education policy analysis archives

A peer-reviewed, independent,
open access, multilingual journal

Arizona State University

Volume 33 Number 12 February 4, 2025 ISSN 1068-2341

Effects of Early AP Coursetaking on High School Outcomes and College Enrollment for Less Academically Prepared Students

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Citation: Lee, H. B., Bahena, S., & Nichols, S. L. (2025). Effects of early AP coursetaking on high school outcomes and college enrollment for less academically prepared students. *Education Policy Analysis Archives, 33*(12). https://doi.org/10.14507/epaa.33.8651

Abstract: The expansion of Advanced Placement (AP) programs to include students from underrepresented racial and ethnic minorities and those from less advantaged socioeconomic backgrounds has made it crucial to assess how effective AP courses and exams are for these groups. As AP programs become more popular, more high school students–especially freshmen and sophomores–are signing up for AP courses. Despite this growing trend, there's still not enough research on how early AP participation affects these particular students. This study fills this research gap by exploring the benefits of early AP involvement for students considered academically underprepared based on prior test scores. We find that early AP course participation leads to higher scores on state exit exams, greater enrollment in early college credit courses, and increased college attendance and completion rates, particularly at four-year institutions. These findings challenge the reliance on prior test scores as the sole

Journal website: http://epaa.asu.edu/ojs/
Facebook: /EPAAA
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Manuscript received: 29/3/2024
Revisions received: 11/11/2024
Accepted: 2/12/2024

predictor of AP success and future academic achievements, suggesting a need for a more comprehensive approach to evaluating students' readiness for the rigors of AP coursework.
Keywords: Advanced Placement; academically underprepared students; early engagement in AP; historical academic performance; Texas

Impacto de la participación temprana en cursos de AP en los resultados de secundaria y la inscripción universitaria de estudiantes menos académicamente preparados

Resumen: La expansión de los programas de Advanced Placement (AP) para incluir a estudiantes de minorías raciales y étnicas subrepresentadas, así como a aquellos de entornos socioeconómicos menos favorecidos, ha hecho que sea crucial evaluar la efectividad de los cursos y exámenes de AP para estos grupos. A medida que los programas de AP se vuelven más populares, un número creciente de estudiantes de secundaria, especialmente de primer y segundo año, se está inscribiendo en cursos de AP. A pesar de esta tendencia creciente, aún hay una falta de investigación suficiente sobre cómo la participación temprana en AP afecta a estos estudiantes en particular. Este estudio aborda esta brecha investigando los beneficios de la participación temprana en AP para estudiantes considerados académicamente no preparados según los puntajes de pruebas previas. Encontramos que la participación temprana en cursos de AP conduce a puntajes más altos en los exámenes estatales de egreso, una mayor inscripción en cursos de crédito universitario temprano y mayores tasas de asistencia y finalización universitaria, particularmente en instituciones de cuatro años. Estos hallazgos cuestionan la dependencia de los puntajes de pruebas previas como único predictor del éxito en AP y de los logros académicos futuros, sugiriendo la necesidad de un enfoque más integral para evaluar la preparación de los estudiantes para los rigores del trabajo académico en AP.
Palabras-clave: Advanced Placement; estudiantes académicamente no preparados; participación temprana en AP; rendimiento académico histórico; Texas

Efeitos da participação precoce em cursos de AP nos resultados do ensino médio e na matrícula universitária de estudantes menos acadêmicamente preparados

Resumo: A expansão dos programas de Advanced Placement (AP) para incluir estudantes de minorias raciais e étnicas sub-representadas, bem como aqueles de origens socioeconômicas menos favorecidas, tornou crucial avaliar a eficácia dos cursos e exames de AP para esses grupos. À medida que os programas de AP se tornam mais populares, um número crescente de estudantes do ensino médio — especialmente calouros e alunos do segundo ano — está se matriculando em cursos de AP. Apesar dessa tendência crescente, ainda há pouca pesquisa sobre como a participação precoce em AP afeta esses estudantes em particular. Este estudo preenche essa lacuna investigando os benefícios da participação precoce em AP para estudantes considerados academicamente despreparados com base em resultados de provas anteriores. Descobrimos que a participação precoce em cursos de AP está associada a pontuações mais altas nos exames estaduais de conclusão do ensino médio, maior inscrição em cursos de crédito universitário antecipado e maiores taxas de frequência e conclusão de cursos universitários, especialmente em instituições de quatro anos. Esses resultados desafiam a dependência dos resultados de provas anteriores como único indicador de sucesso no AP e de conquistas acadêmicas futuras, sugerindo a necessidade de uma abordagem mais abrangente para avaliar a preparação dos estudantes para os rigores dos cursos de AP.
Palavras-chave: Advanced Placement; estudantes academicamente despreparados; engajamento precoce em AP; desempenho acadêmico histórico; Texas

Effects of Early AP Coursetaking on High School Outcomes and College Enrollment for Less Academically Prepared Students

Existing research suggests a strong relationship between a rigorous high school curriculum and academic outcomes. The literature supports the premise that students who engage in challenging high school coursework are more likely to graduate, enroll in higher education, and complete their college degrees (Adelman, 2006; Aughinbaugh, 2012; Horn et al., 2001; Long et al., 2012). Within this academic discourse, the Advanced Placement (AP) program – offered by U.S.-based nonprofit The College Board – is often recognized as a cornerstone of college preparatory education, offering rigorous coursework that purportedly equips students with the skills and knowledge necessary for postsecondary success (see Kolluri [2018] and Warne [2017] for comprehensive reviews). Originating from a collaboration between elite high schools and colleges in the United States, the AP curriculum consists of a series of college-level courses and exams covering a wide range of subjects and was designed to offer academically talented students an opportunity to undertake college-level academic work during their high school years. As such, students who participate in the AP program have the opportunity to earn college credit while in high school and gain a competitive advantage in the college admissions process.

With the increasing need for jobs requiring postsecondary education, enhancing college readiness has become a critical concern for educational leaders and policymakers, and the AP program, in particular, has taken a pivotal role in addressing this challenge. Over time, the AP program has been deliberately expanded to include a wider range of schools, especially those serving underrepresented demographics and low-income student populations. While originally reserved for a small subset of privileged students, the AP program is now available to a substantial proportion of young people. A recent report estimates that 79% of U.S. public school students attended high schools that offered at least five AP courses in the 2022-2023 school year (College Board, 2024). This expansion is part of a broader strategy to make high-quality academic experiences more accessible to all students, irrespective of their socioeconomic status (Schneider, 2011).

Although there might be some disagreement on the specific, much of the existing literature has found a generally positive relationship between the AP program and academic outcomes (Warne, 2017), and yet these benefits are not shared equally or widely. Despite the program's objectives, research indicates that many students fail to reap the anticipated benefits of AP participation (Dougherty et al., 2006; Geiser & Santelices, 2006; Mattern et al., 2009; Sadler & Sonnert, 2010). This gap between expectation and reality has sparked a scholarly debate regarding the inclusivity and effectiveness of AP courses, questioning whether these benefits are equitably distributed or primarily advantageous to students already on a trajectory for academic success. Kolluri (2018) proposed three hypotheses to make sense of the relationship between AP participation and outcomes, one of which suggests that underrepresented student populations do not pursue AP-level coursework because they may not be academically "ready" (typically as measured by past grades or past performance on state standardized tests). Despite the fallibility of such measures and the fact that future academic success is more than one's past performance, many teachers and counselors rely heavily on state standardized test performance and/or past grades to identify (or encourage) student placement in AP coursework. Therefore, underrepresented student populations (those from poorer communities or from historically marginalized Black and Latino communities in the United States) who disproportionately score lower on these "traditional" metrics are also disproportionately left out of AP pursuits. One goal of this paper is to challenge the assumption that only high achieving students (as gauged by performance on state standardized test scores, for example) can persist in and would yield the benefits of AP coursetaking.

The expansion and increasing popularity of AP programs have also contributed to a new and significant trend: students are taking AP courses earlier in their high school journey, with a notable increase in enrollment among freshmen and sophomores. The College Board reports that more than one million 9th and 10th graders took AP courses in 2022 nationally (College Board, 2023). Similarly, in Texas, there has been an increase in the number of 9th and 10th grade students who enroll in AP courses. Between 2021 and 2023, the number of Texas 9th and 10th grade students who participated in AP courses rose from 857,228 (53%) to 915,103 (55%) (Texas Public Education Information Resource [TPEIR], 2023). However, despite this shift towards early engagement in AP coursework, research on its effectiveness remains scarce, particularly for students who may not be academically prepared for such rigorous academic challenges or who take AP earlier in their high school years.

This study examines the effects of early engagement in AP courses for students deemed "academically underprepared," as indicated by their previous state standardized test scores in reading and mathematics. We define "academically underprepared" students as those who scored below their cohort's median on both the mathematics and reading sections of the Texas Assessment of Knowledge and Skills (TAKS) taken in 8th grade (refer to the Study Population section for a detailed definition). By analyzing data from 98,040 "underprepared" students who transitioned from public middle schools to public high schools in Texas during the 2010/11 school year, this research challenges the prevailing assumption that early AP involvement is less advantageous for students with lower prior test scores. Our goal is to understand whether early participation in AP courses might contribute to greater educational equity and enhancement, providing perspectives on how AP involvement can improve academic success and readiness for college among students often considered underprepared. This research not only reassesses conventional measures of academic readiness but also seeks to highlight the AP program's potential as a tool for educational advancement and equity.

We begin with some background on the AP program in Texas, followed by a review of relevant literature on what we know about AP effects and outcomes. Next, we describe our methods and conceptual framework for calculating the effects of AP participation. We then describe our results that include our estimation results, along with several robustness checks to support the validity of the study's findings. Finally, we conclude with a discussion on the implications of our findings and their broader significance.

