Education Research Brief

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Testing New Approaches to Math Tutoring: Lessons from Eight Evaluations

Purpose of this brief

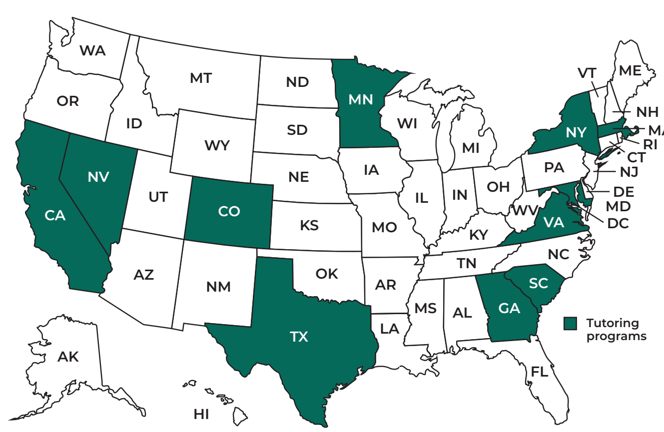
This brief presents results from a series of evaluations that examined the effects of eight tutoring programs on students' math knowledge and explored tutoring participants' math perceptions.

Key takeaways:

- Multiple tutoring approaches, including group and virtual tutoring, can boost math knowledge and may improve students' math confidence and sense of belonging.
- The size of programs' effects on student knowledge aligned with the quality of their implementation. Programs with moderate to large effects had high student attendance, the necessary staffing, and logistics such as scheduling in place. Those with smaller effects encountered challenges implementing core components and had lower student attendance, on average.
- Strong student–tutor relationships may be a key component of successful tutoring. In programs with high attendance and positive effects on learning, a large share of students reported strong relationships and a sense of belonging in their tutoring sessions.

Education organizations, tutoring providers, funders, and researchers can use these takeaways to inform decisions on funding, implementing, and studying tutoring programs.

Educators, policymakers, and families face an unprecedented challenge in supporting students to overcome the effects of the COVID-19 pandemic, which was particularly harmful for math learning. Recent research found that grade 8 math achievement on the National Assessment of Educational Progress fell by roughly three-quarters of a grade level from 2019 to 2022, on average (Fahle et al., 2023). Math tutoring has proven to be an effective strategy to boost students' math outcomes (Nickow et al., 2020), and many believe tutoring is one of the most promising strategies to combat pandemic-related learning loss (Robinson et al., 2021). However, offering traditional one-on-one in-person tutoring to all students who need it is cost prohibitive, and more evidence is needed on tutoring models that can reduce cost, address staffing challenges, and serve a greater number of students.



The Bill & Melinda Gates Foundation Middle Years Math (MYM) Portfolio

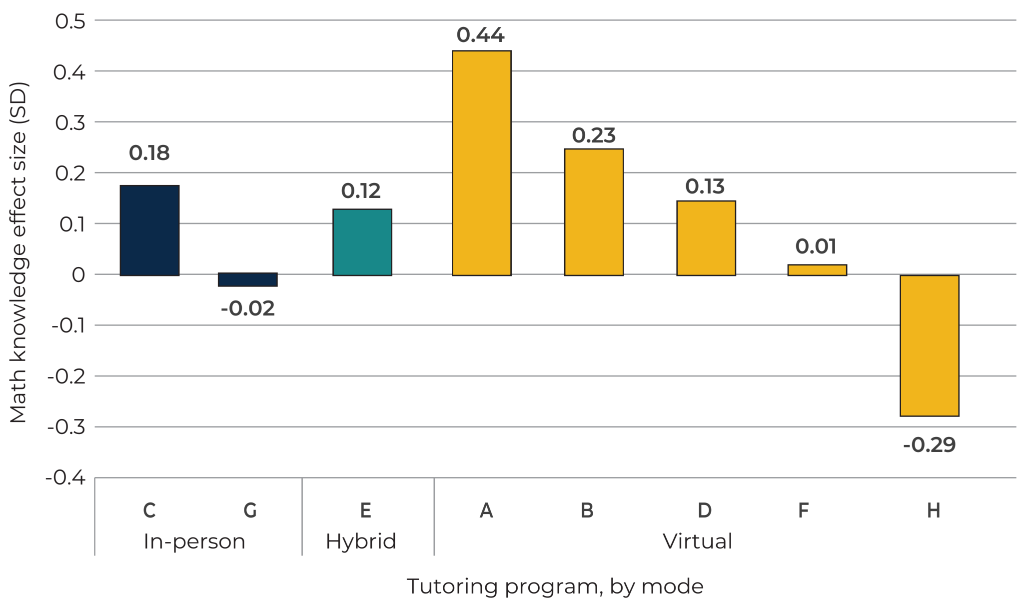
This project provided grants to education providers to co-design and test programs for improving student outcomes. The portfolio's goal is for all students who are Black, Latino, and/or experiencing poverty to deeply **know**, be able to **use**, and **enjoy math** by the time they reach high school.

