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Education Research Brief

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Examining Student and Teacher Math Learning: Lessons from Three Summer Programs

Purpose of this brief

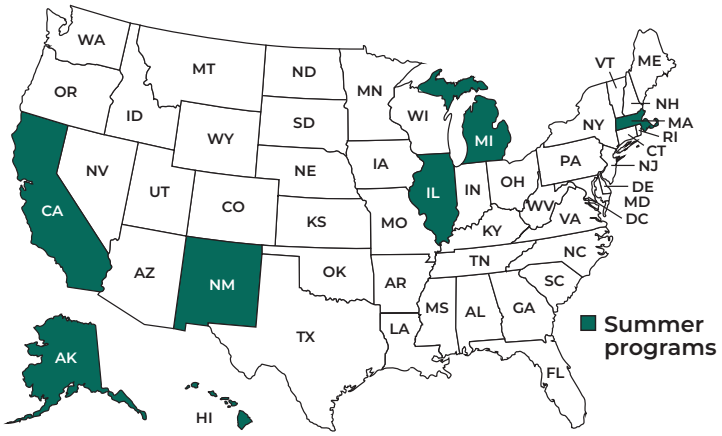
This brief presents evidence on the effect three summer programs have on student math knowledge and explores participants' perceptions and teacher learning during the programs.

Key takeaways:

- In all three programs, students' grades the semester after the program showed large improvements, but evidence of changes in growth mindset or confidence was minimal.
- Teachers made use of new instructional practices they had learned while delivering the programs, suggesting summer programs can be learning labs for new practices.
- The three programs identified lessons on teacher training, program monitoring, and student recruitment that would improve future implementation.

Findings can inform school districts on the implementation of summer programs, highlight lessons for program providers seeking to refine their programs, and point to priorities for future research.

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). Summer math programs can help address student learning needs in multiple ways. They can assist students in gaining proficiency in topics they struggled with during the previous year, pre-teach concepts for the coming year, or enrich their engagement with core concepts through challenging applications. These programs may also give teachers a chance to learn and hone new instructional practices they can apply during the school year. Research has documented summer programs' potential to yield meaningful learning gains for a broad range of students (McCombs et al., 2019). Less is known about the conditions required for successful implementation of summer programs and about such programs' effects on teacher learning or on student perceptions such as confidence and growth mindset.



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 the results of evaluations assessing the effects on student learning among three summer math programs, which took place in the states shown in the map above. The programs used research-based curricula and instructional practices to boost learning among diverse groups of grade 6–8 students during the 2019 and 2020 summers. (See Box 1 and Table 1 for details on program models.) We also present evidence on teacher learning and lessons from the providers' experiences implementing the programs.

Box 1. Key program features

- Standards-aligned curricula used "big ideas" to organize disparate topics into a coherent sequence, support project-based learning, and motivate building core grade-level skills
- Teacher practices encouraged multiple learning styles, supported students' practice of describing their reasoning, included growth mindset messages, and created opportunities to engage in productive struggle
- Culturally responsive elements:
  - Lessons on mathematicians whose identities are underrepresented in math
  - Guest lessons led by STEM professionals who share student participants' identities
  - Teacher assistants/mentors who are high school or college students and share participants' identities
  - Activities that positively link students' math learning to their individual and cultural identities

Student outcomes

The three programs we studied showed rigorous evidence of improved math grades among summer program participants, but findings on changes in student perceptions such as growth mindset and confidence were mixed.

All three programs boosted student math grades

Summer program participants received substantially higher math grades in the semester after the program than similar peers who did not participate.

Table 1. Distinguishing features of summer programs

	Planned Duration (hours)	Intended Participants	Teacher Training (hours)	Mode, by Year (In person, virtual)	District Partners
Provider 1	2019: 30–80	Open to all students	Up to 33	(2019)	11 new
Provider 2	2019: 76 2020: 67	Students building foundations for grade level	24	(2019) (2020)	10 existing
Provider 3	2019: 75 2020: 52	Students building foundations for grade level	Tailored to teacher needs	(2019) (2020)	2 new, 1 existing

Note: Providers 2 and 3 rapidly transitioned to virtual delivery in the summer of 2020 in response to COVID-19, even though their programs were originally designed to be in person.