Review of Relevant Literature

The Advanced Placement Program in Texas: Some Context

The AP program has, by design, been equated with rigor and college readiness. Created in the 1950s for the most "able students" (College Board, 2020), the AP program "enables willing and academically prepared students to pursue college-level studies while still in high school" (College Board, n.d. -a). To that end, AP courses and exams are developed by a committee of college faculty and experienced AP teachers who ensure the content is aligned with college expectations. Currently, school districts in the United States can provide any of the 40 AP courses offered by the College Board. These courses are available in various subjects such as art, English, history and social science, math and computer science, science, and world languages and cultures (College Board, n.d. -b).

While the initial conception of the AP program targeted a relatively exclusive group of students, its reach has significantly broadened in recent decades. This is evident from the growing number of schools that offer the AP program, as well as the increased number of students who participated in AP coursework and took AP exams. The College Board reported a 60% increase in

the number of schools offering AP Exams from the 2002/03 school year to the 2021/22 school year, demonstrating greater accessibility and participation (College Board, n.d. -c). Concurrently, the number of students undertaking AP exams saw a more than twofold increase, from 1,017,396 to 2,659,914 (College Board, n.d. -d). Despite this dramatic increase, there are still inequities in who has access to AP courses. Black and Latino students and those from low-income backgrounds continue to be underrepresented in AP participation (Kim-Christian & McDermott, 2022; Patrick et al., 2022; Xu et al., 2021). In response, the College Board has made it an explicit goal to make AP enrollment and access equitable by introducing a variety of resources to help school leaders reach more students, especially those in traditionally underrepresented groups (College Board, n.d. -e).

Trends in Texas mirror the national participation patterns (Texas Education Agency [TEA], 2022a). Texas has prioritized expanding AP access and participation, particularly for historically underrepresented students (College Board, n.d. -f; Education Commission of the States, 2016). The TEA subsidizes exam fees for students with demonstrated financial need. In addition, the AP Incentive Program allows the appropriation of state funding to reimburse public school districts for teacher training, equipment, and incentive bonuses tied to AP implementation and performance. Participation rates and performance in select AP courses (i.e., in English, math, science, and social studies) have also been incorporated into the state's school accountability system, contributing towards the college and career readiness indicator (TEA, 2022b). This has important implications for their potential transition to college, as the Texas legislature requires all public institutions to adopt policies that grant incoming undergraduate students college credit if they meet the minimum scoring criteria on one or more AP exams.

Texas's decades-long investment in enhancing participation in the AP program seems to have yielded the intended results. In the 2021-22 academic year, Texas saw significant participation in AP examinations, with 321,876 students across all grades in public and nonpublic schools taking a total of 577,350 AP exams. This positioned Texas as the second-highest state in the nation for both the number of AP examinees and the number of AP exams taken. From more than a decade, from 2011-12 to 2021-22, Texas experienced a 55.3% increase in the number of AP exams taken, outpacing the national growth rate of 27.8%. The most popular AP exams in Texas were English Language and Composition, World History: Modern, and Human Geography. This differed slightly from the national preferences, which included United States History and English Literature and Composition among the top three. Texas stood out for having higher percentages of examinees scoring in the 3-5 range on two specific exams: Music Theory and Italian Language and Culture, compared to the overall performance in the United States.

AP Participation and Education Outcomes: Some Evidence, Some Questions

The empirical connections between AP coursetaking and academic outcomes are nuanced and highlight the important distinction between the benefits associated with enrolling in AP courses versus passing the AP exam. Overwhelmingly, as detailed next, research has found that participating in AP courses *and* passing the AP exam correlates with positive academic outcomes. However, what benefits might there be of participating for students who take AP courses early in their high school career and who may initially be considered academically underprepared?

Benefits of Enrolling in AP vs. Passing the AP Exam

The precise extent to which the AP program has a positive impact on student outcomes is much debated. While numerous studies have identified a positive association between enrolling in AP courses and achieving enhanced educational outcomes at both high school and college, others have argued that that effect is overestimated once other variables are taken into account. For

example, some studies have found that compared to their non-AP counterparts, AP students not only score higher on state standardized exams, but also exhibit higher college attendance rates, attain higher grades in college, and demonstrate greater persistence and likelihood of earning college degrees (e.g., Chajewski et al., 2011; Dougherty et al., 2006; Mattern et al., 2013; McKillip & Rawls, 2013; Scott et al., 2010). In contrast, other researchers have argued that when demographic variables, SAT scores, high school GPA, and school characteristics are incorporated into the analyses, the predictive power of AP course participation and AP exam scores on college GPA or student persistence disappears (e.g., Conger, & Iatarola, 2009; Geiser & Santelices, 2006; Kloppgenstein & Thomas, 2009).

Despite the disagreement on the strength of the relationship between AP participation and outcomes, there does seem to be some consensus that it isn't just enrolling in AP coursework that matters, but whether students pass the AP exam (Dougherty et al., 2006; Guarantz, 2021; Kolluri, 2018). Warne et al. (2015) found that students who both took and passed their AP exams achieved higher ACT scores than those who did not pass – and did so even after adjusting for demographic, academic, and socioeconomic variables. Passing AP exams is also linked with several other positive outcomes, including higher rates of college enrollment and retention, improved first-semester college GPAs, and a clearer path to selecting a major in college (Avery et al., 2018; Dougherty et al., 2006; Phillips & Lane, 2021; Scott et al., 2010; Taylor & Yan, 2018). In their analyses, Dougherty et al. (2006) conclude that the number of students who take *and* pass the AP exams is the "best AP-related indicator" for predicting later college graduation rates, emphasizing the need to improve student academic preparation to enroll in AP courses. In contrast, the College Board (2021), using its own findings, has advocated for the benefits of AP course participation irrespective of exam performance. Their research indicates that students, scoring 1 or 2 on their AP exams or maintaining such average scores across all taken AP exams, exhibited more favorable college outcomes than their academically similar peers who did not engage with AP courses. These outcomes included higher participation in subsequent AP courses, improvement on later AP exams, increased enrollment in four-year colleges, and higher GPAs in introductory college courses.

Thus, there is still much to examine to fully understand how rigorous curricula, like AP coursework and exam success, relate to academic engagement and outcomes. While participation in AP courses and performance on AP exams offer pathways to educational advancement, the extent and nature of these benefits are influenced by a complex interaction of student characteristics, academic backgrounds, and the educational contexts within which they are situated.

Potential Benefits of Early AP Participation

The present study seeks to examine the potential benefits of AP participation for a very specific group: students who might initially be deemed academically unprepared and who take the AP courses early in their high school careers. To the extent that educators and policymakers have aimed to increase AP accessibility to a broader range of students, knowing whether these young people benefit from their participation has important implications for both policy and practice.

We hypothesize that academically underprepared students would benefit from early AP participation. In their review of the literature, Kolluri (2018) notes studies in which AP students themselves identify benefits of AP participation that include more engaging curricula, stronger sense of community, and improved class climate. In our own review, we were unable to find studies that examine the benefits of specifically participating in AP courses early in high school, as freshmen and sophomore students, and how such participation may have differentiated benefits for students who might be academically underprepared. Existing literature notes that students may self-select out of taking AP courses if they do not see themselves as "college material" (Zinth, 2016), and others may

be under-identified for participation in programs like AP and Gifted and Talented (e.g., Card & Giuliano, 2016). Coupled with appropriate academic and social support, early AP participation might provide initially underprepared students with exposure to comparatively rigorous curricula that can yield long-term benefits.

Contribution of This Study to the Literature

This study contributes to the literature on AP in two ways. First, our focus on "academically underprepared" students challenges assumptions about the effectiveness of test scores as useful criteria for AP participation. Despite the increased participation of underrepresented students (Kolluri, 2018), who comprised a majority of academically underprepared students, the research exploring the effects of AP participation on this population remains limited. Our study seeks to bridge this gap by exploring the potential benefits that AP courses may offer to academically underprepared students.

Second, traditional patterns saw students opting for AP exams in their junior and senior years as a strategic academic choice. However, recent data indicate a significant trend toward earlier engagement in AP coursework, with a notable increase in students enrolling in AP courses during their freshman and sophomore years. This shift is supported by data from the TPEIR, which documents a substantial rise in the number of younger students taking AP exams (TPEIR, 2023). Despite this trend, the literature on the effectiveness of early AP course engagement is sparse, particularly for students who may not be academically prepared for such challenging coursework. This study aims to fill this void by investigating the effect of early AP course participation on academically underprepared students, defined by their prior standardized reading and mathematics exam scores.

Data and Method

Data Sources

We use student-level administrative records from the Texas Education Research Center (ERC) at the University of Texas at Austin. The ERC maintains longitudinal student- and school-level data provided by the TEA and THECB. For this research, the TEA data provide a rich set of educational records of students who attended public secondary schools (6^{th} to 12^{th} grade), and the THECB data provide students' college enrollment and degree award records in public, private, and for-profit higher education institutions. Moreover, we supplement these data sets with information from the National Student Clearinghouse (NSC) to identify students who enrolled in and graduated from higher education outside Texas.

Study Population

This study examines 98,040 students who transitioned from public middle schools to high schools in the 2010/2011 school year in Texas and were identified as having lower prior academic achievement. More specifically, the study population includes students who attended public middle schools across Texas for the duration of their years in Grades 6-8. In addition, students transitioning to high schools that do not offer AP course(s) were excluded from the study. This exclusion clarifies the distinction between non-enrollment due to AP unavailability and voluntary non-participation in available AP courses, isolating the factors influencing students' decisions to take AP classes when possible and ensuring a focused analysis on access versus interest. Academically underprepared students are defined by scoring below their cohort's median on both the mathematics and reading sections of the Texas Assessment of Knowledge and Skills (TAKS) taken in Grade 8 (Lee &

Villarreal, 2023).[1] Within this population, 6.1% (or 5,940 students) participated in the AP program during their first two years of high school.