This brief presents results from evaluations of eight tutoring programs that piloted alternative tutoring approaches, such as virtual and group tutoring, among diverse groups of students in grades 4 through 10 during the 2021–2022 school year. The studies assessed the effects of the tutoring programs on students' math test scores, examined student–tutor relationships and students' sense of belonging in tutoring, and measured changes in participants' math confidence. We explore patterns of findings from across the eight studies using a descriptive approach. These descriptive findings can help inform decision making of those working to improve access to effective tutoring—such as tutoring providers, schools and districts, and grantmakers. They also highlight areas for future research—such as student–tutor relationships and the effectiveness of alternative tutoring approaches at scale.

Student math knowledge

Overall, the tutoring programs had positive and meaningful effects on students' math knowledge, and multiple models showed promise (Figure 1).[1] Five of the eight tutoring programs demonstrated moderate to large (Kraft, 2020) average effects on students' math test scores (ranging from 0.12 to 0.44 standard deviations). As a reference, Reardon (2011) estimated that one standard deviation (SD) is equivalent to

Figure 1. Effects of tutoring programs on math knowledge, by mode of delivery



Source: Student math assessments

Notes: Seven of eight studies used standardized tests such as the i-Ready Math assessment, the Renaissance Star math assessment, or the NWEA Measures of Academic Progress (MAP) assessment; the other study used a provider-developed assessment of fractions.

Program identifiers (A-H) are assigned in order of effect size.

[1] Throughout this brief, we refer to "effects" as the difference in math test scores between the students receiving tutoring and comparison students. The studies varied in rigor, and two studies that compared gains on test scores against a national sample do not have causal evidence of an effect.

approximately three to six years of math learning in middle and high school.[2] The size of the effects of the tutoring programs did not appear to be related to specific program features, such as mode of delivery (virtual or in person), tutoring group size, or tutor characteristics. Instead, all the tutoring programs with moderate to large effects on math knowledge were successfully implemented—these programs had high student attendance and the necessary staffing and logistics in place. When tutoring providers encountered challenges that affected their ability to implement core program components, such as recruiting and retaining tutors and getting students to complete assignments, the effects on student math knowledge tended to be lower.

Multiple tutoring approaches showed promise.

Previous evidence demonstrated that high-dosage, in-person tutoring offered to students one-on-one or in small groups could produce large effects on students' math knowledge (Nickow et al., 2020). The pilot studies that are the focus of this brief explored whether alternative tutoring approaches that used different group sizes, staffing models, and modes of delivery could still produce strong effects on students' math achievement. We hypothesized that the effects of tutoring would be lower for programs that used larger tutoring groups, volunteer-based tutoring, and virtual tutoring. However, we did not observe clear patterns linking these program characteristics with the efficacy of the tutoring programs (Figure 2).

Virtual tutoring programs can be effective at improving students' math knowledge. Four of the six virtual or hybrid tutoring programs produced moderate to large effects on students' math knowledge. The successful virtual tutoring providers used interactive interfaces and engaging tutors. The providers that delivered virtual group tutoring deliberately created group norms that encouraged interaction among students and fostered positive and culturally responsive learning environments.

Figure 2. Program features and effects on math knowledge across tutoring programs

Tutoring program	Improvement in math knowledge (standard deviation)	Virtual delivery mode	Tutoring group size (number of students per tutor)	Staffing model (paid, AmeriCorps, volunteer, teacher)	High dosage
Program A	0.44	✔	4	$	✔
Program B	0.23	✔	1		
Program C	0.18		2 or 3	$	✔
Program D	0.13	✔	3 or 4	$	✔
Program E	0.12	✔	2 to 10	$	✔
Program F	0.01	✔	2	$	
Program G	-0.02		4	$	✔
Program H	-0.29	✔	1		

Source: Program data and student math assessments

[2] Reardon (2011) estimated that on average, students improve about 1.2 to 1.5 standard deviations from grade 4 to grade 8 and 0.6 to 0.7 standard deviations from grade 9 to grade 12., based on an analysis of the National Assessment of Education Progress scores.

