



Effects of the Pandemic on High School STEM Course-Taking and Performance

Introduction

The effects of the COVID-19 pandemic on K-12 education have been extensive. Research suggests that schools are still recovering from the consequences of COVID-19 in terms of student absences, grades, test scores, and teacher attrition in North Carolina.¹

However, the effects of the pandemic on advanced course-taking remain largely unexplored. This is important because participation in advanced courses helps prepare students for higher education and modern careers. STEM (science, technology, engineering, and math) courses, in particular, are of high interest both because STEM courses often prove to be gatekeepers to postsecondary success and because there is a growing demand for STEM skills in the workforce.²

Using data from the North Carolina Department of Public Instruction (NCDPI), this brief analyzes the effects of the pandemic on enrollment in advanced math and science courses by eleventh- and twelfth-grade students through the 2021-22 school year (the second full school year following the onset of the pandemic). These courses include Advanced Placement, International Baccalaureate, and dual-enrollment classes. We find that:

- (1) Although enrollment in advanced math courses was increasing pre-pandemic, enrollment rates declined in 2020-21 and decreased further in 2021-22.
- (2) Advanced science enrollment increased in 2020-21, though at a slower rate than predicted based on pre-pandemic trends, before decreasing in 2021-22.
- (3) The overall decline in enrollment in advanced math courses was slightly larger than the decline in advanced science courses.
- (4) Negative impacts on enrollment in advanced math and science were relatively larger for Hispanic students than for Black or White students.

These results provide new insights that can help policymakers develop strategies to target resources to support students and courses that were most affected by the pandemic. Most especially, while test scores partially bounced back in 2021-22, this study adds evidence that other key educational outcomes continued to worsen. This suggests a need to target resources towards the recovery of both non-test-score and test score outcomes.

In addition, as in our prior research on student grades and absence rates, we find that Hispanic students experienced especially significant disruptions from COVID-19. This suggests that the impacts of the pandemic may have been exacerbated for students and families with language or cultural differences and thus that students of historically marginalized backgrounds may continue to require the most additional attention to achieve recovery.

Background

The data used in this brief were provided by NCDPI and include student-level demographics and course enrollments from 2015-16 through 2021-22. We examine changes from pre- to post-pandemic in the percentage of students who participated in advanced math and science courses. Because students typically take these courses late in high school, we include only students in grade 11 and above. Our sample includes slightly more than 200,000 student observations per year, or about 1.5 million observations in total.

Our primary goal is to identify whether there has been a change in the percentage of students enrolling in advanced math and science courses since the onset of the pandemic. We therefore compare participation rates in the 2020-21 and 2021-22 school years to the five prior school years. We consider the 2019-20 school year to be pre-pandemic because students would have enrolled in courses prior to the onset of school closures due to COVID-19 in March 2020.

¹ On educator attrition, see: Bastian, K. C., & Fuller, S. C. (2023). *Educator attrition and hiring in North Carolina Public Schools during the pandemic*. Chapel Hill, NC: Education Policy Initiative at Carolina. On test scores, see: North Carolina Department of Public Instruction. (2022). *Report to the North Carolina General Assembly: An Impact Analysis of Student Learning During the COVID-19 Pandemic*. On other non-test-score outcomes, see: Fuller, S. C., Bastian, K. C., Swiderski, T., & Mikkelsen, C. N. (2023). *Effect of the COVID-19 pandemic on student attendance, grades, grade retention, and suspensions in North Carolina through the 2021-22 school year*. Chapel Hill, NC: Education Policy Initiative at Carolina.

² Dubina, K. S., Ice, L., Kim, J., & Rieley, M. J. (2021). *Projections overview and highlights, 2020-30*. Washington, D.C.: Bureau of Labor Statistics.

We define “advanced” courses to include Advanced Placement, International Baccalaureate, and dual-enrollment courses. Our outcomes are indicators of whether a student took any advanced math course and whether they took any advanced science course in a given year.