Overall, these Early Advanced Placement (EAP) students tended to score higher on reading, mathematics, science, and social studies TAKS exit exams, participate in early college coursework at higher rates, and enroll more in postsecondary education than non-EAP students (who did not participate in the AP programs during their first two years of high school). Table 1 presents descriptive statistics of the outcome variables by EAP and non-EAP student groups before propensity score matching.

Table 1

Descriptive Statistics of Secondary and College Enrollment by EAP Participation Before Propensity Score Matching

	EAP Students	Non-EAP Students
	(1)	(2)
High School Outcomes		
Exit Exams a		
Attrition	0.054 (0.225)	0.203 (0.416)
Reading	2273.596 (136.949)	2218.327 (156.453)
Mathematics	2222.002 (133.669)	2164.470 (154.981)
Science	2252.942 (125.119)	2204.115 (142.316)
Social Studies	2406.488 (158.653)	2333.070 (177.522)
Early College Coursework		
AP Participation	0.613 (0.487)	0.138 (0.345)
DE Participation	0.260 (0.439)	0.077 (0.267)
On-Time Graduation	0.940 (0.237)	0.748 (0.434)
Postsecondary Outcomes		
Immediate College Enrollment	0.631 (0.482)	0.350 (0.477)
Four-Year College Enrollment b	0.523 (0.500)	0.312 (0.463)
Associate's Degree Attainment in Two Years	0.129 (0.335)	0.079 (0.270)
Associate's Degree Attainment in Four Years	0.319 (0.466)	0.222 (0.416)
Bachelor's Degree Attainment in Four Years	0.197 (0.398)	0.113 (0.316)
Bachelor's Degree Attainment in Eight Years	0.537 (0.499)	0.358 (0.480)
Observations	5,940	92,100

Notes: EAP–Early Advanced Placement. Standard deviations are reported in parentheses.
a–Descriptive statistics of the exit exam scores are based on students who took the exams in the third year of high school. b–Descriptive statistics of four-year college enrollment are based on students who attended college in the year following their expected high school graduation.

Additionally, EAP students comprised a higher proportion of female students, gifted and talented students, and students with higher cumulative school attendance rates than non-EAP

[1] The study population, composed of academically underprepared students, attained scale scores up to 850 in reading and 769 in mathematics, with mean scores of 764 (SD = 52.44) and 719 (SD = 33.42), respectively. For this exam year, the scale score ranges were 237–2648 for reading and 320–3150 for mathematics. By comparison, students outside the academically underprepared group averaged 972 (SD = 384.16) in reading and 937 (SD = 393.03) in mathematics. Additionally, academically advanced students in the top (fourth) quartile for both reading and mathematics scored mean values of 1638.52 (SD = 627.24) and 1561.87 (SD = 619.51), respectively.

students. EAP students also comprised a lower proportion of special education students, free- or reduced-price school lunch (FRPL)-eligible students, students at risk of dropping out of school, and students who had received disciplinary action reports relative to non-EAP students. (Table 2 presents the descriptive statistics and balance test results of key variables in this study.)

Table 2

Descriptive Statistics of Student Characteristics by EAP Participation Before Propensity Score Matching

	EAP Students	Non-EAP Students	Difference
	(1)	(2)	(3)
Socioeconomic Characteristics			
Age (8th)	13.127	13.287	–0.160***
	(0.397)	(0.513)	(0.007)
Female	0.570	0.476	0.093***
	(0.495)	(0.499)	(0.007)
African American	0.160	0.177	–0.017***
	(0.367)	(0.382)	(0.005)
Hispanic	0.598	0.525	0.073***
	(0.490)	(0.499)	(0.007)
English as a Second Language (6th–8th)	0.052	0.063	–0.012***
	(0.222)	(0.244)	(0.003)
Gifted and Talented (6th–8th)	0.086	0.020	0.066***
	(0.281)	(0.141)	(0.002)
Receipt of Special Education (6th–8th)	0.023	0.091	–0.068***
	(0.151)	(0.288)	(0.004)
Receipt of Free Lunch (8th)	0.392	0.477	–0.085***
	(0.488)	(0.499)	(0.007)
Receipt of Reduced-Price Lunch (8th)	0.089	0.089	1.76 x e-4
	(0.285)	(0.285)	(0.004)
Eligibility for Other Public Assistance (8th)	0.128	0.090	0.037***
	(0.334)	(0.286)	(0.004)
Ability			
TAKS Reading Test Scores at 6th grade	2318.600	2241.378	77.222***
	(170.242)	(167.584)	(2.246)
TAKS Reading Test Scores at 7th grade	2243.750	2171.428	72.322***
	(136.940)	(139.874)	(1.870)
TAKS Reading Test Scores at 8th grade	788.320	762.606	25.715***
	(46.618)	(52.368)	(0.697)
TAKS Mathematics Test Scores at 6th grade	2228.726	2146.098	82.628***
	(163.847)	(169.352)	(2.263)
TAKS Mathematics Test Scores at 7th grade	2186.685	2126.716	59.969***
	(105.787)	(114.167)	(1.522)
TAKS Mathematics Test Scores at 8th grade	734.857	718.360	16.497***
	(25.970)	(33.540)	(0.444)
Behavior and Attendance			
Expulsion (6th–8th)	0.023	0.089	–0.065***
	(0.151)	(0.284)	(0.004)

	EAP Students	Non-EAP Students	Difference
	(1)	(2)	(3)
Suspension (6th–8th)	0.324	0.540	–0.216***
	(0.468)	(0.498)	(0.007)
Attendance Rates (6th–8th)	0.963	0.940	0.023***
	(0.037)	(0.061)	(0.001)
Graduated from a Title I School	0.689	0.670	0.019***
	(0.463)	(0.470)	(0.006)
Observations	5,940	92,100	98,040

Notes: Standard deviations are reported in parentheses in columns (1) and (2), and standard errors are reported in parentheses in column (3).
** $p < 0.05$. *** $p < 0.01$.

To better characterize our study population and their AP course-taking patterns, we provide additional descriptive statistics on the socio-demographic characteristics of both EAP and non-EAP students. These statistics are presented for two groups: all public high school students and the subset of students who graduated from public middle schools during the analysis period. The latter group is particularly relevant to our study, as our primary focus is on students who graduated from public middle schools.

When comparing racial/ethnic composition and FRPL status between academically underprepared students and the overall student population (the second group in the previous paragraph), the data indicate that academically underprepared students had a higher proportion of African American, Hispanic, and FRPL students. These disparities were significantly more pronounced among EAP students within the academically underprepared group compared to all EAP students than they were among non-EAP students in similar comparisons (See Appendix A1). Specifically, EAP students among academically underprepared students had a higher representation of African American students by 7 percentage points, Hispanic students by 19 percentage points, and FRPL students by 24 percentage points relative to all EAP students. Although similar patterns existed in the non-EAP student comparisons, the disparities were less marked. These substantial differences suggest that academically underprepared students who took AP courses early were more likely to be from racial and ethnic minority groups and low-income backgrounds compared to the broader population of early AP participants.

Propensity Score Matching

We began with the potential outcome framework to examine the effects of students' early AP participation on high school and postsecondary outcomes. Denote Y^1 and Y^0 by a potential outcome for a student who took AP courses in the first two years of high school (hereafter, referred to as EAP student) ($T = 1$) and a student who did not participate in AP programs during the period (hereafter, referred to as non-EAP student) ($T = 0$), respectively. The observed outcome for a student i can be written as $Y_i = Y_i^1 \cdot T_i + (1 - T_i) \cdot Y_i^0$. The average effect of EAP then can be defined as $\tau = E(T = 1) - E(T = 0)$. Assuming no difference in characteristics (either observed or unobserved) except EAP participation between the treatment and comparison groups, one can identify the causal relationship simply by comparing the outcome between these two groups of students. However, as discussed in the literature review, a growing body of studies considered AP participation as endogenous in postsecondary education models. That is, students strategically choose whether and when to take AP courses, and their decisions are made based on various individual and contextual factors. Thus, ignoring the difference in characteristics between the EAP

and non-EAP students would cause selection bias in EAP effects, potentially yielding erroneous conclusions and misguided policy recommendations.

To reduce potential selection bias inherent in the endogenous nature of AP participation, we employ propensity score matching (PSM) to calculate counterfactual mean outcomes, which is what EAP students would have accomplished without AP participation. To calculate a matching estimator, we first estimate propensity scores by running a logit regression with select matching covariates that influence both the treatment and outcome variables. We then identify a matching algorithm that best fits the data based on five statistical tests assessing the quality of matching, accompanied by a balance test that compares the statistical difference in the matching covariates between the two groups after the match. With the assurance of the quality of matching, we estimate the average treatment effect on the treated (ATET) by running a weighted regression of the EAP variable (where the weights are calculated based on the matching algorithm and distribution of estimated propensity scores) on the study's outcome of interest.

The robustness of the matching estimator relies on satisfying the conditional independence assumption (CIA), which makes the potential outcome independent of treatment conditional on observed characteristics. In other words, the outcome of interest is independent of treatment if matching estimation includes sufficient predictors, determining EAP participation (Wooldridge, 2010). However, including characteristics that can themselves be influenced by treatment causes the CIA assumption to fail. Therefore, this study includes a rich set of student and school characteristics collected from the 6th to 8th grade, that is, prior to students' earliest AP participation in 9th grade.

Assuming that the CIA holds and there is a sizable overlap in the propensity score distribution between the treatment and comparison groups (known as common support), the PSM estimator for the ATET can be written as, $\tau_{ATET} = E[Y_i|T = 1, P(X)] - E[Y_i|T = 0, P(X)]$, where $P(X)$ is the likelihood of EAP participation based on the observed characteristics, (X).