Group tutoring is a viable alternative to one-on-one tutoring. There was no clear pattern between the number of students in the tutoring group and the size of the effect on students' math knowledge. Many of the providers whose programs had moderate to large effects on student math knowledge tutored students in groups—ranging in size from two to 10 students, depending on the program.

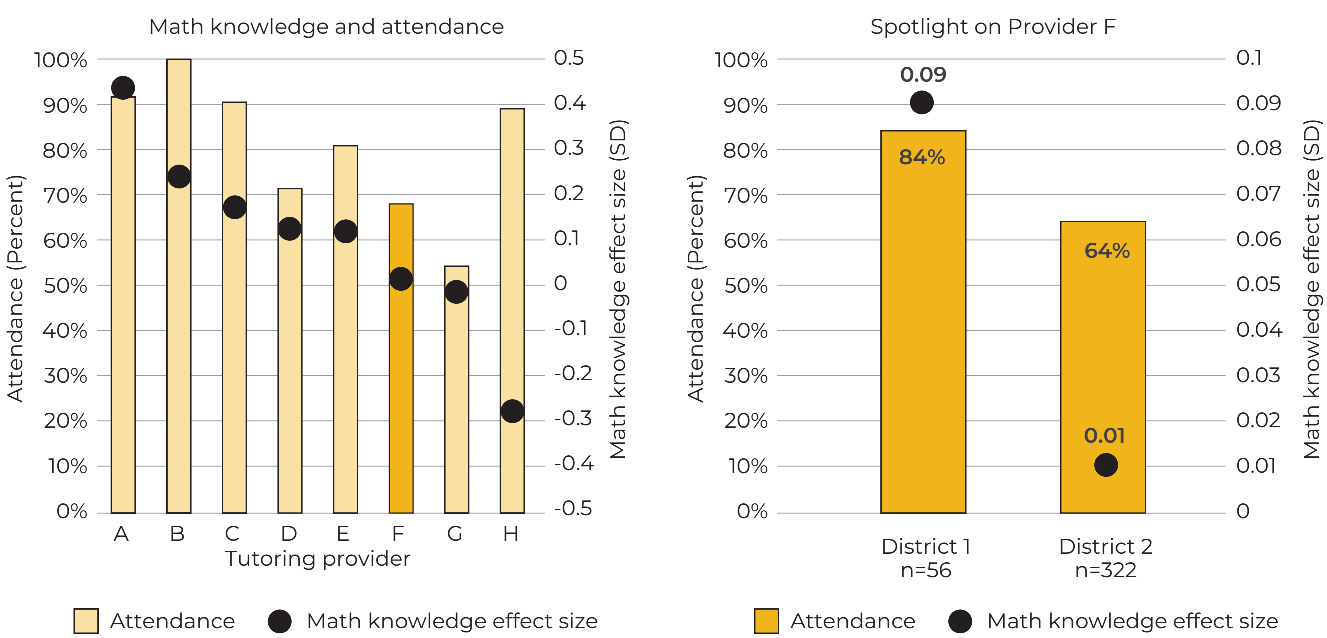
Many types of tutors can support strong math learning for students. Tutoring providers successfully used many different staffing models—experienced teachers, paid tutors, AmeriCorps fellows, and volunteers. Providers that used tutors with less experience—AmeriCorps fellows and volunteers—tended to use scripted lessons and have robust systems of tutor training and support.

Most of the effective tutoring models were high dosage. Four of the five tutoring programs with moderate to large effects offered high-dosage tutoring that was provided two to five times per week for 30 minutes to one hour (a minimum of 90 minutes per week). The fifth tutoring program was a different model that offered on-demand tutoring with incentives for weekly participation in tutoring sessions; results of this program were promising, but additional research is needed to precisely estimate its effectiveness and learn which students participate in and benefit from this type of tutoring.

Higher attendance was related to larger effects on math knowledge.