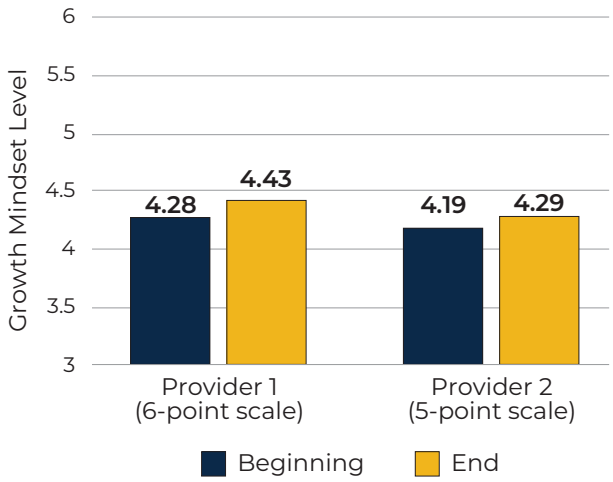
Source: Program data

One way providers measured this impact was by comparing participants' likelihood of receiving a low math grade—a D or F—to the likelihood for similar students who did not participate in the program. Provider 1 found that 16 percent of participants received a low grade in the semester following the program, compared with 21 percent of comparison students (Figure 1). Provider 2 measured impacts among students who participated for two consecutive years and found that only 8 percent of participating students received a low grade the semester after the second summer, compared with 23 percent of comparison students. These findings indicate that the summer programs led to large, statistically significant reductions in the share of students who received low grades—reductions of approximately 24 percent and 65 percent, relative to the comparison group. The third provider found that summer program students' fall math grades were, on average, almost half a grade point larger than similar nonparticipants' grades—a statistically significant difference that was roughly the equivalent of receiving a B instead of a B-.

Program participants did not report large changes in growth mindset

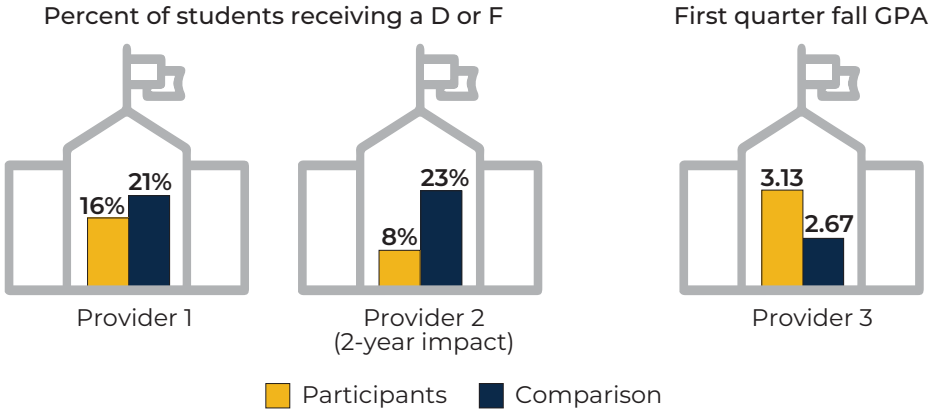
Each program's curriculum included explicit messages designed to boost students' growth mindset, which is the belief that students' math abilities are not fixed but rather improve from engaging with challenges. However, in the two programs that measured student growth mindset, students' survey responses at the beginning and end of the programs did not show large gains in this mindset (Figure 2). (Programs measured growth mindset using short, three- or four-item survey modules with statements such as "If I put in enough effort, I can succeed at mathematics.") These results may indicate that the summer programs did not lead to meaningful changes in student mindset or that the measures were not sensitive enough to detect changes that occurred.

Figure 2. Participants' reported growth mindset before and after the summer program



Source: Student survey data

Figure 1. Effects of the three summer programs on math knowledge



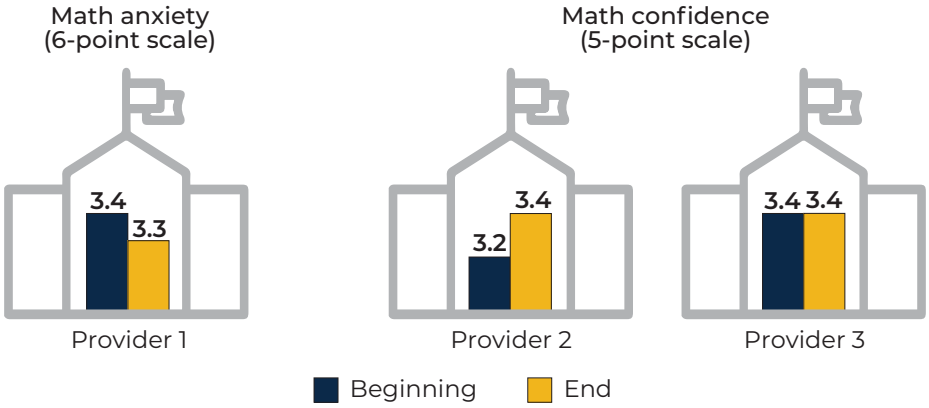
Note: Figure 1 presents a slightly different measure of grades for each provider, based on each provider's evaluation goals and analysis approach.