We present figures that show observed course enrollment rates in each year. However, simple observation of enrollment rates may be misleading for two reasons. First, enrollments in advanced math and science courses had been rising prior to the pandemic. If the pandemic had not occurred, it is likely that enrollments would have continued to rise. Because of this, we additionally aimed to identify how advanced math and science enrollment changed *relative to expected enrollment rates*, where our predictions assume that enrollment rates would have continued to rise at a similar rate as pre-pandemic if the pandemic had not occurred.

Second, the pandemic caused some shifts in the composition of students who chose to remain enrolled in public schools.³ As a result, participation rates could change in part due to changes in the population of students enrolled in public high schools. We therefore also adjusted our predicted enrollment rates to account for these demographic changes.⁴

Results

Main results

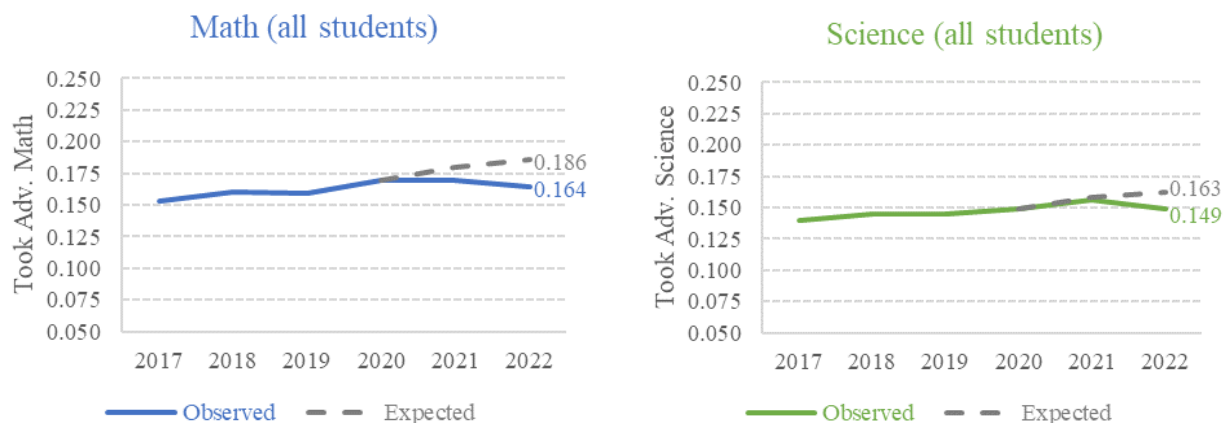
Figure 1 shows enrollment rates in advanced math and science courses for eleventh- and twelfth-grade students in the

2016-17 through 2021-22 school years. Solid blue lines (for math) or green lines (for science) indicate actual enrollment rates, while dashed gray lines indicate predicted enrollment rates in 2020-21 and 2021-22.

Beginning with math, Figure 1 shows that although there was a positive trend in advanced math enrollments prior to the pandemic, enrollments declined in both 2020-21 and 2021-22, dropping from a rate of 17.0% in 2019-20 to 16.4% in 2021-22. Because enrollments in advanced math had been increasing pre-pandemic, we predict that the enrollment rate would have reached 18.6% in 2021-22 had these trends continued. Therefore, by 2021-22, enrollment was 2.2 percentage points (or 12 percent) lower than predicted.

In terms of advanced science, enrollment increased at a rate comparable to – though slightly less than – expected in 2020-21, while enrollments declined in 2021-22. As a result, the enrollment rate in 2021-22 (14.9%) was almost identical to the rate in 2019-20 (15.0%). As with math, there had been an upward trend pre-pandemic in advanced science enrollment, and we estimate that the enrollment rate would have reached 16.3% in 2021-22 had this trend continued. Therefore, enrollment in advanced science was 1.4 percentage points (9 percent) lower than predicted in 2021-22. This reflects a slightly lesser impact of the pandemic on advanced science than math, though the impact was negative for both.