Selection of Variables

Dependent variables include high school and postsecondary outcomes. High school outcomes include the performance of students in their TAKS exit exams in reading, mathematics, science, and social studies, as well as their participation in AP and dual credit courses in the latter half of their high school years.[2] Postsecondary outcomes include immediate college enrollment, four-year college enrollment, and college degree attainment. Early participation in AP courses is the main treatment variable, defined as completing at least one AP course during the first two years of high school.[3]

This study depicts student participation in early AP participation by integrating a wide array of covariates, encompassing students' sociodemographic backgrounds, historical performance on state-mandated standardized exams, and behavioral characteristics during middle school. According to Rose and Betts (2004), there is a persistent challenge in accounting for students' academic abilities

[2] Dual credit courses are high school programs that allow students to earn college credits by taking college-level classes. These classes are usually offered through partnerships between high schools and colleges, providing students with a chance to accelerate their college education while still in high school. The availability and specifics of dual credit programs can differ between educational institutions.

[3] In our data, academically underprepared EAP students averaged 1.06 high school credit hours from AP courses (a standard deviation of 0.4). It was rare for these students to accumulate two or more AP credit hours (1 high school credit hour represents a year-long course). Although a binary measure of AP participation does not capture the full range of variation in students' AP course-taking, course-taking patterns show that most students take only one AP course. Therefore, concerns about the potential influence of varying degrees of AP participation on our effect estimates are likely less influential.

and motivation in higher education models (Rose & Betts, 2004). These traits–neither measurable nor quantifiable–are positively correlated with students' advanced course-taking and educational outcomes, resulting in the estimated effect being biased upward (Lee & Villarreal, 2023; Long et al., 2012; Warne, 2017).

In an effort to mitigate the omitted ability bias in our matching estimation, we incorporate proxy variables encompassing state-mandated standardized mathematics and reading exam scores from the 6th to the 8th grades. The rationale for selecting these standardized exam scores as proxies lies in their potential to partially capture students' academic abilities and motivations. These scores are indicative of the development of foundational mathematical and reading skills, which are critical for succeeding in the challenging curriculum of high school AP courses. However, it is essential to acknowledge that standardized test scores may not fully capture students' potential, particularly in cases where students demonstrate substantial classroom performance despite weaker test results. Additionally, a significant correlation exists between standardized test scores and students' socioeconomic status, suggesting that these scores may not solely measure academic ability but also be influenced by external socioeconomic factors. To address this gap, we include participation in gifted and talented programs as an additional measure, recognizing that such enrollment may influence educators' recommendations for AP courses based on perceived academic potential rather than standardized test performance alone.

Moreover, we consider the implications of students being classified as English as a second language (ESL) learners or receiving special education, which could influence their engagement and success in AP courses. Beyond these characteristics, we include a multitude of characteristics that describe students' academic engagement across racial and ethnic backgrounds and financial status, which can affect both students' AP participation and their secondary and postsecondary outcomes. These include gender, age (at 8th grade), racial and ethnic backgrounds and eligibility for free- or reduced-price school lunch (referred to as FRPL) or other federal assistance programs. Behavioral indicators, such as records of expulsion or suspension and school attendance rates, are also integrated as proxies for student engagement, with regular attendance often correlating with higher academic achievement.

A central question on the effect of AP participation, as discussed in literature reviews, is whether students took and passed AP exams. Unfortunately, our data do not indicate students' AP exam-taking or passing status; it only confirms their enrollment in AP courses. Exam costs are frequently identified as a key barrier to participation, especially for students from low-income families. To improve exam participation rates and promote equity, eligible students received significant discounts. For example, in the 2011-2012 school year, students from low-income families identified by FRPL paid only $9 per AP exam (compared to $87 without the reduction; TEA, 2015). To address potential biases arising from varying eligibility statuses between EAP and non-EAP students, we utilize a three-year trend in students' FRPL status during middle school as a strong proxy for AP test fee reduction eligibility. This allows us to select comparable counterfactual counterfactual groups with similar FRPL status, helping to control for income-based differences in AP exam access. Additionally, to approximate the likelihood of passing AP exams, we employ standardized reading and math test scores as a proxy for students' potential AP exam performance.

Moreover, to further refine our analysis, we control for the heterogeneous variations in EAP offerings across middle schools and counties, acknowledging that differences in the school environment, teacher quality, and regional characteristics would influence EAP participation and the outcomes of interest. Previous PSM literature suggests that accounting for the hierarchical structure of the data by using a fixed-effects (FE) or random-effects (RE) model can decrease a substantial amount of bias from unmeasured confounders at the cluster level (e.g., Arpino & Cannas, 2016;

Thoemmes & West, 2011). In addition, Schuler et al. (2016) recommended using RE over FE when the data contain a large number of small clusters since the data are too sparse to estimate a large number of cluster dummies.

Given the study data containing over 2,000 public middle schools, with a considerable portion being small in size, we adhere to Schuler et al.'s (2016) recommendation and adopt the random-effects model. In order to account for the hierarchical structure of the data, we estimate propensity scores by the logit model, including predictions of cluster-level random effects at the school and county levels in addition to all matching covariates (Arpino & Cannas, 2016). By integrating predicted school- and county-level random effects into our PSM estimation, we enhance the precision of our matching process, enabling the identification of counterfactuals with identical educational and regional backgrounds as the treated students. This methodology ensures a more accurate matching process, reducing the risk of inappropriate matches across disparate regions. Additionally, the inclusion of schools' Title I status serves as a proxy for the availability of resources necessary to support a diverse AP course offering, further enriching our analysis.

Selection of a Matching Algorithm

The PSM estimator compares the outcome of treated individuals (EAP students) to the outcome of their counterfactuals. The counterfactuals can be constructed differently by the definition of the neighborhood of each treated unit and imposition of the common support condition. However, all matching estimators obtained from these algorithms should yield the same results asymptotically as the sample size increases since they become closer to the exact matches (Caliendo & Kopeinig, 2008; Heckman et al., 1997).

Because our comparison sample is large, the probability of finding suitable matches without using replacement is fairly high; therefore, we employ the single-nearest neighbor matching without replacement (single-NN). Without replacement indicates that an untreated unit is used only once as a match for a treated unit. In addition, single-NN matching can face a risk of bad matches if the closest neighbor (distance in propensity scores) is far away. We attempt to avoid this problem by using caliper matching and imposing a tolerance on the maximum distance in the propensity scores allowed. Following the recommendation of others (e.g., Cochran & Rubin, 1973; Rosenbaum & Rubin, 1985), we adopt a caliper of 0.25 standard deviations of estimated propensity scores.

In Table 3, we display five statistical tests that assess matching quality before and after applying PSM. For the entire study population, the test results before matching show that the pseudo-R^2 is 25.7%; the likelihood ratio (LR) test rejects the null hypothesis, indicating that the joint significance of all matching covariates is statistically significant; and, the mean and median standardized biases are 34.4 and 32.3, respectively. We also conduct Rubin's *B* test, which compares the standardized difference of mean propensity scores between treated and matched untreated groups. The *B* test statistic of less than 25 is considered to indicate that the groups are sufficiently balanced (Rubin, 2001). Before matching, Rubin's B test statistic is 154.8, considerably greater than the suggested cut-off point.

After applying a PSM algorithm of single-NN without replacement within the specified caliper width, the pseudo-R^2 becomes very low (0.01%), indicating a negligible difference in the distribution of matching covariates between treated and matched untreated groups. The LR test accepts the null hypothesis with a *p*-value of 0.979. The mean and median standardized biases decrease substantially to 1.2 and 1.1, respectively. Rubin's *B* statistic decreases to 6.1, within the acceptable range. These test results supported high-quality matching. We also impose the common support condition in the matching estimation to ensure that a treatment unit has a comparison unit "nearby" in the propensity score distribution. In the case of no unit in the comparison group having

a similar propensity score to the treatment unit, we exclude the treatment unit due to the weak common support (Heckman et al., 1997). However, Bryson et al. (2002) cautioned that if the proportion of observations lost due to the common support condition is large, concerns may arise on whether the remaining data represent the entire study population. In this study, the proportion of observations lost due to the lack of common support is 2.85%, reducing our concerns about whether the findings generated from the remaining observations lacked external validity.

Table 3

Propensity Score Matching Quality Results Before and After Matching

	Pseudo R^2	LR χ^2 (p-value)	Mean Std. Bias	Median Std. Bias	Rubin's B	Reduction in Observations (%)
	(1)	(2)	(3)	(4)	(5)	(6)
All Students						
Unmatched	0.257	11516.08 (< 0.001)	34.4	32.3	154.8	–
Matched						
Single-NN	0.001	10.72 (0.979)	1.2	1.1	6.1	2.85
Exit-Exam Takers						
Unmatched	0.248	10034.73 (< 0.001)	31.3	29.1	150.1	–
Matched						
Single-NN	0.001	12.34 (0.950)	1.6	1.8	6.7	3.28
College-Going Students						
Unmatched	0.240	5780.49 (< 0.001)	27.4	24.6	143.1	–
Matched						
Single-NN	0.001	7.94 (0.997)	1.3	1.3	6.7	4.45
Two-Year College Enrollees						
Unmatched	0.222	2817.29 (< 0.001)	25.6	21.7	142.4	–
Matched						
Single-NN	0.002	8.35 (0.996)	1.6	1.3	9.7	1.45
Four-Year College Enrollees						
Unmatched	0.222	2817.29 (< 0.001)	25.6	21.7	142.4	–
Matched						
Single-NN	0.003	14.23 (0.893)	2.9	3.1	12.6	8.87

Notes: Std.–Standardized. LR–Likelihood ratio. Single-NN: single nearest neighbor matching with non-replacement and common support; Single-NNR: single nearest neighbor matching with replacement and common support; 3-NN: three nearest neighbor matching with replacement and common support; and 5-NN: five nearest neighbor matching with replacement and common support.