Source: Program data and student math grades collected by the program provider.

Evidence on growth in confidence was mixed

In addition to delivering messages promoting growth mindset, the programs incorporated strategies that sought to boost students' confidence and reduce feelings of anxiety about math. These strategies included providing students opportunities to explain their reasoning, highlighting mathematicians of diverse identities to counter stereotype threat, and pre-teaching math content for the coming year. Math confidence among students in Provider 2's program demonstrated an increase that was statistically significant, and the increase was of a meaningful size (Figure 3). The growth in math confidence was similar in size to the gap between male and female students' reported confidence at the beginning of the program and gender-based confidence gaps documented in past research (Ganley & Lubienski, 2016). Participants in the other two programs reported either no growth in confidence (Provider 3) or a small reduction in math anxiety that was not statistically significant (Provider 1).

Figure 3. Students' math anxiety and confidence before and after the summer program



Note: Provider 1 measured Math Anxiety rather than the Math Confidence construct measured by Providers 2 and 3. These measures represent two different approaches to learning about the same aspect of students' perceptions of math, because students who report high math anxiety are expected to report low math confidence and vice versa.

Source: Student survey data.

Teacher outcomes

One way summer programs can boost students' learning is by helping teachers learn and practice new instructional techniques. In these studies, two providers found that teachers honed evidence-based instructional practices that had been promoted during the summer programs, and two providers found that teachers reported using those practices from the summer program more often during the school year.

During the summer, teachers used practices they learned through the programs' professional development

Both providers that examined teachers' practice during their summer programs found that teachers used the evidence-based practices they learned during their training while delivering instruction in the summer program.[1] Ninety-two percent of participating teachers in Provider 3's program reported using two key practices promoted by the program's professional development—differentiated instruction and grouping students to support collaborative learning. Seventy-nine percent of teachers in Provider 2's program who were observed by instructional coaches demonstrated improvement in at least one of three areas of instruction that were encouraged by the program's professional development. These three areas were providing equitable access to math content; supporting students' agency, authority, and identity; and using assessments of student knowledge to target teaching. Both findings indicate that these summer programs can provide meaningful opportunities for teachers to hone new practices.

Teachers also reported using practices from the summer program during the following school year

Two providers asked teachers in the summer program about their use of the practices in the following school year. More than 70 percent of teachers in Provider 2's program reported using seven of the eight practices from the summer program during the next school year. Teachers in Provider 1's program were approximately four times more likely to increase their use of practices from the summer program than decrease their use, as documented in teaching logs collected before and after the summer program. These findings provide some evidence that programs that give teachers opportunities to practice evidence-based instructional techniques may have helped teachers transfer these practices to their school-year instruction.

In some programs, teachers' adoption of practices was uneven

Study findings indicated that teachers may require ongoing support to consistently integrate new instructional approaches into their practice. For example, video observations Provider 1 collected during the summer showed that teachers sometimes adopted new, promising practices while still using old practices that were counterproductive. When Provider 3 asked students and teachers about teachers' use of the same set of practices, students reported lower levels of usage than teachers did. This might indicate that teachers overreported their use of practices they understood to be desirable or that they were trying out the new practices but were not using them consistently enough for students to remember and report them.

Lessons learned during implementation

Additional and more tailored professional development may make programs more effective

Two providers concluded from their implementation experience that they should not only boost the amount of professional development they offer but should also target it to specific teacher needs. Additional professional development was the most requested support among teachers and district leaders in Provider 3's program, with 43 percent requesting this additional support. Survey respondents indicated they were particularly interested in professional development on culturally responsive elements of the program. Some respondents noted that different approaches to culturally responsive instruction might be needed to respond to specific student identities in different program locations. In Provider 2's program, teachers returning to the summer program after serving in a previous summer continued to need professional development support, so the provider planned to require tailored professional development for returning teachers.