Figure 1: Enrollment rates in advanced math and science courses



	Adv. Math						Adv. Science					
	'17	'18	'19	'20	'21	'22	'17	'18	'19	'20	'21	'22
Observed	15.3	16.0	15.9	17.0	16.9	16.4	14.0	14.4	14.5	15.0	15.6	14.9
Predicted					18.0	18.6					15.9	16.3

Note. Year refers to the spring of the academic year (e.g., 2017 refers to 2016-17).

³ See Bastian, K. C., & Fuller, S. C. (2021). [Enrollment Shifts between Public and Non-Public Schools During the COVID-19 Pandemic in North Carolina](#). Chapel Hill, NC: Education Policy Initiative at Carolina.

⁴ Specifically, we ran an Ordinary Least Squares (OLS) regression in which we controlled for student grade level, gender, race/ethnicity, economic disadvantage, English Learner status, academically/intellectually gifted status, disability status, and a linear time trend for years 2015-16 through 2021-22. “Treatment” is a 3-category indicator of time (pre-COVID, 2020-21, or 2021-22). We identify the expected enrollment rate in 2020-21 as observed enrollment plus the coefficient on the 2020-21 year indicator, and the expected enrollment rate in 2021-22 as observed enrollment plus the coefficient on the 2021-22 year indicator.

Results by race/ethnicity

We next examined enrollment rates in advanced math and science by race/ethnicity (focused on White, Black, and Hispanic students; see Figure 2).⁵ We find that advanced math and science enrollment declined most substantially for Hispanic students. Hispanic student enrollment in advanced math declined from 11.5% in 2019-20 to 11.1% in 2020-21 and 10.5% in 2021-22. Further, had pre-pandemic trends continued, we predict that the advanced math enrollment rate among Hispanic students would have been 12.9% in 2021-22. Therefore, advanced math enrollment by Hispanic students was 2.4 percentage points (21 percent) lower than predicted in 2021-22.

In science, Hispanic student enrollment rates plateaued in 2020-21 and then decreased in 2021-22, dropping from 10.4% to 9.5% between 2019-20 and 2021-22. We predict that Hispanic student enrollment would have reached 11.6% in 2021-22 had pre-pandemic trends continued, so the enrollment rate in 2021-22 was 2.1 percentage points (18 percent) lower than predicted.

By contrast, among Black students, enrollment in advanced math was relatively low and rising only slowly prior to the onset of the pandemic. In 2020-21, the enrollment rate did not change, while in 2021-22, it decreased slightly, dropping from 8.4% to 8.1%. In 2021-22, Black student enrollment in advanced math was 0.7 percentage points (8 percent) lower than our predictions, a much smaller decline than that experienced by Hispanic students.

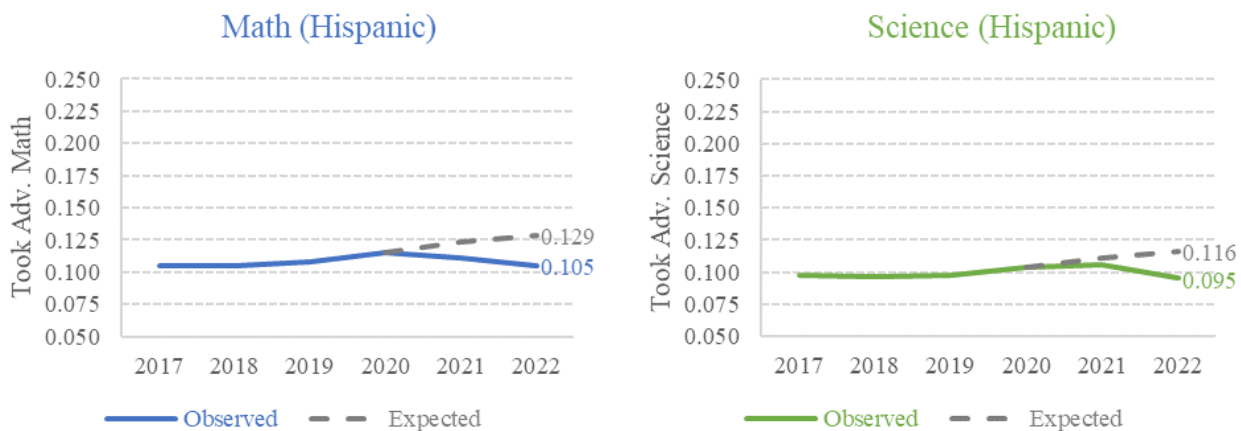
In terms of advanced science, enrollments by Black students grew from 7.6% in 2019-20 to 8.2% in 2020-21 before decreasing to 7.5% in 2021-22. The rate in 2021-22 was about 0.6 percentage points (7 percent) lower than we predicted.

