Learning Conditions Are an Actionable, Early Indicator of Math Learning

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INTRODUCTION

Decades of research have documented the impact of certain *learning conditions* on student engagement and academic outcomes. For example, academic engagement is higher and learning outcomes are better when schoolwork is made to feel relevant and meaningful ("meaningful work");[1-3] when critical feedback is provided in an affirming, growth-oriented way ("feedback for growth);[4-11] and when student-teacher relationships are supportive ("teacher caring").[12-16] These learning conditions can influence learning outcomes through multiple causal mechanisms. For example, positive learning conditions can support learning both by enhancing students' motivation, and also by mitigating anxieties that divide students' attention[17-20] and reduce the brain's capacity to process information.[21, 22]

Although research has rigorously documented the causal impact of learning conditions on learning outcomes,[1, 5, 14, 23-31, 32] it has not yet supplied practical tools that educators could use to systematically improve those conditions. To close this gap, PERTS and University of Chicago Consortium on School Research (UCCSR) are developing a continuous improvement framework called **Elevate**.

The Elevate framework provides evidence-based recommendations for improving learning conditions side-by-side with practical measures that educators can use to monitor those conditions in real time. The learning conditions measures play a crucial role in the framework because they equip educators to make data-driven decisions about what practices to adopt, adapt, or abandon in the service of building an optimal environment for students. An educator, for example, could use Elevate's ***meaningful work*** measure to learn that only 40% of their students find assignments to be meaningful. The same educator could then reassess meaningful work to test the impact of a new practice that was implemented to make work relevant. (For more, see Paunesku & Farrington, 2020.)

This report quantifies the relationship between math achievement and the Elevate learning conditions, as well as variability in conditions over time.

Students were more than **2x more likely to earn a B or better in math** when they rated learning conditions most positively rather than most negatively. Shifts in learning conditions were also early indicators of shifts in learning outcomes: when learning conditions shifted for the better—or for the worse—students' grades followed in the same direction. In light of these findings, it is troubling that, absent intentional action, learning conditions grew significantly worse over a school year. More encouragingly, new analyses shed light on intentional practices and support that enable teachers to reverse this downward trend and build better learning conditions over time.

HOW WE COLLECTED THE DATA IN THIS REPORT

We partnered with the Character Lab Research Network to collect data from over 4,000 U.S. 8th - 12th graders during October through March of the 2019-20 academic year. The **Technical Supplement** describes in detail the data and the participants, including the timeline of data collection, study participants, and measures. Students rated classroom learning conditions on a 7-point Likert scale from Strongly Disagree (1) to Strongly Agree (7), where Strongly Agree corresponded to the most positive rating.

STRONG LEARNING CONDITIONS PREDICT STRONG STUDENT LEARNING

We examined how three learning conditions—Teacher Caring, Meaningful Work, and Feedback for Growth[33]—related to students' chances of earning a grade of B or better in mathematics. We used "B or better" as a threshold to measure student learning because (1) educators frequently wish to help their students meet high standards, rather than merely earning good enough grades to pass the class, and (2) earning A and B grades is more strongly associated with college success than passing courses with a grade lower than a B.[34]

