IES Institute of Education Sciences

APPENDIXES
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Regional Educational Laboratory Northeast & Islands
At Education Development Center

The Cost-Effectiveness of Providing Early College Programs in Rhode Island

See the full report on the Institute of Education Sciences website.

Appendix A. About the study

Many states now offer high school students the opportunity to earn credit toward a high school diploma and a postsecondary degree simultaneously, with the aim of improving their college readiness and on-time college graduation rates (An & Taylor, 2019). Some of these programs allow students to take college classes taught by faculty on a college campus or online (referred to as *dual enrollment* in this study), while others offer college-credit courses taught by a high school instructor at a high school (referred to as *concurrent enrollment* in this study). Other programs, such as Advanced Placement (AP) and International Baccalaureate courses, offer standardized curricula and assessments that colleges may accept for college credit. These programs have been expanded and integrated into many K-12 settings. For example, 48 states and the District of Columbia have state-level dual enrollment or concurrent enrollment policies (Education Commission of the States, 2022).

In Rhode Island these programs are collectively referred to as *early college opportunities*. However, this term has a more specific meaning in some other states, where it refers to a comprehensive model that offers student supports and sets expectations for completion of a postsecondary certificate or associate's degree during high school (for example, in North Carolina [Edmunds et al., 2017]) and may include a focus on career and technical education (for example, the P-TECH model in New York [Rosen et al., 2023]). This report uses *early college programs* as an umbrella term for programs offering college credit during high school.

Education outcomes of early college programs

Previous research, including a study in Rhode Island that preceded this one (Shields et al., 2021), has found positive impacts of dual enrollment, concurrent enrollment, and AP on earning college credit during high school. In experimental studies comprehensive early college programs in high school have resulted in higher rates of high school graduation, college enrollment, and college completion (Berger et al., 2014; Edmunds et al., 2017; Haxton et al., 2016; Rosen et al., 2023). Rigorous quasi-experimental studies of dual enrollment have likewise found positive effects on college enrollment and completion (An, 2013; Giani et al., 2014), and a meta-analysis of experimental and quasi-experimental studies of dual enrollment found a positive effect on college enrollment and persistence, among other outcomes (Schaller et al., 2023). Fewer studies have focused specifically on concurrent enrollment programs in which college-credit courses are offered at the high school. One randomized controlled trial found that concurrent enrollment produced mixed results, with positive impacts on subsequent math courses in high school and on enrollment in a four-year college rather than a two-year college but no effect on college enrollment in general or on college math performance (Hemelt et al., 2020). Despite the potential for different benefits and barriers associated with early college programs, few studies compare the effects of courses offered on a college campus with the effects of courses offered at the high school (An & Taylor, 2019). One quasi-experimental study comparing student outcomes related to programs in these two settings using a nationally representative dataset found no differences in college enrollment or developmental course placement (Hu & Chan, 2021).

Previous studies have also found positive relationships between AP participation and academic performance and between AP participation and postsecondary outcomes such as college persistence (Mattern et al., 2009), college course grades (Kaliski & Godfrey, 2014; Wyatt et al., 2015), and degree attainment (Mattern et al., 2013). In addition, studies have found that AP students are more likely to double major in college and to take more advanced coursework than non-AP students (Ewing et al., 2018).

Some research evidence speaks to how these programs may affect different groups of students in different ways. Some evidence suggests that the positive effects of dual enrollment are stronger for student populations that are historically underrepresented in college (Henneberger et al., 2022) or at least equivalent to the effects on other students (Berger et al., 2014). For example, dual enrollment in Texas increased the rates of lower-income students enrolling in a four-year college rather than a two-year college (Struhl & Vargas, 2012). Studies have yielded conflicting results about differences in effects for students with higher and those with lower academic proficiency. One lottery-based study of a comprehensive early college program targeting students from populations that were less likely to enroll in college found larger positive effects on postsecondary outcomes for students who start high school with above-average achievement (Song & Zeiser, 2019), whereas a quasi-experimental study of dual enrollment and concurrent enrollment found larger effects for students with below-average achievement (Buckley et al., 2020).

Costs of early college programs

Several cost studies have been conducted for comprehensive early college programs. A benefit-cost analysis comparing the cost of such programs to business as usual found that although the early college program was costlier than the traditional high school model, the lifetime benefits associated with the increased postsecondary attainment for participants in the program substantially outweighed the costs (Atchison et al., 2019). A benefit-cost study of the less-intensive dual enrollment and concurrent enrollment models statewide in Colorado found a strong return on investment in terms of lifetime earnings, taxes, and savings (Reichardt & Christeson, 2020).

