BRIEF

Hot test days, lower math scores:

How heat affects student achievement

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KEY FINDINGS

- Test-day temperatures over 80°F were associated with lower MAP® Growth™ scores in math but not reading. Even when it wasn't that extreme, testing on a day that was unusually hotter than average was associated with slightly lower math test scores.
- High heat had up to twice the impact on students' math scores in high-poverty schools compared to low-poverty schools.

Introduction

In recent years, schools across the United States have faced longer and more intense heat waves, posing increasing challenges for student learning. Schools are increasingly forced to close or dismiss early due to heat, interrupting school operations and cutting short instructional time. At the same time, many school facilities lack the up-to-date infrastructure that is needed to manage extreme heat, and there is significant variability across the country in the condition of schools' facilities. As of 2020, about half of US schools required costly updates to their HVAC systems in order to adequately respond to rising temperatures. In short, weather-related disruptions to learning have become a widespread challenge.

Extreme heat doesn't just make students uncomfortable; it can affect their ability to concentrate, perform, and learn. Research shows that heat takes a toll on learning both immediately (when students test on warmer days) and cumulatively (when much of their learning occurs in hot classrooms). However, much of the available research is constrained by geographic scope or grade level, which limits our ability to understand which students and schools may be most vulnerable to the effects of extreme heat.

In this brief, we use recent, large-scale student-level test score data across a range of school locales to fill that gap. We combined daily temperature data from the National Oceanic Atmospheric Administration (NOAA), data on school location and other characteristics from the Common Core of Data (CCD), and fall MAP Growth scores in third to eighth grade across six states in various regions of the country. The dataset includes roughly three million test events from the fall testing terms in 2022, 2023, and 2024 across the six states, providing enough variation in both temperature and context to detect meaningful patterns. This allows us to test how test-day temperatures affect student performance and whether the effects of test-day heat are more extreme for students in high-poverty schools, where cooling conditions may be less reliable.

Are test scores lower on hotter testing days?

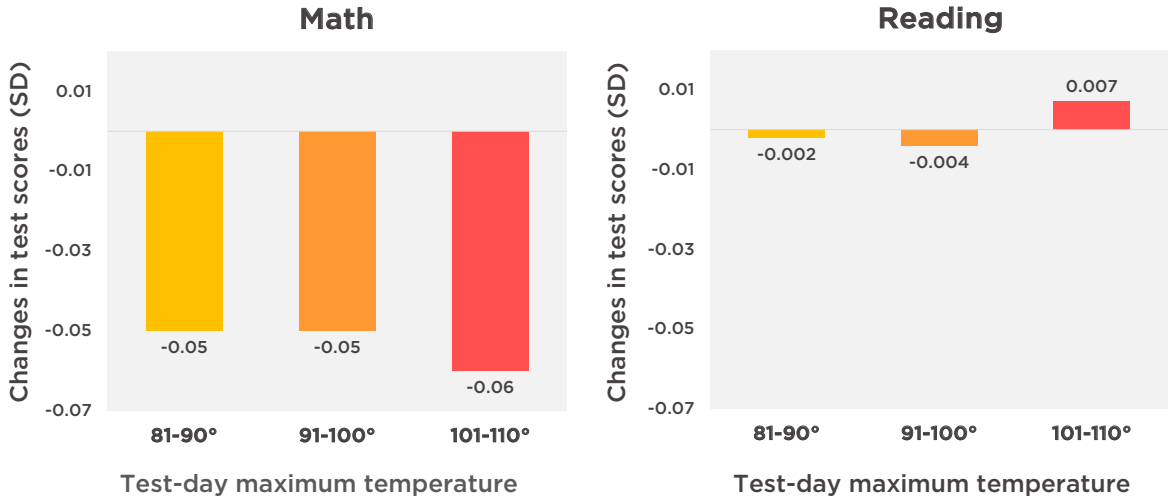
We examined the relationship between test-day maximum temperature and student achievement.[1] To separate temperature effects from broader differences across states or student groups, our models accounted for prior achievement, grade level, year assessed, race, gender, and state. We also controlled for whether students tested in the morning or afternoon, since heat peaks in the afternoon. To make the results easier to interpret, we grouped temperature into six 10-degree ranges and then estimated the difference in predicted test scores in each range relative to a baseline maximum temperature day of 51°F–60°F.[2]

1 Our independent variable is the test-day maximum temperature (e.g., the highest temperature observed on the day of testing). For parsimony, we refer to this simply as test-day temperature throughout the brief.

2 We used 51°F–60°F as our baseline because 51 was the lowest test score temperature in our final sample, and because this range represents a moderate, typical fall temperature against which hotter conditions could be compared.