FIG. 1
Learning Conditions Predict Strong Student Learning

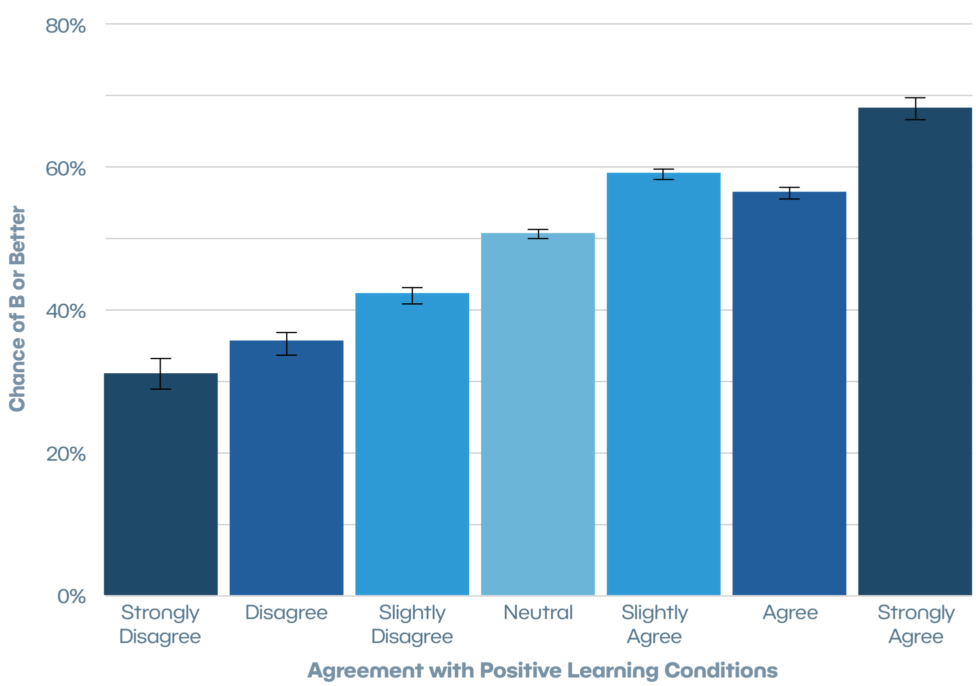

Figure 1. Percent of students earning an A or B in their math classes for different levels of agreement with statements about positive learning conditions. Each increment in the composite score is associated with 6% more students earning A's and B's, on average.

> Our results show that learning conditions are **powerful predictors** of students' likelihood of earning an A or B in mathematics.

Students who average in the "Strongly Agree" range across all learning conditions—indicating strongly positive learning conditions—are more than two times as likely to earn a B or better in math that term compared with students in the "Strongly Disagree" range. Even small differences in how students rate their learning conditions are important, especially on the low end, below the "neutral" point of the scale.

Further, the relationship between learning and math grades holds up even when controlling statistically for student race, gender, age, grade level, Free and Reduced Price Lunch (FRPL) status, and previous grades in the same math class.[35] These statistical controls rule out many alternative explanations for the findings. For example, we know that the relationship between learning conditions and math grades cannot be accounted for simply by assuming students reporting positive learning conditions had stronger math skills at the start of the school year. Combined with rigorous laboratory studies in the published research literature which demonstrate causal links between learning conditions and academic achievement,[1, 5, 14, 23-31, 32] we view these controls as strong evidence that learning conditions are early indicators of student learning and achievement.

Learning Conditions Matter for Students Across Demographics

Previous research suggests that learning conditions support student engagement and achievement among students from various racial, ethnic, and socioeconomic backgrounds.[1, 5, 14, 23-31, 32, 36-38] In some cases, learning conditions have been found to be especially important for students who have been less well-served—students who are initially performing less well or are members of marginalized groups.[4, 23-24, 26, 30-31, 36, 39]