Across the tutoring programs, attendance in tutoring sessions and effects on math knowledge were strongly related (Figure 3). The one exception is Tutoring Program H, which is an after-school homework-help program that focused on several subjects—not exclusively math. Students in Tutoring Program H regularly attended tutoring, but because they spent limited tutoring time on math, we would not expect this program to have effects on students' math outcomes. Leaving this program aside, the correlation between a program's average attendance rate and average effect on math knowledge was 0.79.[3]

Figure 3. Student attendance rates and effects on math knowledge across tutoring programs (left) and across districts using one tutoring program (right)



Source: Student attendance in tutoring and student math assessments

A similar pattern emerged when looking at variation in attendance and math knowledge results across districts served by a single provider. In the district with relatively high attendance, Tutoring Program F had a substantially larger effect on students' math knowledge than the district with lower attendance. The strong relationship between attendance and math achievement is intuitive—students need to be present to learn. However, attendance rates were low primarily in programs with challenges implementing core components; missing program components also could have led to smaller math effects.

Tutoring conducted during the school day had higher student attendance and was associated with larger improvements in math knowledge.

On average, attendance rates in tutoring programs offered during the school day were 12 percentage points higher than rates in tutoring programs offered after school (83 percent versus 71 percent). This difference in attendance was also apparent within one tutoring program that operated in school at some schools and after school at others: the in-school tutoring had higher attendance than the after-school tutoring (by 15 percentage points). This tutoring provider reported that students in the after-school program were less engaged and more likely to leave before the lesson was over due to conflicting commitments or parent pickup schedules.

The average effect on math knowledge was also much higher among in-school programs than after-school programs. The in-school tutoring programs had an average effect of 0.18 standard deviations (a moderate to large effect), while the after-school programs had no effect on students' math knowledge, on average.

Math confidence

Confidence in math can predict longer-term student outcomes, such as pursuit of a college major in science, technology, engineering, and math (STEM) areas (Moakler & Kim, 2014). After adjusting for test scores, students with higher math confidence tend to persist in STEM more than those with lower math confidence. Across the eight studies, most programs showed small increases in student self-reported math confidence, based on a survey administered at the beginning and end of the program.

Improvements in students' math knowledge are associated with improvements in reported math confidence.

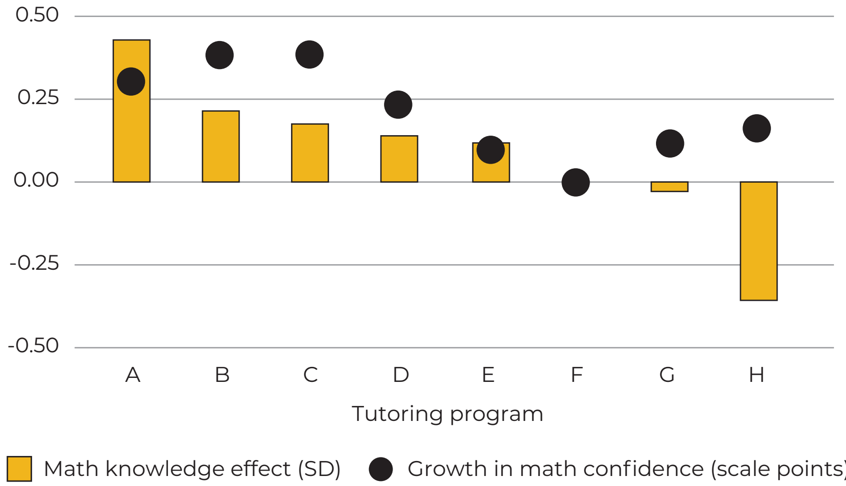
Tutoring programs with the largest increases in student confidence also had the highest effects on math knowledge (Figure 4). Changes in math confidence were based on a student survey that included a series of math confidence questions such as "How certain are you that you can learn everything taught in math?," with responses on a 5-point scale. Growth in math confidence was correlated with positive effects on math knowledge. However, for a few programs, the link between increases in math confidence and math knowledge effects did not hold; in these cases, students reported increased confidence, on average, without a corresponding positive math knowledge effect. Given prior research on the potentially complex relationship between math confidence and learning (see, for example, Ganley & Lubienski, 2016), these mixed findings underscore the need for further research on the relationship between these outcomes.

Student–tutor relationships

Earlier studies have hypothesized that student–tutor relationships may be an important mechanism through which tutoring improves student outcomes (Nickow et al., 2020). Across seven tutoring providers that measured relationships, students' ratings of their relationship with their tutor were positively correlated with math knowledge gains, attendance, and sense of belonging in the tutoring program. Tutoring providers in these studies used a range of strategies to foster strong relationships.