Several studies provide details on the cost of a singular resource (such as testing fees) or a subset of costs for early college programs. A study of investment to cover AP testing fees and student participation incentives in three states suggests that the benefits did not offset the costs (Davis et al., 2015; Warne, 2017). A few studies looked specifically at state or district spending on college tuition for high schoolers and found that state and district investment varies widely, even within states (Pierson et al., 2017; Roza & Brooks, 2017). Another study examining the dual enrollment costs incurred by community colleges found that such programs may not be financially sustainable as currently structured, though opportunities exist for more efficient resource use (Belfield et al., 2023). These studies did not look at the comprehensive costs of offering programs at the high school and college levels, including additional support needs such as counseling and incremental increases in the costs of books and equipment.

Many economic analyses do not distinguish between courses taught at high schools and courses taught at colleges or between courses taught by high school instructors and courses taught by college instructors. Estimated costs for each early college program are particularly important in the Rhode Island context because of the programs' differences in student populations served, scale and setting, and resources required. For example, participation by students from populations that have been less likely to enroll in college is higher for dual enrollment than for the other two programs, and evidence from other studies suggests that additional resources may be needed to cover a wider set of support activities that require additional investment (Fink & Jenkins, 2023; Hooker et al., 2021). Additionally, prior research on the impact of scale on education costs suggests that the small size of some programs may drive differences in costs per student across the programs (Andrews et al., 2002). Concurrent enrollment programs in Rhode Island also require instructors to have specific credentials accepted by the college offering the credit.

Finally, although the prior literature comprehensively assessing the cost-effectiveness of early college programs is limited, a recent study offers the strongest opportunity for comparison with this study's findings on dual enrollment and concurrent enrollment. Rosen et al. (2023) compared the cost and cost-effectiveness of high schools in New York City that provide the P-TECH 9-14 program with the cost and cost-effectiveness of comparable high schools that do not provide the program. The study found that the program was costlier than traditional high school, largely because of higher costs per student at the schools, and needed industry partner time and resources and additional administrative support from a central district office (Rosen et al., 2023). Specifically, the authors estimate the incremental cost per student to be \$19,000–\$29,000 for six years of programming. This result, when considered as an annual cost, is comparable to the current study's estimates for dual enrollment and concurrent enrollment—especially given that Rosen et al. (2023) does not include estimates for the cost of transportation or textbooks, both of which are included in the current study. Additionally, Rosen et al. (2023) finds mixed results for cost-effectiveness, with one of the cohorts earning postsecondary credentials more efficiently, at a reduced estimated cost per degree, while the second cohort earned credentials at a lower rate and was not cost-efficient.

Evidence on potential reductions in college completion costs

A potential benefit of early college programs addressed in some economic analyses is the possibility of lower costs for participating students to complete their postsecondary education. Put simply, students who secure transferable course credit or can skip entry-level coursework in college can avoid the cost of those courses. From the perspective of families, state support for early college programs can reduce higher education costs. If the total amount of postsecondary education a student consumes is fixed regardless of the student's participation in early college programs and likewise if the student's postsecondary costs are fixed, then the program costs reflect a transfer of postsecondary costs to students' high school and increase efficiency by allowing students to engage in coursework that helps satisfy their high school curriculum and their postsecondary education goals.

However, it is also important to consider whether these potential savings are consistent for all program participants. If students who would otherwise not attend college enroll because of their participation in an early college program, their postsecondary costs are a result of that participation and a net increase in costs for those students overall. If students would enroll in a four-year college regardless of whether they participated in an early college program, completing college early would also yield cost savings. In this case the evidence indicates that early completion is more common among dual enrollment participants than among nonparticipants (Schaller et al., 2023), resulting in net savings on costs overall. In short, the net effect on postsecondary education consumption resulting from dual enrollment participation is unclear.

Finally, although a net increase in postsecondary education consumption would bring additional costs, these costs are thought to return many benefits, the examination of which is beyond the scope of this study. Research suggests that college enrollment and completion might result in better health outcomes, lower crime, and greater workforce participation. Previous work has found that the benefits of comprehensive early college programs and less-intensive dual enrollment and concurrent enrollment strongly outweigh the costs (Atchison et al., 2019; Reichardt & Christeson, 2020). Some studies include caveats to these conclusions—for example, examinations of early college programs focus more narrowly on the impact of overall state investment in higher education and find that on the whole these programs are not expected to reduce state spending (Roza & Brooks, 2017). A full assessment of the balance of the monetary costs and benefits of these programs, though beyond the scope of this study, is worthy of consideration by the state before making program investment decisions.

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Appendix B. Methods

This appendix describes the data, sample, and analytic methods used in the study.