FIG. 2

Learning Conditions Predict Math Grades For Many Different Students

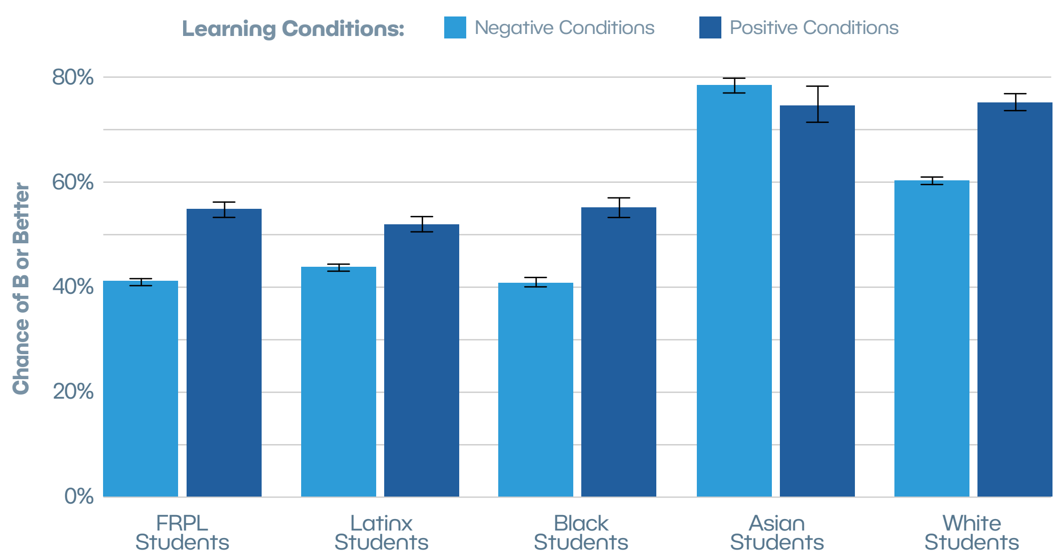

Figure 2. Chances of earning a B or better for students experiencing negative vs. positive learning conditions, defined as scale composite scores ≥ 5 (positive) vs. < 5 (negative) on a seven-point scale as a function of race and FRPL status.

Consistent with prior research, learning conditions predicted academic outcomes for students from a variety of backgrounds. In Figure 2, we see that the relationship between positive learning conditions and strong academic performance is present for White, Latinx, and Black students, as well as for students who qualify for Free and Reduced Price Lunch (FRPL). The relationship between learning conditions and math grades was not moderated by race or by qualifying for FRPL vs. not qualifying.[40] This indicates that improving learning conditions is likely to help *all* students learn more effectively, regardless of race, ethnicity, or socioeconomic class.[41]

> In addition to helping all students learn, improving learning conditions can actually be **even more helpful** among groups that have been initially less well-served.

For example, in this study, we found that students who are eligible for Free and Reduced Price Lunch (FRPL) because of their family income were 34% more likely to earn a B or better if they rated learning conditions positively. Additionally, Black students were 35% more likely to earn a B or better if they rated learning conditions positively.[42] This is in contrast to White students who are not eligible for FRPL and were found to be 21% more likely to earn a B or better if they rated learning conditions positively. **So while learning conditions are critical to *all* students' learning, they make the most difference to students who have not yet been served well by the educational system and can help to create more equitable outcomes.**

With such a large and diverse sample, we believe the patterns in this study are likely common across many different contexts. However, every school and student population is unique, and we encourage educators to measure and disaggregate learning conditions in their own contexts before deciding how—and for whom—to improve learning conditions.

As Learning Conditions Improve, Learning Improves

The previous analyses demonstrated that students are more likely to earn good grades when they experience positive learning conditions in a given academic term, but they did not examine what happens when learning conditions change over time. In this study, learning conditions were measured twice over the course of the 2019-20 academic year: in October, and again in February. The data therefore allow us to ask what happens to students' academic performance when learning conditions get better or worse over time and how learning conditions change in typical classrooms.