Since neither all students took exit exams in their third year of high school nor enrolled in higher education right after high school, we conduct separate matching analyses for exit-exam takers and college-going students. After matching, the test results show that the pseudo-R^2 values are very low at or below 0.3%, and the LR statistics lead us to accept the null hypothesis with p-values close to 1. Their mean and median standardized biases are less than 3, and Rubin's B test statistics are placed within the suggested cut-off range.

As an additional step to ensure the quality of matching, we perform a balance test that compares a statistical difference in each matching covariate between EAP and non-EAP students. The results from the balance test, reported in Appendix A2, show that none of the 22 matching covariates shows a statistically significant difference between the two groups. The diagnostic test results from the five quality indicators and subsequent balance tests affirm that the matching process succeeds in generating counterfactuals that are not statistically distinguishable from EAP students based on observables.

Results

Characteristics of Students Who Early Engaged in AP Program

To calculate propensity scores, we run a logistic regression analyzing students' early AP participation based on a set of student and contextual characteristics. Due to different sample sizes across the outcomes, we conduct separate analyses for all students, exit-exam takers, and college-going students. Overall, we find similar regression results, although the magnitudes of the coefficients are slightly different across the subgroups (see Appendix A3). The results show that female students and those enrolled in gifted and talented programs were more likely to participate in EAP, while participation rates were lower among older students, those in special education, and students with suspension records. Furthermore, the coefficient on the FRPL variable was neither statistically insignificant nor varied in significance across groups; however, students from Title I schools were more inclined to engage in AP programs compared to their peers. Hispanic students showed a higher likelihood of EAP participation, while African American students' participation rates were similar to those of non-minority students. Across all grades, math and reading exam scores were positively associated with students' EAP participation, and scores taken in the latter years of middle school were more relevant to program participation. Additionally, students who maintained higher cumulative attendance rates were more inclined to engage in AP programs at an early stage. The analysis also incorporated random effects at both school and county levels, which were found to be highly significant. This indicates notable variations in EAP participation rates among students across different schools and counties.

List of AP Courses Taken by Academically Underprepared Students

In this section, we shift focus to explore the specific AP courses taken by academically underprepared students. The data indicate that a substantial proportion of these students enrolled in AP World History (62%), followed by AP Spanish (17.1%), AP Human Geography (11.6%), and AP Biology (2.2%), among others. In contrast, the course enrollment patterns for the overall high school population were markedly different. Among the entire student population, the highest enrollment was in AP English Language and Composition (15.2%), followed by AP United States History (13.6%), AP English Literature and Composition (10.8%), AP World History (10.2%), AP Calculus AB (6%), and AP U.S. Government and Politics (4.73%). Notably, academically underprepared students demonstrated a disproportionately higher enrollment in AP Spanish—a course not commonly among the most popular AP courses for the broader student body. This trend may be linked to the greater representation of Hispanic students within the academically

underprepared cohort, suggesting a potential correlation between demographic background and course selection. These findings suggest that the EAP effects observed in this study are more likely to encourage enrollment in language arts-related AP courses rather than in math-intensive or STEM-related AP courses. The emphasis on language-related courses points to a potential gap in broader AP course diversification, especially regarding math and science fields among academically underprepared students.

Effects of Early AP Participation

Table 4 presents the ATET estimators for EAP effects on high school and college outcomes, the robust standard error (reported in parentheses), and the matched counterfactual mean. We report the average marginal effect for binary outcome variables. The results show that EAP students were predicted to have a higher probability of participating in AP and dual credit programs in their latter two years of high school by 33.8 and 11.5 percentage points relative to the matched non-EAP students with a group mean of 27.3% and 13.9%, respectively. Here, we find that the AP participation rate for matched non-EAP students was 13.5 percentage points higher than the entire non-EAP student population. This finding suggests that EAP students were matched to a subgroup of non-EAP students who were above average in AP participation among all non-EAP students (see Table 1 for the descriptive statistics of the outcomes for the entire non-EAP students). A similar pattern is found for dual credit participation, where matched non-EAP students participated at a rate 6.2 percentage points greater than the entire non-EAP student cohort. Additionally, EAP students demonstrated a 6 percentage point lower likelihood of attrition from exit exams in their third year of high school compared to matched non-EAP students, 11.4% of whom did not take the exams timely. Exit exam attrition can occur for several reasons, such as grade repetition, exam exemption, and exam absence that might also be associated with, but not limited to, student academic performance, physical and mental illness, and behavioral problems. Our data do not explicitly describe the reasons for exam attrition, but exam exemption and the absence of exams due to unpredictable reasons such as illness and family-related issues should not be considered as an adverse outcome. Hence, we suggest using this analysis to inform the overall trend in "on-trackness" measuring the degree to which students adhere to the learning schedule in high school.

EAP participants also outperformed matched non-EAP students across all exit exam subjects, with particularly pronounced effects observed in social studies. Specifically, EAP students scored an average of 17.6 and 19.2 scale points higher in reading and mathematics, respectively, with matched non-EAP students averaging scores of 2254.8 and 2201.4. The advantages extended to science and social science exams, where EAP students outscored their counterparts by 20.7 and 33.6 scale points, against averages of 2232.5 and 2373.7, respectively. These estimates are equivalent to saying that EAP students showed higher test scores compared to their non-EAP peers, with gains of 0.113, 0.124, 0.146, and 0.189 standard deviations in reading, math, science, and social studies, respectively. While these effect sizes are weak (to modest), they indicate a positive academic benefit, particularly in social studies, where the largest improvement was observed. Other factors might also explain these findings; however, the stronger effect observed in the social sciences likely relates to the specific types of AP courses chosen by EAP students. As noted in the previous section, a significant number of EAP students tended to enroll in AP courses such as AP World History, AP Spanish, and AP Human Geography. These courses align closely with language arts and social studies. This tendency to select AP courses in these areas might, therefore, explain the heightened EAP effects observed in social studies (and non-English language arts) exam performance.

Table 4

EAP Effects on High School and College Outcomes

High School Outcomes	Exit Exams					Early College Coursework		On Time HS Graduation
	Attrition	Reading	Mathematics	Science	Social Studies	AP Participation	DC Participation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EAP	–0.808***	17.597***	19.157***	20.699***	33.576***	1.433***	0.745***	0.873***
	(0.071)	(2.665)	(2.636)	(2.446)	(3.102)	(0.040)	(0.049)	(0.067)
Marginal effect	–0.060					0.338	0.115	0.074
Matched CG Mean	0.114	2254.791	2201.373	2231.271	2371.592	0.273	0.139	0.865
Γ	1.9-2.0	1.2-1.3	1.2-1.3	1.3-1.4	1.4-1.5	3.9-4.0	1.9-2.0	2.1-2.2
Observations	11,540	10,850	10,850	10,850	10,850	11,540	11,540	11,540

College Outcomes	Immediate College Enrollment	Four-Year College Enrollment	Certificate or Associate Degree Attainment		Bachelor's Degree Attainment	
			Within Two Years	Within Four Years	Within Four Years	Within Eight Years
	(9)	(10)	(11)	(12)	(13)	(14)
EAP	0.580***	0.539***	0.384***	0.353***	0.584***	0.492***
	(0.038)	(0.048)	(0.109)	(0.075)	(0.094)	(0.068)
Marginal effect	0.142	0.133	0.037	0.072	0.077	0.122
Matched CG Mean	0.487	0.383	0.092	0.248	0.120	0.411
Γ	1.6-1.7	1.5-1.6	1.2-1.3	1.2-1.3	1.5-1.6	1.4-1.5
Observations	11,540	7,164	3,522	3,522	3,576	3,576

Notes: CG–Comparison group. Weights calculated from single-NN with no sample replacement, common support, and the caliper of 0.25 standard deviations of estimated propensity scores (0.024 for attrition, early college coursework, and on-time graduation; 0.026 for reading, mathematics, science, and social studies; 0.024 for immediate college enrollment; 0.032 for four-year college enrollment). Robust standard errors were reported in parenthesis. ** $p < 0.05$. *** $p < 0.01$.

Furthermore, EAP students exhibited an on-time high school graduation rate that was 7.4 percentage points higher than that of the matched comparison group, with a rate of 86.5%. These findings align with earlier observations, showing that matched non-EAP students generally achieved higher exam scores and graduation rates on time than the entire comparison group. The results also show that EAP students were predicted to have a higher likelihood of enrolling in any form of postsecondary institution in the year following their expected high school graduation by 14.2 percentage points than matched non-EAP students with a group mean of 48.7%. Moreover, of those college-going students, EAP students were more likely to attend four-year colleges than two-year colleges by 13.3 percentage points than matched counterfactuals who did not take AP courses during their first two years of high school and enrolled in college immediately after high school. For those entering two-year colleges, EAP students were more likely to complete certificates or associate degrees within two and four years of college entry by 3.7 and 7.2 percentage points than their counterparts, respectively. Additionally, a significant gap was observed in bachelor's degree attainment, with EAP students being 7.7 and 12.2 percentage points more likely to earn their degrees within four and six years of college entry, respectively, compared to matched non-EAP students who pursued four-year college degrees immediately after high school. Overall, these findings are consistent across different propensity score matching specifications, though there is some variation in the magnitude of the estimates.