[3] Positive correlations can range from 0 to 1. We consider a high correlation to be above 0.7, a moderate correlation between 0.5 and 0.7, and a low correlation below 0.5 (Hinkle et al., 2003).

Figure 4. Effects on math knowledge and growth in math confidence, by tutoring program



Source: Student survey data and student math assessments

Note: Math knowledge effects and changes in math confidence are on the same scale for simplicity, but the units are different: math knowledge effects are displayed in standard deviations, while math confidence changes are displayed as points on a 5-point scale.

Relationship-building strategies

- Recruiting tutors with similar backgrounds to students served
- Recruiting tech-savvy tutors with engaging personalities for virtual tutoring positions
- Providing tutors robust culturally responsive or trauma-informed training
- Incorporating morale-boosting or team-building activities for students. ◢

Remote tutors built strong relationships with their students in a virtual setting.

Given the hypothesized importance of strong relationships to effective tutoring, a key question in these studies was whether remote tutors would be able to forge strong relationships with their students in virtual or hybrid settings.

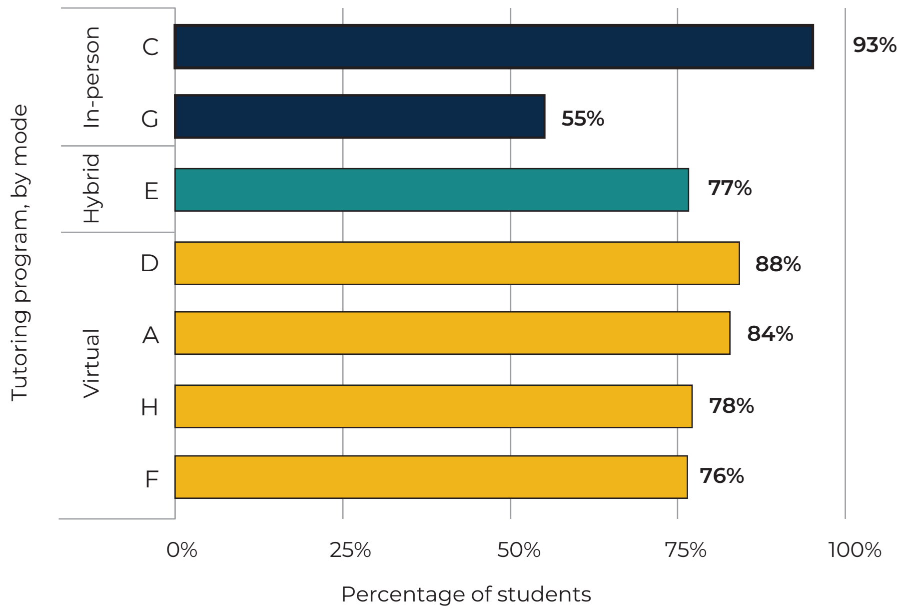
The results indicate many virtual tutors were successful at building strong relationships with their students. Tutors in virtual and hybrid models forged positive relationships with students, with 76 to 88 percent of students reporting strong relationships with their tutors (Figure 5). We defined strong relationships as students agreeing or strongly agreeing with a set of statements such as "My tutor cares about my life outside of school." There was no clear pattern linking relationship strength with in-person versus virtual or hybrid delivery.

Student–tutor relationships, math learning, and attendance appear to be linked.

We hypothesized that strong relationships would be an important component in tutoring programs leading to improved math knowledge, based on previous research (see, for example, Gehlbach et al., 2016). The results of the studies that are the focus of this brief provided additional evidence to support this link. Among tutoring programs focusing on math instruction (all except Tutoring Program H), those with larger effects on math knowledge also had higher shares of students reporting strong relationships with their tutors (Figure 6).