FIG. 3

As Learning Conditions Improve, Grades Improve

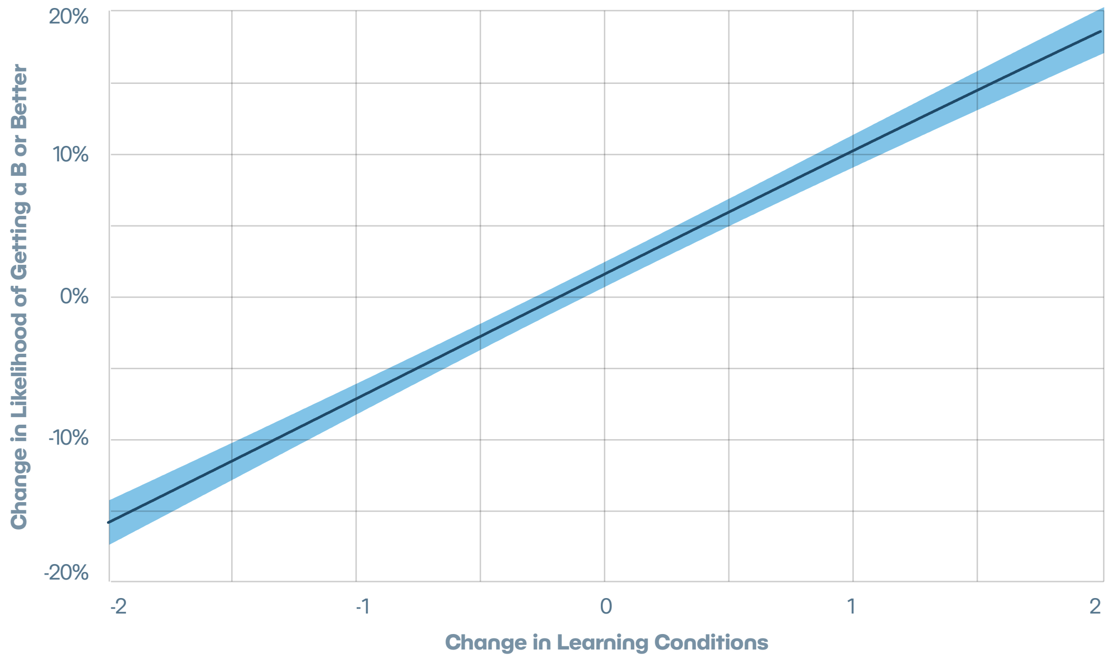

Figure 3. Change in likelihood of getting a B or better in math as a function of change in learning conditions (the shaded area represents the standard error). Learning conditions were measured on a seven-point scale, and 90% of students experienced shifts in the -2 to +2 range displayed on the graph. For model specifications used to generate the graph, please see the technical supplement.

Shifts in learning conditions predicted subsequent shifts in learning outcomes: When learning conditions improved, students became more likely to earn B or better in the following academic term. Figure 3 shows students' likelihood of earning a B or better in math in March, given different levels of change in learning conditions between October and February. For example, when a student experienced a positive change of two scale points on a seven-point scale, their likelihood of a B or better in Quarter 3 (March) was approximately 17% higher than it would have been if they experienced no change in learning conditions.

These results hold even when controlling for students' demographics, math grades in the first quarter of the year, and their learning conditions in October.

> This means that **it is always possible for students to see meaningful growth in their learning** when they experience more caring from their teachers, see more meaning in their work, and receive stronger feedback about their math strategies and progress. This is true regardless of students' level of academic preparedness at the start of the school year, and regardless of their experience with learning conditions in the first two months of the year.

LEARNING CONDITIONS TEND TO WORSEN OVER TIME, ABSENT EFFORTS TO IMPROVE THEM

Given that improved learning conditions result in better learning over time, we wanted to know whether learning conditions tend to improve over time, or get worse.

We found that **learning conditions did not get better without focused effort** to improve them. In fact, in this study's sample, learning conditions got slightly but significantly *worse* over time. Figure 3 shows that Meaningful Work, Teacher Caring, and Feedback for Growth all worsened by .07 to .15 points on a seven-point Likert scale between October and February—and the decrease was statistically significant (paired *t*'s ≥ 3, *p*'s ≤ .001). This pattern is consistent with research showing that U.S. students' engagement with school tends to decline steadily throughout the middle and high school years.[43-45]