Finally, among White students, enrollments in advanced math stalled in 2020-21 and declined in 2021-22, dropping from 21.4% to 20.6% between 2019-20 and 2021-22. Based on pre-pandemic trends, we predict that the enrollment rate in 2021-22 would have reached 23.4%, meaning that enrollments in 2021-22 were 2.8 percentage points (12 percent) lower than predicted. Thus, White students experienced a larger percentage point decrease than Hispanic students, but a smaller relative (percent) change from their predicted value.

In science, White student enrollments grew in 2020-21 but decreased in 2021-22, such that there was essentially no difference between 2019-20 (18.6%) and 2021-22 (18.7%). However, we predict that the enrollment rate would have increased to 20.1% by 2021-22 based on pre-pandemic trends. Therefore, enrollment in advanced science by White students was 1.4 percentage points (7 percent) lower than predicted in 2021-22. Thus, in science, White students experienced smaller negative effects than Hispanic students both in terms of the percentage point change and the relative change from the predicted value.

Figure 2: Participation in advanced math and science courses by race/ethnicity

Panel A. Hispanic

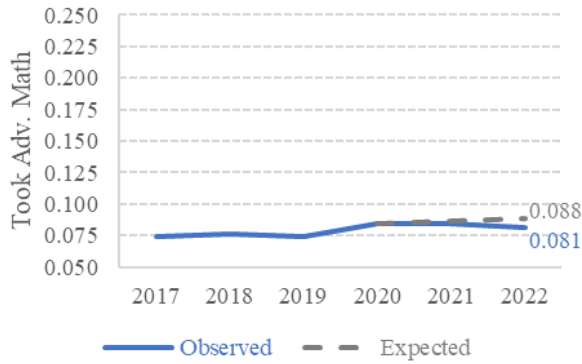


	Adv. Math						Adv. Science					
	'17	'18	'19	'20	'21	'22	'17	'18	'19	'20	'21	'22
Observed	10.5	10.5	10.8	11.5	11.1	10.5	9.8	9.6	10.8	10.4	10.6	9.5
Predicted					12.4	12.9					11.1	11.6

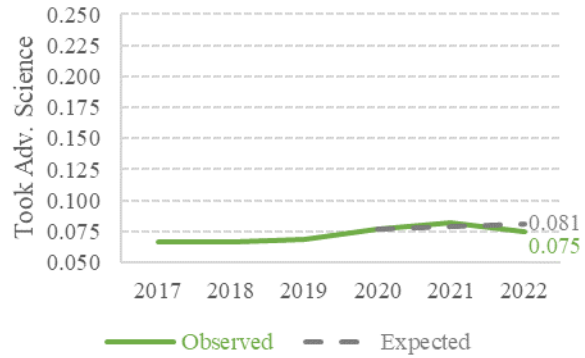
⁵ We generated results for subgroups using the same method as described previously, with separate regressions run for samples restricted to members of each subgroup.