Figure 1 shows the estimated difference between test scores at the three highest temperature ranges relative to a 51°F–60°F maximum temperature day for math (left panel) and reading (right panel). In math, test scores were about 0.05 SD lower when temperatures reached 81°F–100°F, and 0.06 SD lower on days above 100°F. In other words, students who tested on a 101°F day scored roughly 0.06 SD below students who tested at 60°F. To put these results into context, 0.06 SD is the equivalent of about 10 percent of the learning typically gained in a school year for a fifth-grader.

Figure 1. Math scores drop on hot test days; reading stays steady.



Note. Differences shown are relative to a mild 51°F–60°F day. For context, a 0.06 SD equals about 10 percent of the learning typically gained in a school year for a fifth-grader.

Reading scores were less sensitive to high temperatures, with effects ranging from -0.004 SD to 0.007 SD (none of which were statistically meaningful). Although the reason behind these findings is unclear, other studies have shown similar inconsistencies, suggesting that the effects of heat are not uniform and are sensitive to both subject and time of testing.

Our data does not include a measure of whether schools have functioning air conditioning (AC) units at the time of testing. The presence or absence of AC may explain some of the patterns observed, particularly if cooling systems are only activated once temperatures reach a certain threshold. Access to working, up-to-date AC depends on a number of factors that extend beyond local weather trends, including the ability to fund infrastructure repairs. Because access to reliable cooling likely depends on school resources, we next look at whether students in high-poverty schools are hit harder by heat on test days.

What are the relative effects of testing on hotter days?

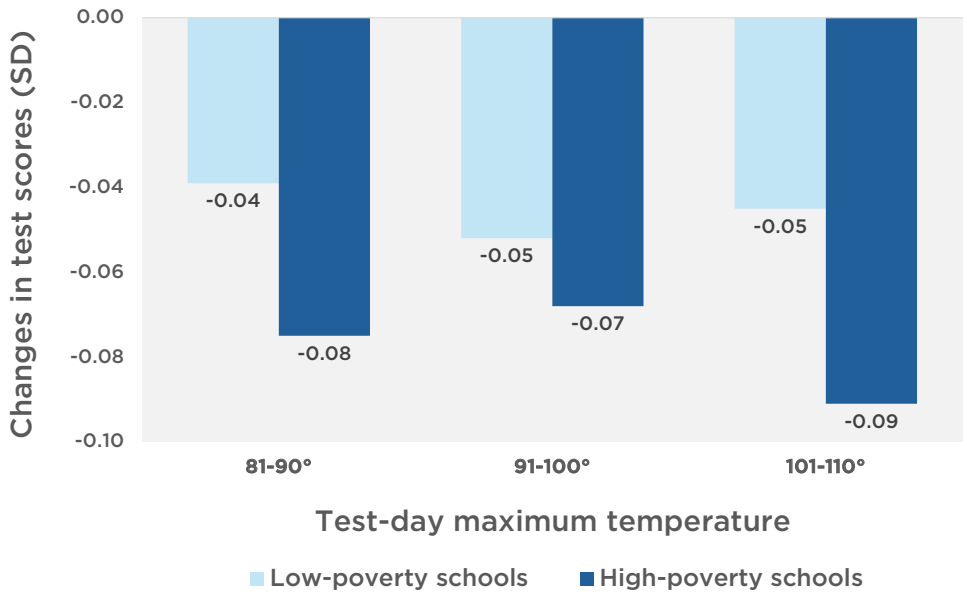
Our analysis demonstrates that higher test-day temperatures (especially temperatures above 100°F) are associated with lower math scores. But not all schools are likely to experience days over 100°F during the fall. For a school in a cooler climate, a test-day temperature that is 20°F–30°F above the fall norm could still have a negative effect. To test this, we also examined whether a hotter test day relative to a school's average fall test-day temperature impacts outcomes. In math, we found slight, but statistically significant, reductions in test scores associated with a 10 degree increase above the average school temperature (about -0.01 SD) and slight increases in scores in reading. Though small, this shows that unusually hot days can still lower math scores, suggesting that relative temperature spikes matter, not just absolute heat.

Are students in high-poverty schools hit harder by high test-day temperatures?

Next, we tested whether the effects of high test-day temperatures were larger in high-poverty schools.[3] Figure 2 shows these effects on math scores for the lowest- and highest-poverty groups. For math, we observed a clear pattern: students in high-poverty schools (greater than 75% FRPL) experienced larger declines in scores at high test-day temperatures compared to lower-poverty schools (<=25% FRPL).[4] On 101-110°F test days, effects for students in high-poverty schools were twice as large (-0.09 SDs) as those in the low-poverty schools, who saw a smaller decline (-0.05 SDs).

To put the finding for the highest poverty group into context, an effect of 0.09 SD is equivalent to about 14% of learning typically gained in a school year for a fifth-grader. We did not find meaningful variation by school poverty level in reading.