FIG. 4

Learning Conditions Get Worse Over Time

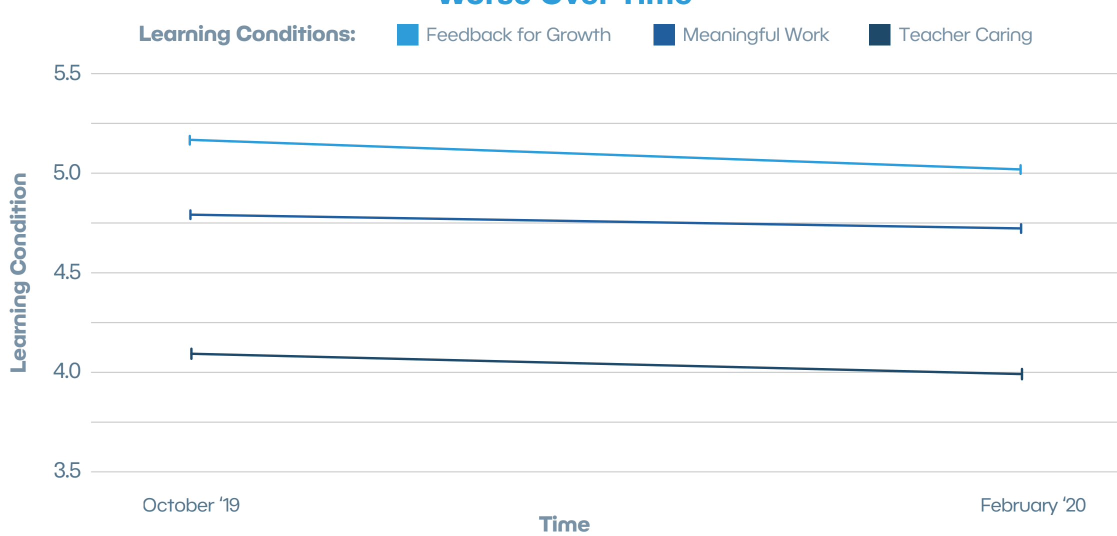

Figure 4. Average Learning condition ratings (on a 6-point scale)" in October 2019 and February 2020, as reported by the same group of students.

HOW EDUCATORS CAN IMPROVE LEARNING CONDITIONS

Even though learning conditions typically get worse over time, research shows this trend can be reversed through targeted, evidence-based efforts to improve student experience. Causally rigorous laboratory and field studies show that self-persuasion activities targeting key beliefs about belonging and the capacity to grow one's abilities can help students develop adaptive learning strategies with subsequent impacts on academic outcomes.[1, 5, 14, 23-31, 32] Guided reflections that help students connect subject matter to their lives can improve performance in science courses,[1-3] and activities leading teachers to employ an empathic mindset with students have reduced suspension rates—key contributors to high school disengagement and dropout—among many different student populations.[14, 28] As such, we have substantial evidence from the scientific literature showing that improvements in learning conditions cause improvements in academic outcomes.

Several networked improvement communities have also made great headway in applying this research outside of controlled research settings. For example, the **Carnegie SAIC network** has helped educational institutions improve learning conditions and academic achievement in high school mathematics education, while others have had similar success in higher education math and STEM learning.[36, 46]

A Scalable Infrastructure for Systematically Improving Learning Conditions

In the hopes of increasing the number of educators and institutions that utilize systematic approaches to effectively improve learning conditions, PERTS and UCCSR have been developing software-enabled tools and processes that dramatically reduce the cost and complexity of such efforts. One product of this collaboration is **Elevate**: a continuous improvement platform that equips educators to use research-quality measures and analytics to assess, disaggregate, and track learning conditions over time. Educators can use Elevate to test the impact of their practices on learning conditions and work on teams to identify the highest impact practices in their own contexts.

Over the 2021–22 school year, more than 900 teachers at more than 150 schools used Elevate to gain actionable insights into the classroom experiences of middle and high school students. Just as important, many of our partners leveraged their data to gain insight into the practices that educators can use to establish positive learning conditions and improve the student experience (e.g., **Impact Florida**, **West Buffalo Charter School**, the **Building Equitable Learning Environments Network**).

As our partners use their Elevate data to understand which classroom practices improve learning conditions, the PERTS and UCCSR research teams have started to use Elevate data to understand which professional learning practices facilitate educators' ability to identify, adopt, and adapt those classroom practices effectively. Even though these efforts have only started, certain clear trends are already starting to emerge.