Panel B. Black

Math (Black)



Science (Black)

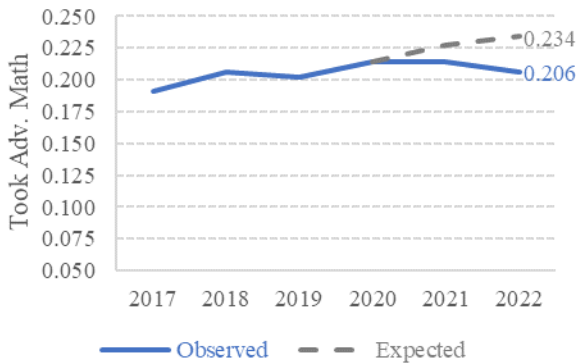


	Adv. Math					
	'17	'18	'19	'20	'21	'22
Observed	7.4	7.6	7.4	8.4	8.4	8.2
Predicted					8.7	8.8

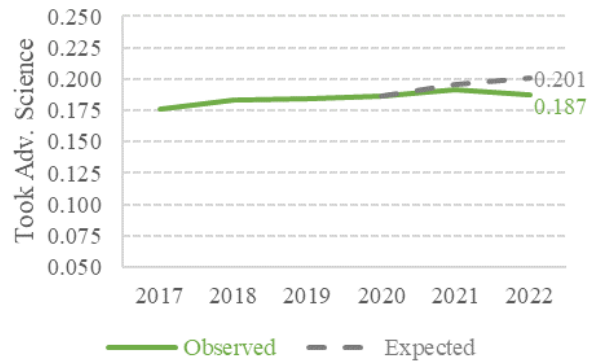
	Adv. Science					
	'17	'18	'19	'20	'21	'22
Observed	6.7	6.7	6.9	7.6	8.2	7.5
Predicted					7.9	8.1

Panel C. White

Math (White)



Science (White)



	Adv. Math					
	'17	'18	'19	'20	'21	'22
Observed	19.1	20.6	20.2	21.4	21.3	20.6
Predicted					22.6	23.4

	Adv. Science					
	'17	'18	'19	'20	'21	'22
Observed	17.6	18.3	18.4	18.6	19.2	18.7
Predicted					19.6	20.1

Note. Year refers to the spring of the academic year (e.g., 2017 refers to 2016-17).