The link between student–tutor relationships and attendance in tutoring sessions was also strong: in programs that had higher student attendance, a larger share of students reported strong rela-

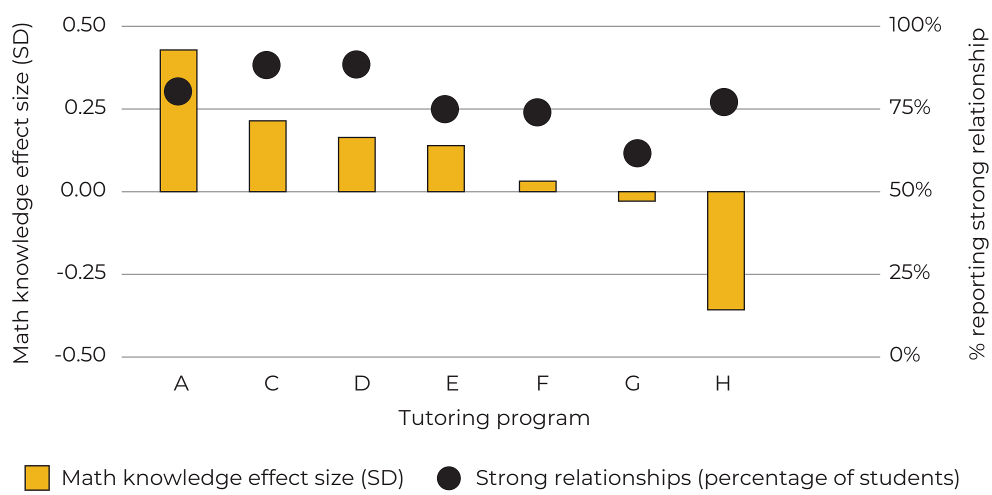
Figure 5. Share of students reporting strong relationships with tutors, by mode of delivery



Source: Student survey data collected at the end of tutoring

Note: Program B was an on-demand tutoring program, and tutors were not consistent over time. Therefore, Program B did not measure student-tutor relationships and is excluded from this analysis.

Figure 6. Effects on math knowledge and share of students reporting strong relationships with their tutors, by tutoring program



Source: Student survey data collected at the end of tutoring and student math assessments

Note: Program B did not measure student-tutor relationships and is excluded from this analysis. The correlation between effects on math knowledge and percentage of students reporting strong relationships = 0.58 (excluding Program H).

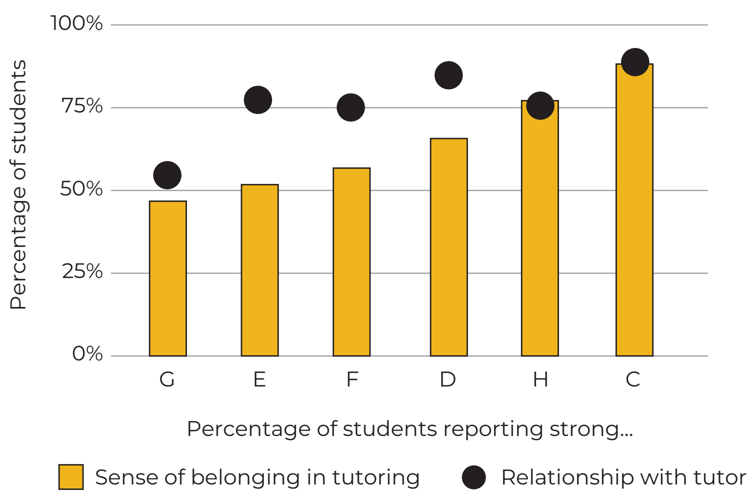
Program H was excluded because it is a homework-help program that focused on several subjects—not exclusively math.

tionships with their tutors. It is not clear whether positive student–tutor relationships help improve attendance or whether students' presence in tutoring sessions is necessary for them to develop strong relationships with their tutors, but strong student–tutor relationships could be effective levers in driving students to attend tutoring and thus to learn more through increased exposure to tutoring.

The strength of student–tutor relationships was associated with students' sense of belonging in tutoring.

Tutoring programs with high percentages of students reporting strong relationships with their tutors also had high percentages of students reporting a strong sense of belonging in the tutoring program (correlation is 0.81; Figure 7). We define a strong sense of belonging as agreeing or strongly agreeing with statements on the end-of-year survey, such as "I feel comfortable sharing my thoughts and opinions in my tutoring sessions." This link is logical, given that the strategies that tutors and programs use to foster strong relationships may also boost students' sense of belonging. These include recruiting tutors with similar backgrounds to students, using culturally responsive strategies, and encouraging participation and interaction between students. In addition, a student's relationship with their tutor could be an important component of their sense of belonging.

