices.

A study by the National Center for Education Evaluation and Regional Assistance found that the most effective math teacher professional development programs include intensive math content courses, supported by follow-up workshops. These intensive courses took place over the summer, with the follow-up workshops focused on designing lessons around the content from the summer course. Involvement in this professional development program led to a significant improvement in student math achievement.⁹⁹

Create Teacher Mentoring Programs to Support Training Efforts

Professional development programs can also use teacher “math ambassadors” who receive training from the district and mentor teachers in their buildings.¹⁰⁰ Experienced and knowledgeable teachers are a valuable source of effective math teaching techniques. More experienced teachers can also act as a resource for sharing strategies and activities for rich mathematics learning.

Teacher mentoring programs are particularly useful for new teachers who have entered the field in the post-pandemic learning environment. Administrators can provide new math teachers with teaching coaches to offer more personalized training and support as they work to enact new teaching methods in the classroom.¹⁰¹

Additionally, encouraging mentoring helps foster a sense of community and support. Teachers may feel isolated as they take on the challenge of increasing math achievement, and creating partnerships between teachers creates a support network for teachers.

98) MacGillis, A. (2023, June 19). [Can America's students recover what they lost during the pandemic?](#) ProPublica.

99) Gersten, R., Taylor, M. J., Keys, T. D., Rolhus, E., & Newman-Gonchar, R. (2014). [Summary of research on the effectiveness of math professional development approaches](#). National Center for Education Evaluation and Regional Assistance.

100) Schwartz, S. (2023, February 6). [What professional development for math teachers should look like](#). Education Week.

101) Jariswal, Sarjana. [Standardizing teacher-support coaching practices](#). (2019). EAB.

Components of successful teacher mentoring programs¹⁰²



1:1 Meetings: Mentors regularly meet individually with mentees. Meeting frequency can decrease as time goes on to prevent taking up too much teacher time.



Classroom Observations: Mentors observe mentees' teaching and provide feedback. Mentees may also observe their mentors' teaching, or other teachers'.



Mentor-led Group Professional Development: Designated leaders or mentors organize professional development opportunities.



Written Reflections: Mentees write regular reflections and discuss them with their mentors.

Encourage Teacher Collaboration to Create a Cohesive Learning Path for Students

For more information on the effectiveness of teacher collaboration, see EAB's [Professional Learning Communities \(PLC\)](#) brief.

Instead of working independently to create teaching programs for their own classes, teachers should work together to formulate activities. Schools with higher levels of collaboration saw higher levels of student achievement.¹⁰³ Studies indicate that teachers that engage in "group instructional practice," during which they prepare for instruction together and participate in co-teaching and observation, had better student achievement.¹⁰⁴

Collaboration between teachers creates paths and supports learning that continues through the course levels, following students as they advance from one grade to the next. Teachers across the grade levels need cohesive teaching methods, ensuring that students are not only familiar with the necessary concepts in later years, but with learning approaches as well.

Give Teachers Time to Enact Changes in Pedagogy Styles to Bring Sustainable Grade Improvement

Solutions that effectively support sustained grade improvement will not be immediate. It takes time to enact meaningful change, and demanding immediate results may lead to unsustainable grade improvement measures or increase teacher burnout.

102) Berger, Michelle. [New teacher mentorship programs](#). (2019). EAB.
103) Ronfeldt, M., Farmer, S. O., McQueen, K., & Grissom, J. A. (2015). [Teacher Collaboration in Instructional Teams and Student Achievement](#). *American Educational Research Journal*.
104) Ibid.

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