FIG. 5

Student Experience Improved When Partners Planned More Cycles

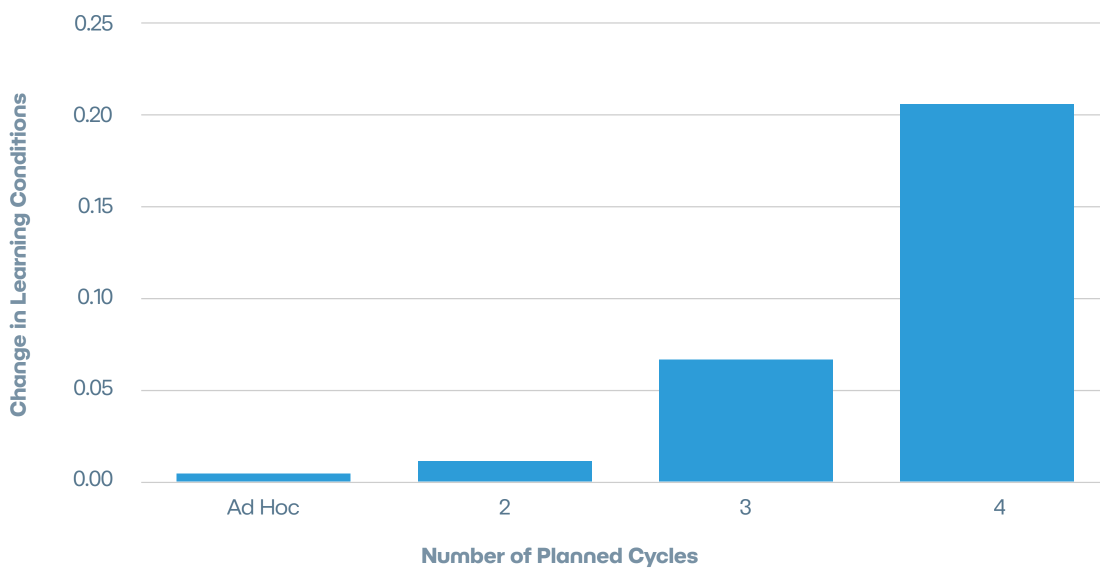

Figure 5. Median class-level change in learning conditions (on a 6-pt scale) as a function of number of planned continuous improvement cycles.

The strongest and perhaps least surprising finding was that partners were more likely to improve learning conditions if they planned and implemented more improvement cycles. In our 2021–22 Elevate data, when people had ad-hoc implementations (implementations with no clear plan for how many improvement cycles teachers would engage in), or used Elevate for only two planned cycles, we see that learning conditions did not improve. However, when educators did four or more cycles of continuous improvement to measure and improve learning conditions, the improvement was marked.

(See this **case study** for a detailed example of one such school.)

> These data show that **learning conditions *can* be improved** by schools when they make the **concerted effort** to do so.

Not only can schools improve learning conditions on average, but each of our partners saw individual classes where the improvements were much stronger than average. Figure 6 shows histograms of class-level changes in learning conditions over the course of the 2021–22 academic year. Each graph's bottom axis (i.e., the x-axis) shows learning condition change scores, ranging from -1 to +1 (on a 6-point Likert scale). The height of the bars in each graph represent the number of classes with a given change score; e.g., if the bar at the "zero" mark in one of the graphs goes up to the number 20 on the left axis (i.e., the y-axis) of the graph, that means 20 classes had average improvement scores of zero.