Providers used data from digital learning platforms to monitor engagement and identify issues

Two providers used digital learning platforms to deliver or supplement instruction, and they found that by reviewing usage data, they could measure student engagement and determine which platforms were useful for students. While Provider 3 was piloting a virtual version of its summer program in 2020, student completion of homework in an online platform, ALEKS, was roughly in line with student attendance at the program. In contrast, use of an online coding instruction program was much lower, with only 2 percent of students using it the recommended amount. The provider concluded that students found ALEKS more usable and useful than the coding program and explored ways to incorporate ALEKS into future in-person programming.

Provider 2 examined user data from its Nearpod online learning platform to assess student engagement in its virtual program during summer 2020. Engagement was high, with 88 percent of students completing at least one activity in the platform each session. Among students who did at least one activity, they completed 68 percent of activities on average. This type of granular tracking of engagement with learning activities can help teachers and program directors determine the value and usability

that students and teachers perceive for different technology investments. Program managers may wish to explore engagement data from platforms as a tool to identify students in need of additional or different support, which might in turn improve programs' ability to boost student outcomes.

Successfully recruiting the students that programs wanted to participate required targeted efforts

In alignment with the goal of the grant program, all three summer programs prioritized recruiting students who were Black, Latino, or experiencing poverty. Two providers found that when recruiting students to participate, they needed to consider distinct communication preferences and other needs of the students or their families. For instance, in one provider's region, phone calls to Latino students' families were a much more effective means of outreach than emails or text messages. Two providers also found that gathering input on families' scheduling needs could help them address important barriers to students' participation. Learning the needs and preferences of the students and families that a provider wishes to serve in a summer program is an important aspect of successful program implementation.

Takeaways

- Summer programs can lead to meaningful improvements in math knowledge for students, including those whose access to prior learning opportunities has not been adequate to build grade-level proficiency. Successful programs combined standards-aligned, challenging curriculum with evidence-based, culturally responsive instruction and a dosage of approximately 50 hours on average.
- Some findings for Providers 2 and 3—including the math knowledge gains—were measured during the summer of 2020 (or the combination of 2019 and 2020, for Provider 2). The pandemic required these providers to rapidly design and implement their programs in a virtual setting for the first time while simultaneously responding to the heightened need for summer learning after a disrupted school year. As a result, the effects observed in these studies may not translate directly to other contexts, and there is value in further research to understand these programs' impacts in the current educational landscape.
- Evidence is more mixed on whether these programs improve students' math confidence and growth mindset, and measurement limitations may have influenced these findings. For example, among two providers, students reported high levels of growth mindset at the outset of the program, leaving little room for improvement. Future research should continue to explore strategies to measure—and improve—this aspect of student perceptions.
- Program providers who use digital learning platforms can review data on student usage to monitor student engagement, which may highlight opportunities to boost engagement and improve outcomes.
- Achieving summer programs' full potential to improve student learning and teachers' instructional practice likely requires refining professional development offerings based on input from teachers on their specific learning needs.
- Recruiting the student participants who may benefit most from these programs requires attention to the specific needs of their families.

Evaluation methods

Methods for measuring student math knowledge

The three pilot studies each used matched comparison methods to estimate the effects of their summer programs on student math knowledge. The study sample sizes of the combined treatment and comparison groups were 2,417 for Provider 1 (including 536 participants and 1,881 matched comparison students), 172 for the estimate of two-year effects produced by Provider 2, and 210 for Provider 3. Providers 2 and 3 included equal numbers of treatment and comparison students in their analysis samples.

Methods for measuring student perceptions

All three studies administered surveys to students participating in the summer programs, and all three programs used survey items that had published reliability information. All surveys included items that measured either math confidence or math anxiety, and two of the providers' surveys also measured growth mindset. Provider 1 used items previously developed and validated in an earlier study (Boaler et al., 2018). Provider 2 used survey items drawn from the Becoming Effective Learners survey (Farrington et al. 2013). Provider 3 used items drawn from the Math and Me survey to measure math confidence (Adelson & McCoach, 2011). For students who participated in the summer programs, the studies examined the average change in math confidence and growth mindset over the course of the program. ◢

Endnotes

[1] The third program examined practices only among a small subset of teachers who shared video observations of a representative lesson they had recorded. Findings from those observations are discussed on page 5.

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Findings from this project are also described in:

- Testing New Approaches to Math Tutoring: Lessons from Eight Evaluations
- Selecting and Supporting Math Tutoring Programs: Recommendations for School Districts
- 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.