Figure 7. Share of students reporting strong relationships with their tutors and strong sense of belonging, by tutoring program



Source: Student survey data collected at the end of tutoring

Note: Programs A and B did not measure students' sense of belonging in tutoring, and Program B did not measure student-tutor relationships; therefore, they are excluded from this analysis. The correlation between percentage of students reporting strong sense of belonging and percentage of students reporting strong relationships = 0.81.

Takeaways

- Districts and funders seeking to expand access to tutoring should consider group and virtual options in light of growing evidence of their effectiveness.
- In this set of studies, attendance was closely linked to improvements in math knowledge and student–tutor relationships. Tutoring providers, schools, and districts should closely monitor program attendance in an ongoing way and explore methods to boost attendance, including delivering tutoring during the school day.
- Tutoring providers, schools, and districts may also want to incorporate relationship-building strategies into tutoring offerings. Although results from these studies do not prove that strong relationships between students and tutors are driving gains in math learning, the link between these outcomes suggests that building strong relationships may at least complement other instructional strategies.
- Future research can explore the mechanisms of student–tutor relationships and how they may improve students' attendance and math knowledge. In addition, the studies that contributed to this brief are small in scale, and future research can explore whether providers operating virtually and delivering group tutoring are able to expand their programs and maintain positive effects on students' math outcomes. These studies documented but did not investigate the role of other important tutoring features, such as the use of supplemental AI-driven online learning platforms and the alignment between the curriculum providers used and the school's math curriculum. Future research should examine these and other features as well.

Evaluation methods

Methods for student math knowledge

The eight pilot studies used various methods to estimate the effects of the tutoring programs on student math knowledge. The study sample sizes of the combined treatment and comparison groups ranged from 99 to 1,273 students, and most studies had about 200 to 300 students.

- Three studies used randomized controlled trials, where participants were randomly selected from an eligible pool of students. One study took place in a single district, one took place in two districts, and a third was outside of school across multiple geographic areas. In two of these studies, comparison students participated in business as usual, or what they would have received in absence of the tutoring. The third study compared students who were randomly assigned to receive an incentive to participate in tutoring to other students who could access the tutoring but did not receive the incentive; in practice, this compared a higher versus lower dosage of the tutoring.
- Three studies used quasi-experimental designs to compare tutoring students to similar comparison students in a single district (one study) or across two districts (two studies). In all three of these studies, students in the comparison group participated in business as usual.
- Two studies measured gains on an assessment, compared to expected growth of a national sample of students.

Seven of eight studies used standardized tests such as the i-Ready Math assessment, the Renaissance Star math assessment, or the NWEA Measures of Academic Progress (MAP) assessment; the other study used a provider-developed assessment of fractions knowledge.

Methods for student perceptions

All eight studies administered surveys to students participating in the tutoring programs. The surveys measured students' perceptions of their relationship with their math tutor, sense of belonging in their math tutoring sessions, and math confidence. The student survey drew from several existing scales: the relationship scale came from the PERTS Copilot-Elevate measure and/or a Search Institute–developed relationships instrument; the math confidence scale was drawn from the Patterns of Adaptive Learning Scale; and the belonging scale was drawn from the Copilot-Elevate survey (Bruch et al., 2022). For students who participated in tutoring, we examined the average change in math confidence over the program, as well as their assessment of their relationship with their tutor and sense of belonging at the end of the program.

Summarizing findings across studies

In this brief we describe patterns of findings from across the eight studies, drawing on average estimates for each outcome of each program, as well as the program-level correlations across outcomes. We also include some qualitative information on tutoring implementation, where available. ◢

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Findings from this project are also described in:

- Selecting and Supporting Math Tutoring Programs: Recommendations for School Districts
- Examining Student and Teacher Math Learning: Lessons from Three Summer Programs
- Air Tutors' Online Tutoring: Math Knowledge Impacts and Participant Math Perceptions
- Blueprint Math Fellows Tutoring Program: Math Knowledge Impacts and Participant Math Perceptions
- Breakthrough Collaborative's Tutoring Program: Math Knowledge Gains and Participant Math Perceptions
- Cignition Group Tutoring: Impacts on Students' Math Knowledge and Perceptions
- Impacts of UPchieve On-Demand Tutoring on Students' Math Knowledge and Perceptions
- Math Corps' Tutoring Program: Math Knowledge Impacts and Participant Math Perceptions

Mathematica has also released the Measurement and Evaluation Toolkit used for this project, which is available at https://mathematica.org/features/advancing-educational-equity.