Figure 2. Impact of heat on math scores is up to double in high-poverty schools.



Note. Differences shown are relative to a mild 51°F–60°F day. For context, a 0.09 SD equals about 14 percent of the learning typically gained in a school year for a fifth-grader.

Our findings suggest that students in high poverty schools may be more vulnerable to the effect of extreme heat drop on math performance. These differences may not reflect lower learning itself, but rather the environment in which tests are taken. In schools without reliable cooling, heat can depress scores and mask students' true achievement, suggesting that some apparent gaps in performance may stem from unequal testing conditions rather than unequal ability.

3 Consistent with the first analysis, we estimated the effects of test-day temperatures on test scores for the three highest 10°F bins of maximum test-day temperature relative to a 51°F–60°F test day. Test-day temperature bins were interacted with school poverty levels to explore differences in the effect of heat by school poverty.

4 Results for the schools in the mid-poverty levels (25–50% and 50–75% FRPL) were not significantly different than the low-poverty schools and are therefore not shown in the figure. For a full table of results, see Tables 6–7 in the technical appendix.

Summary

Extreme heat poses challenges for an increasing number of schools each year. Our analysis across three years of six states' fall testing administrations found that math scores decrease significantly on hotter test days, with significant negative effects on test scores for temperatures 80°F and above. The largest effects were observed on 101° to 110° days, when students experienced decreases in math scores of approximately 0.06 SDs. We also found that a hotter testing day relative to a school's average testing temperature in a term had a small but negative effect on math scores.

Importantly, we found that schools that serve higher poverty student populations (or have greater than 75% eligible for free or reduced-price lunch) are more severely affected by test-day heat than lower-poverty schools in math. These differences may be linked to disparate conditions of school facilities, as higher-resourced schools may be able to prioritize updated HVAC systems. While we did not observe the same effects in reading, our findings in math underscore how environmental conditions can compound existing educational inequities. Taken together with recent research, our findings suggest that systemic inequities in education extend to how schools are affected by high temperatures. Geographic factors, such as the intensified impact of heat in cities, are also important to consider. As extreme weather becomes more common, ensuring that every school can provide a safe, climate-resilient learning environment is not just a facilities issue but is fundamental to educational equity and student success.

What can school and district leaders do with this information?

Our findings contribute to a growing consensus that high temperatures can be detrimental for students' motivation and achievement. To mitigate these effects, we offer the following recommendations.

Recommendations for school leaders:

- **Plan around local weather patterns.** Whenever possible, testing conditions should mitigate the effects of high outdoor temperatures by scheduling testing during cooler periods in the term.
- **Create optimal testing conditions.** When feasible, consider ways to improve testing environments, such as moving testing to cooler areas. Testing students in the morning can also improve performance and may avoid afternoon heat accumulation.

Recommendations for district/state leaders:

- **Invest in resilient facilities.** As temperatures around the country continue to increase, district and state leaders should prioritize investing in updated school HVAC infrastructure, which will help reduce weather-related school closures and can improve student engagement. Districts can leverage student outcome data as evidence of the direct benefits of facility improvements to strengthen support for these investments.
- **Plan with equity in mind.** As extreme weather events such as high temperatures become more frequent, districts should consider environmental resilience as a key component of facilities planning, testing schedules, and resource allocation. Ensuring that every school, especially those serving high-poverty communities, has access to updated HVAC systems in schools is an issue of environmental equity as much as academic fairness.

ABOUT THE AUTHORS

Sofia Postell is a research analyst at NWEA. Her research focuses on academic recovery, measurement of trends in student achievement, and the effects of school resources and policy changes. She received a BS in computer science and sociology from Northeastern University.

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Susan M. Kowalski uses quantitative and descriptive approaches to understand how state and district educational policy decisions influence science instruction in the US. Her research includes a wide range of topics, from science curriculum and professional development research to meta-analysis. Susan's work has been published in the *Journal of Research on Educational Effectiveness*, the *American Educational Research Journal*, the *Journal of Research in Science Teaching*, and *Science Education*. Before NWEA, Susan was a senior research scientist and director of research at BSCS Science Learning. She also spent several years teaching high school physics and physical science in Bloomington, MN. She completed her PhD in curriculum & instruction at the University of Minnesota.

Jazmin Isaacs is a research analyst for NWEA's Research and Policy Partnerships team. Throughout her career, she has been fortunate enough to hone her research and project-based skills in several settings (e.g., academia and higher education, nonprofits, private corporations, etc.). Cumulatively, she has nearly a decade of experience in conducting equity and education-focused research, creating high-impact, data-driven reports and presentations, and engaging in thoughtful data management and analysis work. Isaacs completed a bachelor's degree in economics at Stanford University and received a master's degree in education from the University of Oxford.

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