Results by gender

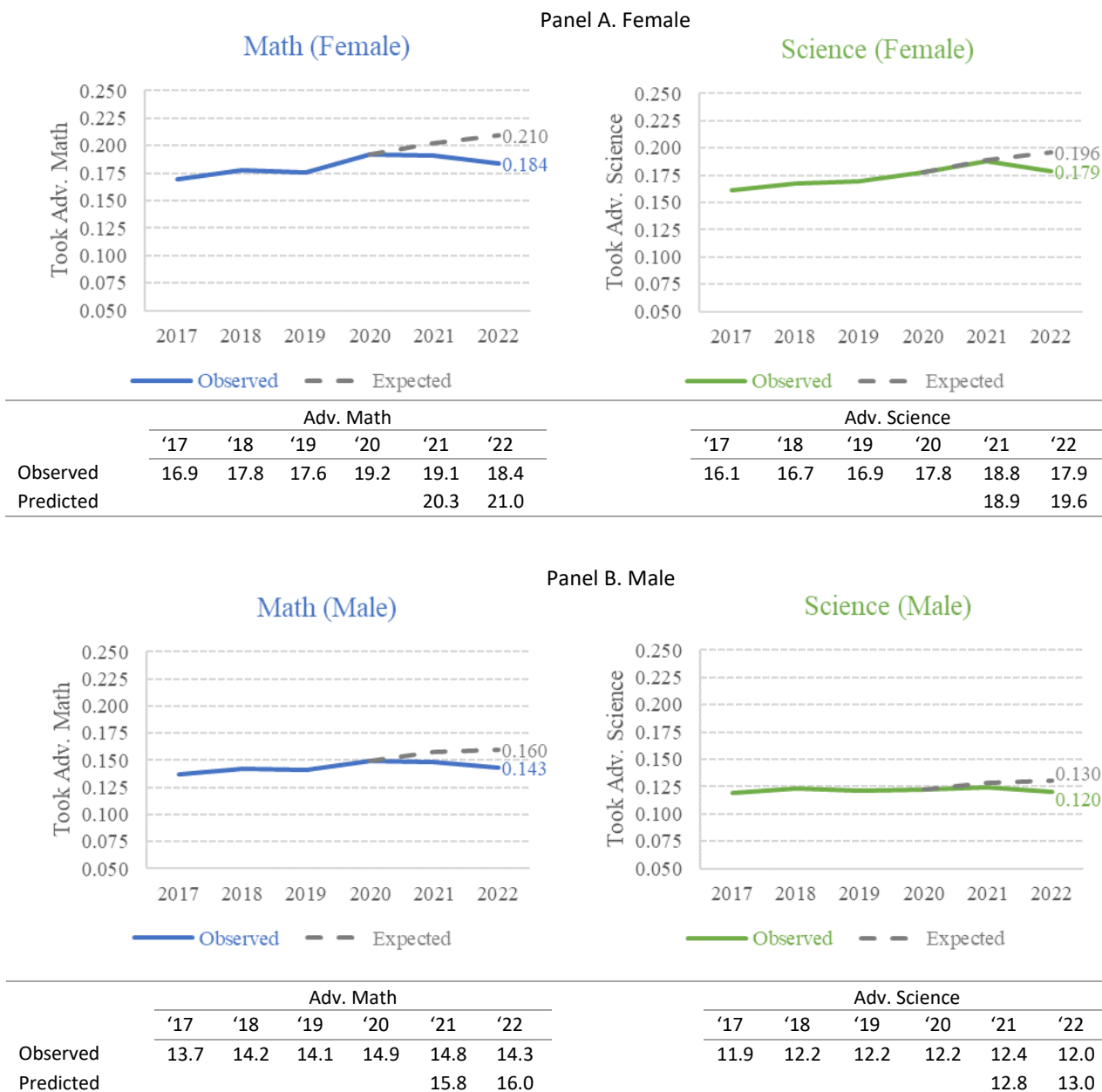
By gender, male and female students each experienced declines in advanced math enrollment by 2021-22. The advanced math enrollment rate by female students stalled in 2020-21 and declined in 2021-22, dropping from a rate of 19.2% in 2019-20 to 18.4% in 2021-22. The rate in 2021-22 was 2.6 percentage points (12 percent) lower than predicted.

Results were similar, though at a lower enrollment rate, for male students. Male student enrollments in advanced math dropped from 14.9% to 14.3% between 2019-20 and 2021-22. The rate in 2021-22 was 1.7 percentage points (12 percent) less than predicted based on pre-pandemic trends.

In science, female student enrollment rates continued to grow in 2020-21 but declined in 2021-22, such that the rate in 2019-20 (17.8%) was similar to the rate in 2021-22 (17.9%). The rate in 2021-22 was 1.7 percentage points (9 percent) less than predicted based on pre-pandemic trends.

Similarly, advanced science enrollments by male students grew slightly (from 12.2% to 12.4%) between 2019-20 and 2020-21 but declined (to 12.0%) in 2021-22. The rate in 2021-22 was 1.0 percentage point (8 percent) lower than predicted based on pre-pandemic trends. Therefore, male and female students were affected similarly, but female students' enrollment rates decreased more in percentage point terms because they had higher enrollment rates pre-pandemic.

Figure 3: Participation in advanced math and science courses by gender



Note. Year refers to the spring of the academic year (e.g., 2017 refers to 2016-17).

Discussion

Participation in advanced math and science courses in high school provides important preparation for postsecondary education and helps promote interest in STEM. While the pandemic did not change growing employment demands for postsecondary credentials and STEM skills in particular, the pandemic did cause many students to exit high school with less interest in and preparation for college. Restoring high enrollments in advanced math and science courses in high school should therefore be a key policy concern.