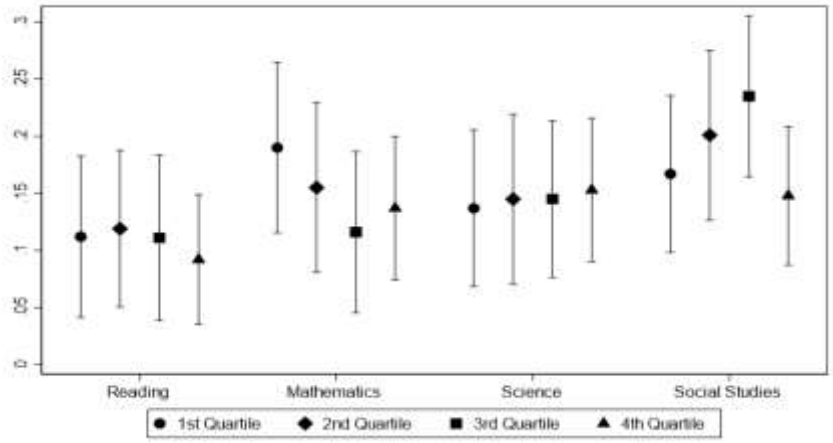
We then analyze the subgroup effect of EAP by examining high schools with different proportions of FRPL students (see Figure 1). Schools are divided into quartiles based on the proportion of FRPL students, allowing us to compare EAP effects across these groups. The results suggest that the EAP effect on AP participation in the last two years of high school was most pronounced among students attending schools in the first quartile (those with the lowest FRPL proportions). Conversely, the effect on dual credit participation, on-time graduation rates, and bachelor's degree attainment within eight years was strongest for students attending schools in the fourth quartile (those with the highest FRPL proportions).

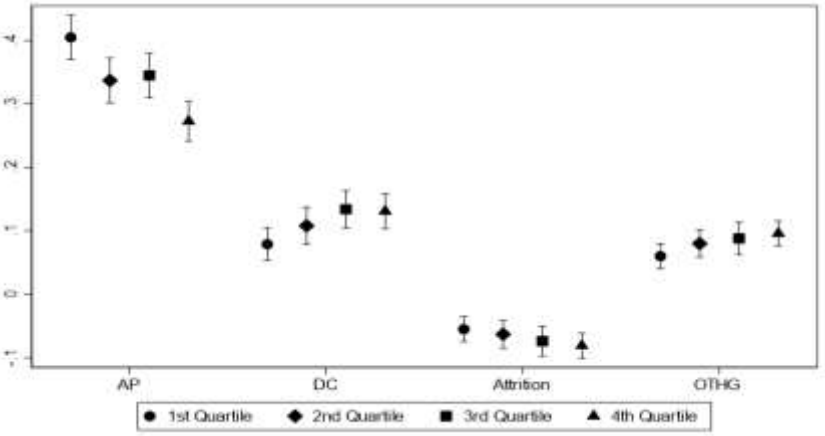
The EAP effect on college enrollment immediately following high school graduation appeared relatively similar across all quartiles, while the effect on associate degree attainment tended to be higher for students attending schools within the middle quartiles. Additionally, the effects of EAP on standardized test scores were generally consistent across subjects, with a notably larger gap observed in mathematics between students attending schools in the first and third quartiles. Students attending schools in the middle quartiles tended to experience larger EAP effects in social studies compared to students attending schools in other quartiles.

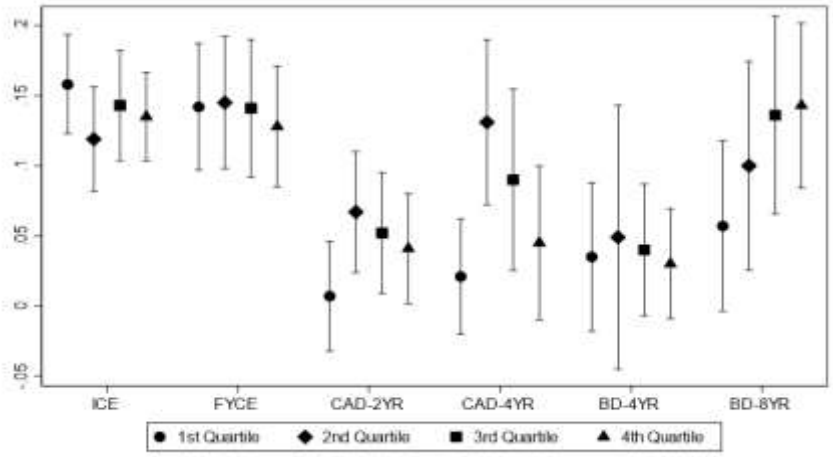
Overall, these findings are consistent across different propensity score matching specifications, though there is some variation in the magnitude of the estimates. These findings indicate that the effect of the EAP program varied according to the financial composition of a school's student body. Specifically, in schools with a higher percentage of students eligible for FRPL, the EAP appeared particularly beneficial by supporting low-income students in overcoming obstacles to educational progress, such as access to dual-credit programs, graduation rates, and degree attainment. Conversely, in schools with fewer FRPL-eligible students, the EAP primarily promoted increased enrollment in additional AP courses. Given that schools in wealthier, non-rural areas typically offered more AP courses than those in high-poverty or rural areas (e.g., Theokas & Saaris, 2013), this substantial increase in AP participation during the latter two years of high school might align with the more affluent provision of AP courses—opportunities often unavailable in high-poverty schools.

Figure 1

Heterogeneous EAP Effects Across Schools Categorized by Quartiles of FRPL Student Proportions







AP:	AP participation
DC:	DC participation
Attrition:	Exit exam attrition
Mathematics:	Exit exams mathematics scores
Reading:	Exit exam reading scores
Science:	Exit exam science scores
Social Studies:	Exit exams social studies scores
OTHG:	On-time HS graduation
FYCE:	Four-year college enrollment
ICE:	Immediate college enrollment
CAD-2YR:	Certificate or associate degree attainment within 2 years
CAD-4YR:	Certificate or associate degree attainment within 4 years
BD-4YR:	Bachelor's degree attainment within 4 years
BD-8YR:	Bachelor's degree attainment within 8 years

Note: The standardized effects of EAP on the TAKS exit exams are used in the figure.

Robustness Check 1: Rosenbaum Sensitivity Analysis

The unbiased PSM estimator requires the selection equation to be correctly specified. However, despite the study's rich set of matching covariates depicting students' early AP participation, the estimated effects may still suffer from omitted variable bias if student ability or other determinants were not fully accounted for in the postulated model. Although it is not possible to test whether the model is correctly specified or not, we can conduct a Rosenbaum's sensitivity analysis relying on the sensitivity parameter Γ that assesses the extent to which unobserved characteristics (or "hidden bias") can alter the statistical inference of the matching estimator (Becker & Caliendo, 2007; Rosenbaum, 2002). While there is no consensus about what level of Γ assures that an estimate is sensitive or robust to unobservables in an observational study, we consider a Γ of 1.5 or below as the estimate is vulnerable to unobserved heterogeneity (Lee & Villarreal, 2023).

Γ values, as reported in Tables 4 exceed the 1.5 thresholds for outcomes related to AP and dual credit course participation in later high school years, exit exam attrition, on-time high school graduation, immediate college enrollment, enrollment in four-year colleges, and bachelor's degree completion. This suggests that an increase in unobserved factors by more than 1.5 times within the matching estimation would not alter the inference of our effect estimates, thereby confirming their robustness against unobserved heterogeneity. Conversely, Γ values below 1.5 for exit exam scores and attainment of certificates or associate degrees imply that a 50% increase (or less) in unobserved factors could undermine these statistical relationships. While this does not directly imply biased estimates due to unobserved variables, it warrants a cautious interpretation of these results.

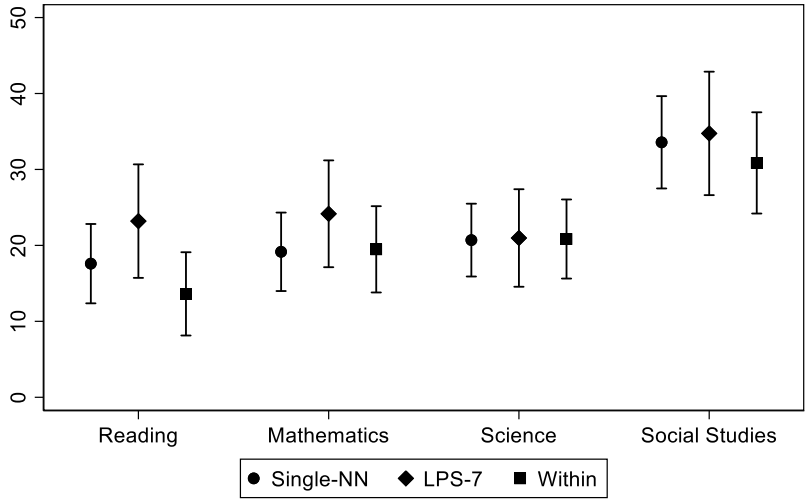
Robustness Check 2: Further Accounting for Students' Transition to High School for Matching

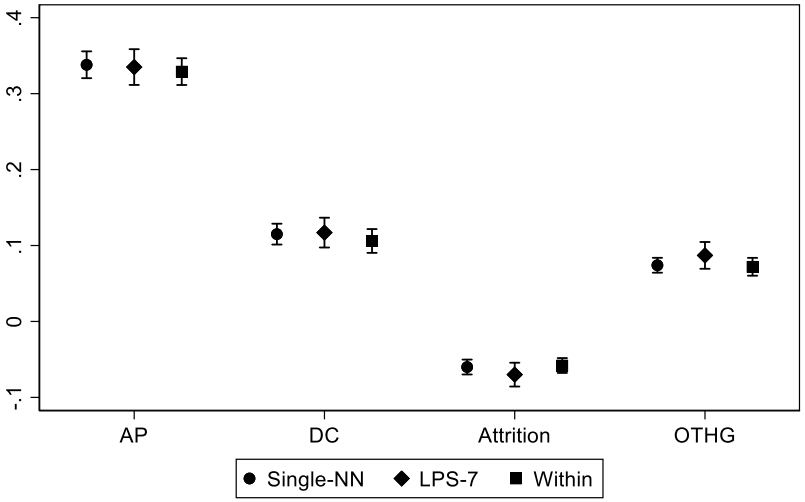
Our initial method for matching takes into consideration the schools and counties where students completed their middle school education. This strategy enables us to compare the secondary and post-secondary outcomes of students with similar regional backgrounds in middle school. However, this approach has limitations, particularly concerning students who moved to different regions after middle school. For instance, students moving from a rural to an urban county or to another district in pursuit of a better academic environment highlight that controlling solely for the origin middle schools and counties would be insufficient to account for dynamics in student mobility and educational outcomes. We refine our analysis to ascertain whether the inference of effect estimates will alter after incorporating additional regional dimensions, both the origin and destination school districts. This refinement involves constraining the treatment units to be compared exclusively with those within the same school districts as their respective high schools, as well as those districts from which they graduated middle school. This method, called the Within Matching Estimator, involves excluding treatment observations that lack sufficient counterparts that meet the selection criteria in the control group, and it reduces 16.4% of the treatment group students.