Outcome analysis

Data

The outcome analysis estimating the effects of early college programs was based on statewide administrative data on public high school students in Rhode Island. The state longitudinal data system links student-level information from K–12 schools, the state's public colleges, and National Student Clearinghouse records for public and private colleges nationwide.

Sample

The population of interest for assessing program outcomes was a cohort of Rhode Island public school students who were first-time grade 9 students in 2014/15, who had attended a public school (including charter schools) in the state in grade 8 the previous year (meaning that baseline data were available), and who graduated on time in spring 2018. Because systematic statewide tracking of dual enrollment and concurrent enrollment began in 2015/16, this was the most recent cohort with reliable data on intervention status and college persistence at the time of analysis. Limiting the sample to students who graduated from high school ensured that the intervention and comparison groups had the same opportunity to participate in early college programs.

Sample exclusions. All students who met the cohort definition were included, with the following exceptions:

- Students whose 2014/15 grade 9 enrollment was less than 30 days, indicating that they did not start their high school experience that year in a meaningful way (< 1 percent of the original pool of cohort students).
- Students whose records were not associated with a specific high school, making it impossible to account for school effects or the availability of Advanced Placement (AP) and concurrent enrollment in their school (1 percent).
- Students whose school closed before the end of the study period (2 percent).
- Students whose record showed an implausible graduation date of 2016 or earlier (2 percent).
- Students whose standardized math or reading assessment score was more than ±3 standard deviations from the mean (3 percent).
- Students whose school had fewer than 10 students enrolled in the cohort (< 1 percent).

In addition, 3 percent of students who were in the state in grade 8 did not have one or both valid standardized assessment scores for that year, meaning that no baseline measure of academic achievement at the start of high school was available. Because this level of missingness was low, these students were also excluded. These criteria excluded 10 percent of the original pool of 7,812 students, with some students excluded for multiple reasons, leaving 7,015 students. In this group, 192 students participated in both dual enrollment and some other early college program, representing a set of intervention categories that were deemed too small for constructing matched comparison samples. The resulting pool of students available for matching in the analyses consisted of 3,713 intervention students across the three early college programs and 3,120 comparison students, a total of 6,833 students.

Participation in early college programs among students in the sample. The early college programs in Rhode Island all provide opportunities for students to earn college credit while still in high school, but they meet this end in different ways. A little more than half the students participated in an early college program (table B1). Although a small group participated in dual enrollment (3 percent), larger proportions participated in concurrent enrollment (12 percent) or Advanced Placement test-taking (18 percent). Some students participated in more than one program during high school; the most common mode of participation was the combination of concurrent enrollment and AP test-taking (21 percent of the cohort, or 36 percent of all participants in early college programs).

Dual enrollment was implemented in a wide variety of ways during the study period. Some students enrolled in courses on an individual basis, while others participated as part of a comprehensive model that had explicit goals for completing college credits or credentials and, in some schools, provided “high-touch” supports to help students persist. The Running Start model also began toward the end of the study period, allowing high school seniors to enroll full time in the state’s community college system.

The state’s recent investment has yielded steady increases in participation in early college programs (Rhode Island Department of Education, 2023), but opportunities are not equally available to all students. This pattern is typical of these programs nationwide. In the current study’s cohort, participants in early college programs were less likely than nonparticipants to be multilingual learners or to have an Individualized Education Program (IEP) and were more likely to be female (see table B1). Although participants in concurrent enrollment and AP included a higher proportion of White students and a lower proportion of students eligible for the National School Lunch Program than nonparticipants, participants in dual enrollment were much more similar to nonparticipants on these measures and on suspensions and chronic absences.

Table B1. Characteristics of participants in early college programs and nonparticipants at baseline (grade 8), 2014/15 grade 9 cohort

Student characteristic	Advanced Placement test-taking only (*n* = 1,229)	Concurrent enrollment only (*n* = 842)	Dual enrollment only (*n* = 211)	Both concurrent enrollment and Advanced Placement test-taking (*n* = 1,431)	Nonparticipants (*n* = 3,120)
Percent of participants					
Share of cohort	18	12	3	21	46
Multilingual learner	3	4	5	2	6
White	66	73	49	77	63
Black	6	5	13	5	8
Hispanic	21	16	33	12	22
Asian	4	2	5	4	3
Female	58	54	65	56	42
Eligible for the National School Lunch Program[a]	35	35	62	26	55
Chronically absent[b]	25	31	42	21	42
Has an Individualized Education Program	2	7	9	1	19
Has one or more suspensions	5	5	13	3	15
NECAP math score of proficient or above	83	69	56	91	43
NECAP reading score of proficient or above	93	86	74	96	68
Mean score					
NECAP math	848.10	843.32	841.79	850.26	838.61
NECAP reading	857.69	852.08	849.25	861.41	845.35

NECAP is New England Common Assessment Program.