FIG. 6

When Partners Planned More Cycles, More Bright Spots Emerged

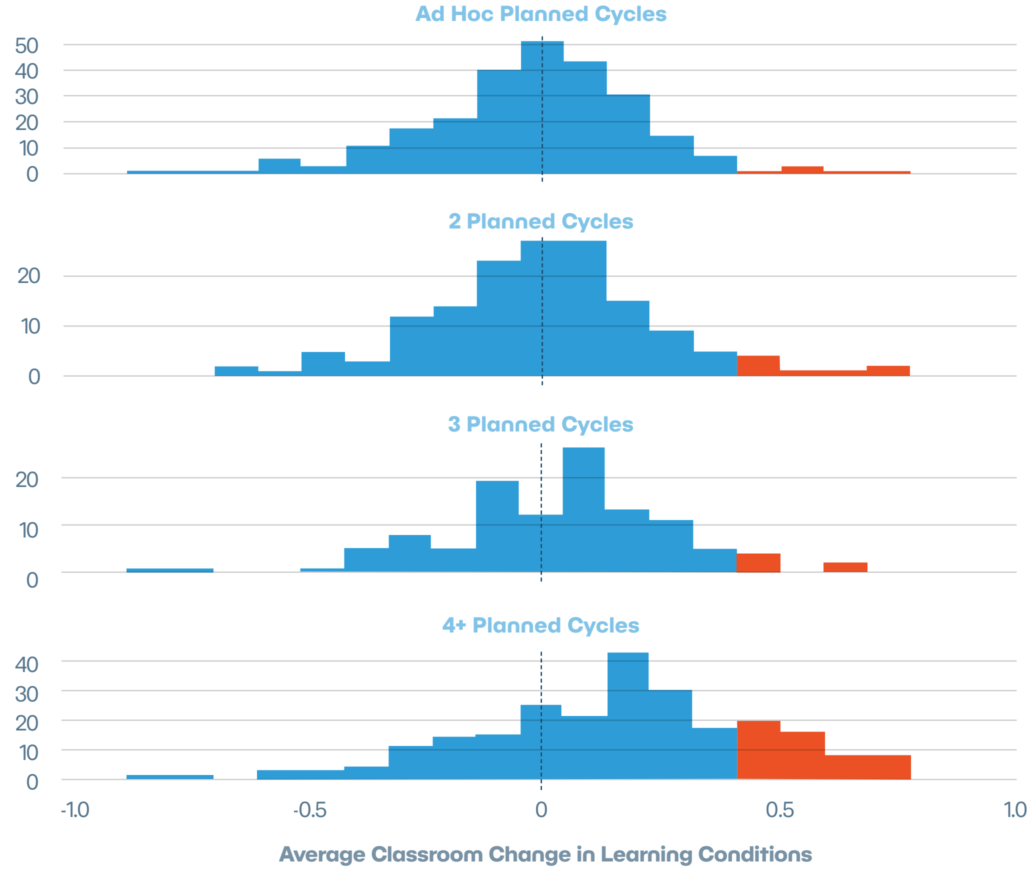

Figure 6. Histograms of class-level change scores for different numbers of planned cycles. The x-axis shows classroom-level change scores on a 6-point Likert scale. Blue represents average changes < .5 scale points, and orange represents changes ≥ .5. The dashed lines highlight which bar corresponds to zero change in each distribution.

When we look at sites with ad-hoc implementations and those with only two planned cycles, we see the vast majority of classes have change scores close to zero. Very few classes show more dramatic positive shifts (represented in orange). Even when we look at classes with 3 planned cycles, which had a small but positive overall shift in learning conditions, few achieved the dramatic positive improvements represented in orange. However, when we look at classes with 4+ planned cycles, we see that a substantial number of them did show large improvements.

Besides being good news for students, these large improvements (sometimes called "bright spots") are useful in continuous improvement efforts because they often correspond to unusually effective strategies—or to unusually effective ways of implementing a common strategy. When improvement teams see bright spots like these, they have an opportunity to investigate them and figure out what went "right" in these classes. We know from our partners who have implemented multiple cycles that they have utilized strategies to investigate what went right—holding community of practice discussions and talking to students about the data, as well. The strategies or approaches hypothesized to be effective can then be disseminated to others on the improvement team (i.e., those classes still in "blue"), to see if they start seeing more dramatic shifts as well. Over time, successful improvement efforts will notice that levels of positive performance that were once bright spots become commonplace, and levels of poor performance that were once commonplace become increasingly rare.[47] Classes that planned at least 4+ cycles of improvement are already starting to see this distributional shift in their data.

The ceiling on how much impact educators can have on learning conditions with these sorts of efforts is likely much higher than what we see in the 2021–22 data, even for those schools that engaged in 4+ cycles of improvement. As we learn with our partners over time how to best improve learning conditions, and as educators learn to spread these innovations reliably, we expect to see schools make deeper gains in learning conditions with each year that goes by.

CONCLUSIONS

In this report, we saw that learning conditions are important leading indicators of B or better math grades for middle and high school students. We saw that these learning conditions matter for students across racial and socioeconomic lines, and that when learning conditions improve, so does students' likelihood of earning a B or better in math. Unfortunately, learning conditions tend to get worse over time in the absence of intentional efforts on the part of schools to improve them. **But when schools do make such efforts, they can move the needle in a positive direction, while helping the field amass wisdom about how to create outstanding learning environments and experiences for all students.**

ACKNOWLEDGEMENTS

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40. See the Technical Supplement for **details** on model specifications and results.

41. Although Asian American students (n = 259) did not show a relationship between learning conditions and math grade outcomes in the aggregate, this pattern is an artifact of Asian students' higher grades at baseline. Simply put, learning conditions matter less when students are already performing well, and the Asian students in this sample happened to be performing exceptionally well at baseline. There was no moderation of the relationship between learning conditions and grades by membership in any racial group.

42. In contrast with Black students and those eligible for FRPL, the effects for Latinx students appeared to be somewhat smaller than those for the other groups. Because the difference in effect size for Latinx students was not statistically significant, this could be random variation. Future research will examine this finding in more detail.

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