This brief looks at how enrollment in advanced math and science courses in the final years of high school changed during the COVID-19 pandemic, including a focus on racial/ethnic and gender subgroups that tend to have lower access to advanced STEM coursework and careers. These analyses produce several findings that are relevant to educators and policymakers as they consider how to target and prioritize resources for pandemic recovery.

First, advanced math and science enrollments stalled or declined somewhat in 2020-21 and then declined further in 2021-22. When considering that there were steady upward trends in enrollments pre-pandemic, enrollment declines in 2021-22 appear especially large. These results show that there has been a reversal of previous steady increases in enrollments in these subjects, reflecting a need for additional investments to recover prior momentum.

Declines in advanced course enrollments, particularly in math, may reflect that students typically must complete standard-level prerequisite courses at a high level of performance to be allowed to enroll in more advanced courses. If students were unable to take preparatory coursework or performed poorly in their coursework during pandemic disruptions, it would be challenging for them to proceed to a subsequent advanced course. In support of this idea, our prior work has shown that student GPAs declined substantially, while course failure rates nearly doubled, during the 2020-21 school year.⁶ Academic recovery may help address this challenge for future cohorts, but cohorts of students that were thrown off-track by the pandemic may need new and creative opportunities to both catch-up and accelerate to get back on-track.

Declines in advanced course enrollments could also in part reflect declining student interest in attending college, such that students do not see the need to take college-

preparatory coursework, and worsening student mental health, which could lead them to opt-out of potentially high-stress coursework. These possibilities are particularly worrying because they suggest that advanced course enrollments could continue to stagnate even if and when learning recovery is achieved, suggesting a possible need for additional interventions focused on non-test-score outcomes.

Indeed, we find that advanced course enrollments decreased through the 2021-22 school year. This stands in contrast to results showing that test scores recovered partially in 2021-22, but aligns with findings that other non-test-score outcomes, such as student absences, did not.⁷ These results highlight that academic recovery cannot be limited to and measured solely by test score recovery, but must be considered holistically across a range of outcomes.

Additionally, we find that declines in advanced course enrollment were largest among Hispanic students. This aligns with our prior work showing that Hispanic students also experienced the largest declines in GPAs and attendance during the pandemic.⁸ This suggests that Hispanic students may have experienced unique challenges during the pandemic that exacerbated their outcomes even more than students of other marginalized groups, suggesting a need for deeper inquiry into their experiences and targeting of recovery efforts towards these students.

Finally, though much research has focused on the impacts of the pandemic among the most at-risk learners, these results highlight that there is also a need for resources to support recovery among advanced students, especially advanced students of subgroups traditionally underrepresented in higher education and advanced STEM careers.

Overall, as the long-run effects of the pandemic on students' academic, social, and emotional outcomes continue to evolve, the results of this study highlight that achieving full recovery depends on devoting attention and resources to addressing a holistic set of education outcomes affecting students facing a wide range of circumstances.

⁶ Fuller, S. C., Bastian, K. C., Swiderski, T., & Mikkelsen, C. N. (2023). *Effect of the COVID-19 pandemic on student attendance, grades, grade retention, and suspensions in North Carolina through the 2021-22 school year*. Chapel Hill, NC: Education Policy Initiative at Carolina.

⁷ For national test score trends, see: Lewis, K., & Kuhfeld, M. (2023). *Education's long COVID: 2022-23 achievement data reveal stalled progress toward pandemic recovery*. NWEA. For non-test-score outcomes including absences, see: Fuller, S. C., Bastian, K. C., Swiderski, T., & Mikkelsen, C. N. (2023). *Effect of the COVID-19 pandemic on student attendance, grades, grade retention, and suspensions in North Carolina through the 2021-22 school year*. Chapel Hill, NC: Education Policy Initiative at Carolina.

⁸ See: Fuller, S. C., Swiderski, T., Mikkelsen, C. N., & Bastian, K. C. (2023). *In school, engaged, on-track? The effect of the pandemic on student attendance, course grades, and grade retention in North Carolina*. EdWorkingPapers: <https://edworkingpapers.org/index.php/ai23-747>

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