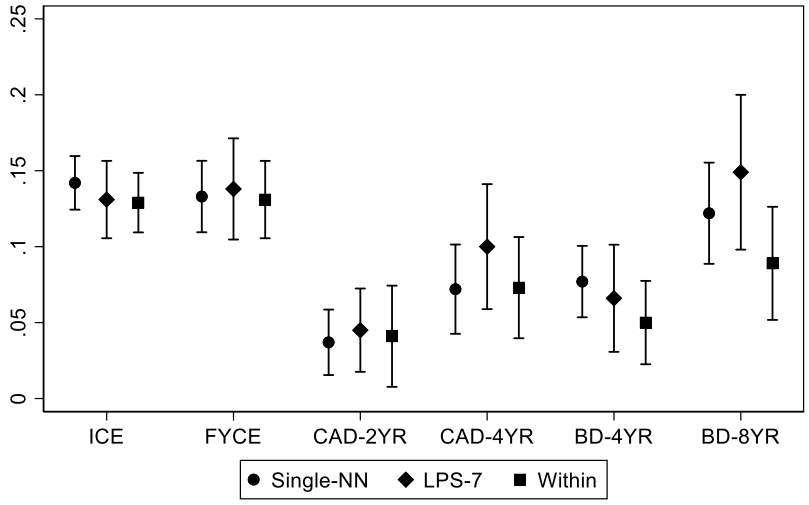
Figure 2 plots the magnitudes of AP effects across the outcome variables, comparing estimates obtained from the original matching process with those from this alternative matching strategy (noted as 'Within'). Although excluded for the sake of brevity, all matching coefficients are statistically significant at least at a 5% level; however, the size of the effects is marginally smaller than those obtained from the original matching model. This observation implies that making adjustments for school transitions does not significantly change the overall interpretation of the effect estimates, suggesting that the main conclusions drawn from the original model remain robust even when accounting for the dynamics of school transitions.

Figure 2

Comparison of AP Effect Sizes on Secondary and Postsecondary Outcomes Between Original and Alternative PSM Models







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BD-8YR:	Bachelor's degree attainment within 8 years

Robustness Check 3: Expanding the Definition of Academic Underpreparedness to 7th grade

In this section, we address the concern that relying solely on 8th grade test scores might not accurately identify students who are underprepared. A key issue is that some students, potentially high achievers under normal circumstances, may perform poorly on test days due to factors like illness or stress, which could introduce bias into our matching estimator. To mitigate this potential bias, we refine our selection criteria to include only students whose scores fell below the median on reading and mathematics tests in both 7th and 8th grades. This modification resulted in a substantial decrease in the sizes of both our treatment and control groups by approximately 51.8% and 29.7%, respectively.[4]

Figure 2 shows that students classified as underprepared in both 7th and 8th grades (noted as 'LPS-7') displayed larger effect sizes relative to the original estimates, while still maintaining statistical significance at the 5% level. This outcome strengthens our preliminary claim that broadening the criteria for under-preparedness to encompass 7th-grade performance does not weaken the observed positive correlation between participation in AP courses and outcomes in secondary and post-secondary education. Instead, this result supports our initial hypothesis, indicating that the methodological refinements we've implemented serve to further confirm the reliability and robustness of our conclusions.

Discussion

Reconsidering AP Placement Processes

Our findings suggest that educators and school leaders should think carefully about their selection processes and the criteria by which they identify potential AP students. Specifically, we argue that educators should guard against determining students' academic potential largely based on their academic histories. Our data suggest that underprepared students (defined here as those with low standardized test scores) are capable of succeeding in AP coursework and subsequently reaping the academic benefits. Similarly, educators should work to encourage students who might otherwise self-select out of AP due to low academic achievement. The Education Commission of the States (ECS) policy brief (Zinth, 2016) highlights that students may sometimes self-select themselves out of taking AP courses if they do not view themselves as "college material." Rather than discounting students who may initially not be as academically prepared, school policies should provide adequate support and comprehensive assistance that can help students succeed in AP classes and yield benefits from participation that extend beyond the exam scores themselves.

In their own analysis, the College Board (2021) reported that AP students who earn a score of 1 or 2 on their AP exam still have better postsecondary outcomes than similar college students who did not participate in an AP course. AP test-takers are more likely to enroll in a four-year college immediately after high school graduation and earn higher grades in their introductory college courses. Furthermore, if students take the AP exam earlier in their high school years, they are also more likely to take an AP exam in subsequent years and earn higher scores on it when they do. A separate study examining the under-representation of low-income and minority students in gifted education programs found that universal eligibility screening programs helped increase the representation of Black and Latino students, English learners, low-income students, and girls (Card & Giuliano, 2016). They hypothesized that their underrepresentation may be explained by the existing process of identifying gifted students that relies on parent and teacher referrals and could

[4] The regression results of the alternative models described in the robustness check 2 and 3 will be available from authors upon request.

"systematically miss many potentially qualified disadvantaged students" (p. 1). In a similar vein, AP access could also be improved if school leaders reconsider how students are identified and redefine who is considered to have potential.

Enhancing Student Support for Success

As others have argued, access in itself is not enough to guarantee that students will enroll and succeed in AP courses. In a recent report, the Center for American Progress (Chatterji et al., 2021) highlights that despite having AP offerings in schools, the proportion of students who enroll in an AP course, take the AP exam, and successfully pass the exam shrinks with each step. The authors noted that for every 1000 students, only 174 enroll in at least one AP course, 129 take at least one AP exam, and only 74 ultimately earn a passing score. Indeed, within the context of our study, the academically less prepared students would have contributed to this trend. Providing additional support systems is just as necessary as increasing access to ensure student success. The ECS's recommendations support both the educators teaching AP courses and the students taking them, such as pre-AP workshops or summer institutes and teacher training and professional development (Zinth, 2016).

Counselors can also play an important role in cultivating a school environment that is conducive to student success in AP courses. Davis et al. (2013) described a collaboration between a school counselor, AP teacher, and a counselor educator that developed as part of the school's effort to improve the underrepresentation of African American students in their AP courses. Selected students participated in a two-week intensive summer program facilitated by their future AP teacher and in a series of group and individual counseling sessions. While the study participants' performance on their AP exam was not significantly different from the performance of other Black test-takers who did not participate in the program, the authors find that the gap between the performance of Black and White students narrowed. The authors attributed this to the close relationships developed within the cohort and between the cohort and the instructor. They added that participating in the program also shaped the way the students saw themselves as scholars. One student in their study had previously failed English, but after participating in the program, he became a top performer in his AP course exams, made the honor roll, and earned a college scholarship.

These findings highlight that, with appropriate support, academically less prepared students are able to succeed and benefit from exposure to the AP program. Indeed, our findings suggest that less academically prepared students who participate in AP courses early in their high school years have better secondary and postsecondary outcomes compared to similar students who did not take AP courses during their freshman or sophomore year. Positive, supportive classroom climates can be part of a holistic strategy to support these students in successfully completing their AP courses.

In this study, we defined underprepared students as those who scored below the median on high-stakes standardized tests in Texas at the time. We recognize this criterion is an imperfect proxy for indicating the extent of students' "academic preparedness" and, as a result, does not serve as an adequate stand-in for students' level of engagement or motivation in topic areas or even the depth of their understanding in any given discipline. However, the correlation of test scores with student SES does suggest that low-performing students are likely to include disproportionate numbers of students of poverty and from minoritized backgrounds. In this regard, this proxy offers a substantive way to identify and analyze the experiences of underrepresented groups as it relates to AP coursetaking. Still, it is a narrow marker of students' actual "preparedness" and "motivation" for academic pursuits. Additional research is needed to understand the academic, psychological,

motivational complexity of student engagement, interest, and ambition regarding the pursuit of challenging coursework such as AP.

Study Limitations and Future Research

In this study, we use PSM to examine the effect of EAP on secondary and postsecondary outcomes for academically underprepared students. PSM is widely regarded as a powerful method for impact assessment in quasi-experimental research designs. While randomized controlled trials (RCTs) offer the ideal approach for estimating unbiased causal effects by eliminating confounding biases, RCTs are often impractical in educational settings. For instance, we cannot randomly assign some students to take AP courses and others to abstain, as this would be infeasible for AP and most other coursework. Instead, PSM allows us to construct a plausible counterfactual by matching students on a robust set of relevant variables that capture their likelihood of enrolling in AP courses. By accounting for a sufficient set of covariates that describe the treatment status, we can significantly reduce bias in the estimated effects, making PSM particularly valuable when RCTs are unfeasible.

One of the most significant criticisms of propensity score matching lies in its vulnerability to omitted variable bias. This issue arises when the model fails to account for all relevant covariates, thereby complicating the inference of causal relationships. For example, some high school students may be "tracked" into AP courses due to limited availability of honors or other advanced courses, such as those in art, music theory, or psychology, at their schools. Investigating this phenomenon could uncover critical factors that influence students' decisions to enroll in advanced courses, which may vary significantly based on the specific courses available at their schools. This insight could contribute to a deeper understanding of how course access shapes educational pathways. Consequently, we have recommended further research in this area to broaden our understanding of AP course accessibility and its wider implications. Furthermore, incorporating AP exam participation and pass/fail results could significantly enhance the depth of our research by allowing for more nuanced analyses around AP effects. This approach would enable a comparison among students who simply took an AP course, those who passed the AP exam, and those who did not pass, thereby revealing any differential influences associated with AP course completion versus AP exam success. Unfortunately, neither TEA nor THECB collect data on whether students took AP exams or their pass/fail outcomes.

Despite our thorough efforts to depict students' EAP participation through a broad set of covariates, the challenge of confidently asserting causality remains. Rosenbaum's sensitivity analysis, while useful for assessing the effect of unmeasured variables, cannot conclusively establish causality but rather highlights our findings' susceptibility to unseen factors. Given these limitations, our results should be cautiously interpreted as indicating an association, not causation, between EAP participation and educational outcomes.

Nonetheless, our research furnishes valuable insights into the educational pathways of students who are deemed underprepared or contemplating enrollment in AP courses during their early high school years. Our main findings reveal the significant effect of early AP participation on improving student outcomes, such as increased involvement in advanced coursework and better performance on exit exams. These outcomes underscore the EAP's essential role in creating a smooth transition from high school to college, ensuring student readiness and success in higher education. The findings suggest that the EAP goes beyond being simply an academic program; it serves as a transformative mediator in education, affecting the long-term educational journeys of students, especially those with lower test scores historically.

Conclusions and Implications

The implications of these findings extend beyond AP and speak to the benefits of exposing all students, including low-performing students, to high-quality, rigorous curricula. Of course, as many other scholars have indicated, efforts to increase access should also be coupled with resources to support students in successfully meeting the expectations of those courses (including investments in tutoring, workshops, and other strategies that support student learning). Closing gaps in educational attainment will require addressing the gaps in academic preparation (Reber & Smith, 2023) and fostering positive classroom climates with high expectations (Patrick et al., 2022).

The mission of the AP Program has broadened to be inclusive of a broader range of students than when it was first designed. Indeed, the College Board has explicitly committed to "developing college-level knowledge and skills…built on the deep conviction that all students who are academically prepared - no matter their location, background, or socioeconomic status – deserve the opportunity to access the rigor and benefits of AP" (College Board, 2014, in Kolluri, 2018, p. 671). In expanding their purpose, alongside state policies that also increase AP offerings and opportunities, access to rigorous curriculum options has become a relatively cost-effective way of improving student human capital and thereby promoting their academic success in high school and college (Conger et al., 2021).

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Volume 33 Number 12 February 4, 2025 ISSN 1068-2341

Appendices

Appendix A1

Socio-demographic Characteristics for All High School 9th Graders and Those Who Graduated from Public Middle Schools in Texas

	All High School 9th Graders		High School 9th Graders who Graduated from Public Middle Schools	
	EAP	Non-EAP	EAP	Non-EAP
Female	54%	47%	54%	48%
Male	46%	53%	46%	52%
White	38%	33%	38%	35%
African American	9%	15%	9%	14%
Hispanic	41%	48%	40%	47%
Other Races	12%	4%	12%	4%
FRPL	37%	57%	37%	55%
No FRPL	63%	43%	63%	45%
Observations	55,464	291,351	51,710	246,113

Appendix A2

Balance Test Results After Propensity Score Matching for All Students

	EAP Students	Non-EAP Students	*p*-value of Balance Test
	(1)	**(2)**	**(3)**
Socioeconomic Characteristics			
Age (8^{th})	13.13	13.14	0.267
Female	0.569	0.566	0.735
African American	0.162	0.166	0.546
Hispanic	0.594	0.602	0.436
ESL (6^{th}–8^{th})	0.052	0.054	0.507
Gifted and Talented (6^{th}–8^{th})	0.075	0.081	0.282
Receipt of Special Education (6^{th}–8^{th})	0.024	0.024	0.952
Receipt of Free Lunch (8^{th})	0.394	0.395	0.954
Receipt of Reduced-Price Lunch (8^{th})	0.089	0.089	0.974
Eligibility for Other Public Assistance (8^{th})	0.123	0.127	0.554
Ability		0.364	0.224
TAKS Reading Test Scores at 6^{th} grade	2316.0	2312.9	0.327
TAKS Reading Test Scores at 7^{th} grade	2241.6	2240.6	0.692
TAKS Reading Test Scores at 8^{th} grade	787.64	787.15	0.565
TAKS Mathematics Test Scores at 6^{th} grade	2226.1	2223.2	0.343
TAKS Mathematics Test Scores at 7^{th} grade	2184.6	2183.5	0.548
TAKS Mathematics Test Scores at 8^{th} grade	734.51	733.97	0.270
Behavior and Attendance			

	EAP Students	Non-EAP Students	*p*-value of Balance Test
	(1)	**(2)**	**(3)**
Expulsion (6th–8th)	0.024	0.025	0.591
Suspension (6th–8th)	0.329	0.334	0.580
Attendance Rates (6th–8th)	96.25	96.12	0.071
Graduated from a Title I School	0.685	0.688	0.748
Random-Effects			
α^H	0.760	0.775	0.339
α^C	1.757	1.766	0.309

Notes: α^H and α^C denote predictions of cluster-level effects at the high school and county levels, respectively.

Appendix A3

Propensity Score Logistic Regression Results

	All Students	Exit-Exam Takers	College-Going Students	Two-Year College Enrollees	Four-Year College Enrollees
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Socioeconomic Characteristics					
Age (8th)	–0.111***	–0.096***	–0.060**	–0.020	–0.090**
	(0.018)	(0.020)	(0.028)	(0.036)	(0.046)
Female	0.120***	0.118***	0.071***	0.080***	0.041
	(0.016)	(0.016)	(0.021)	(0.029)	(0.033)
African American	0.060**	0.051	–0.027	–0.097	–0.102**
	(0.026)	(0.027)	(0.035)	(0.052)	(0.049)
Hispanic	0.073***	0.071***	0.055	0.113***	0.046
	(0.021)	(0.022)	(0.029)	(0.038)	(0.045)
ESL (6th–8th)	0.185***	0.194***	0.130**	0.124	0.155
	(0.035)	(0.037)	(0.054)	(0.066)	(0.096)
Gifted and Talented	0.388***	0.369***	0.343***	0.272***	0.379***
(6th–8th)	(0.034)	(0.035)	(0.044)	(0.065)	(0.060)
Receipt of Special	–0.302***	–0.315***	–0.274***	–0.342***	–0.119
Education (6th–8th)	(0.041)	(0.044)	(0.059)	(0.076)	(0.096)
Receipt of Free Lunch (8th)	–0.051***	–0.045**	0.011	0.072**	–0.031
	(0.019)	(0.020)	(0.027)	(0.035)	(0.041)
Receipt of Reduced-Price	–0.035***	–0.038	0.026	0.079	–0.003
Lunch (8th)	(0.029)	(0.030)	(0.039)	(0.051)	(0.061)
Eligibility for Other Public	–0.047	–0.032	–0.039	–0.048	0.050
Assistance (8th)	(0.029)	(0.031)	(0.041)	(0.056)	(0.061)
Ability					
TAKS Reading Test	0.0003***	0.0004***	0.0004***	0.0003**	0.0004**
Scores at 6th grade	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
TAKS Reading Test	0.0007***	0.0007***	0.0007***	0.0007***	0.0006***
Scores at 7th grade	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)

	All Students	Exit-Exam Takers	College-Going Students	Two-Year College Enrollees	Four-Year College Enrollees
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
TAKS Reading Test	0.0023***	0.0023***	0.0023***	0.0020***	0.0023***
Scores at 8th grade	(0.0002)	(0.0002)	(0.0003)	(0.0004)	(0.0004)
TAKS Mathematics Test	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***
Scores at 6th grade	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
TAKS Mathematics Test	0.0009***	0.0009***	0.0010***	0.0009***	0.0008***
Scores at 7th grade	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
TAKS Mathematics Test	0.0036***	0.0034***	0.0037***	0.0035***	0.0031***
Scores at 8th grade	(0.0003)	(0.0004)	(0.0005)	(0.0006)	(0.0008)
Behavior and Attendance					
Expulsion (6th–8th)	–0.096**	–0.045	–0.077	–0.065	–0.092
	(0.043)	(0.049)	(0.079)	(0.103)	(0.124)
Suspension (6th–8th)	–0.289***	–0.255***	–0.218***	–0.191***	–0.223***
	(0.017)	(0.018)	(0.023)	(0.031)	(0.037)
Attendance Rates (6th–8th)	0.034***	0.029***	0.033***	0.025***	0.041***
	(0.002)	(0.002)	(0.003)	(0.004)	(0.005)
Graduated from	0.045**	0.055***	0.057**	0.097***	0.051
a Title I School	(0.018)	(0.019)	(0.025)	(0.033)	(0.038)
Random-Effects					
$\boldsymbol{\alpha^H}$	0.598***	0.613***	0.649***	0.634***	0.702***
	(0.009)	(0.009)	(0.013)	(0.018)	(0.020)
$\boldsymbol{\alpha^C}$	0.496***	0.511***	0.532***	0.532***	0.569***
	(0.015)	(0.016)	(0.021)	(0.030)	(0.040)
Constant	–13.742***	–13.564***	–14.413***	–13.649***	–13.085***
	(0.421)	(0.462)	(0.645)	(0.847)	(1.010)
Pseudo R^2	0.257	0.249	0.240	0.222	0.237
Observations	98,018	78,339	35,969	23,940	12,029

Notes: α^H and α^C denote predictions of cluster-level effects at the high school and county levels, respectively. Robust standard errors are reported in parentheses.
** $p < 0.05$. *** $p < 0.01$.