Note: The sample is limited to students who were first-time grade 9 students in fall 2014, who graduated on time in spring 2018, and who had attended a public school in the state for grade 8 the previous year. The small number of students who participated in both dual enrollment and another early college program (182) were excluded from the analyses.

a. Used as a proxy for family socioeconomic status.

b. Defined as missing 10 or more days per year.

Source: Authors' analysis of data from the Rhode Island Department of Education.

Variables

Table B2 presents the measures used in the study and their sources.

Table B2. Measures used in the study and their sources

Measure	How used in study		Data source
Participation in dual enrollment in grades 10-12[a]	Intervention		RIDE
Participation in concurrent enrollment in grades 10-12[a]	Intervention		RIDE
Advanced Placement test taken in grades 9-12[b]	Intervention		RIDE
High school diploma received on time	Inclusion criterion		RIDE
Enrollment in any postsecondary institution within 12 months of high school graduation date	Outcome: College enrollment		NSC/RIOPC
Continued enrollment for a second year in any U.S. postsecondary institution within 24 months of high school graduation date	Outcome: College persistence		NSC/RIOPC
Level of postsecondary institution of initial enrollment (two or four year)	Outcome: College level		NSC/RIOPC
	Covariate for		
Covariate	Coarsened exact matching[c]	Intervention effect estimation	
Student			
Eligible for the National School Lunch Program[d]	Yes		RIDE
Scaled NECAP math score, grade 8	Yes	Yes (moderator)	RIDE
Scaled NECAP reading score, grade 8	Yes	Yes (moderator)	RIDE
Race/ethnicity (American Indian/Alaska Native, Asian, Black, Hawaiian Native/Pacific Islander, Hispanic, White, more than one race/ethnicity or multiracial)	Yes	Yes	RIDE
Sex (male, female)	Yes		RIDE
Multilingual learner, grade 8	Yes	Yes	RIDE
Has an Individualized Education Program, grade 8	Yes	Yes	RIDE
Took Algebra I, grade 8	Yes		
Chronically absent,[e] grade 8	Yes	Yes	RIDE
Has one or more suspensions, grade 8	Yes		RIDE
School			
School of student's first grade 9 enrollment record (level-two cluster membership indicator)		Yes	

NECAP is New England Common Assessment Program. NSC is National Student Clearinghouse. RIDE is Rhode Island Department of Education. RIOPC is Rhode Island Office of the Postsecondary Commissioner.

Note: School-level measures reflect 2013/14 values.

a. Reliable and complete data on dual enrollment and concurrent enrollment were available starting in 2015/16, which corresponds to the grade 10 year for the 2014/15 grade 9 cohort. The vast majority of students enroll in such courses in grades 11-12, suggesting that the unobserved grade 9 data will represent a very small number of students.

b. Data on Advanced Placement course enrollment were unavailable, so data on Advanced Placement test-taking were used as a proxy.

c. Because coarsened exact matching attempts an exact match on categorical variables, not all the categorical variables were used in a given model. However, the balance across conditions in the matched samples was verified for all the variables listed before the matching results were accepted.

d. Used as a proxy for family socioeconomic status.

e. Defined as missing 10 or more days per year.

Source: Authors' analysis of data from the Rhode Island Department of Education.

Participation in either dual enrollment or concurrent enrollment was defined as having one or more enrollment records at a public Rhode Island college for such a course in grades 10-12. Participation in AP test-taking was defined as having taken one or more AP tests in grades 9-12.

Data limitations affecting the measures used in the study include:

- Dual enrollment at private colleges could not be included in the definition of program participation. Although the Dual Enrollment Fund covers tuition for courses at three private colleges in the state, the Rhode Island Department of Education (RIDE) does not have centralized data collection in place to identify in the longitudinal data system students who take such courses. Based on the aggregate enrollment counts available from RIDE, the study team estimated that 1,000 high school students per year took courses at private institutions. Such students would be misclassified as nonparticipants for the purposes of this study, potentially deflating the intervention effects of dual enrollment. If most of those students were in grades 11 and 12, most graduated high school, and each took only one dual enrollment course at a private college during high school, approximately 500 students in the study cohort (or about 7 percent) might have been misclassified in this way.
- The Rhode Island longitudinal data system includes data on AP tests taken by individual students but does not flag AP courses as such, meaning that data on individual student course enrollment are not systematically available at the state level. Students who enrolled in an AP course but did not take the test would be misclassified as not participating in the program. Likewise, students who took an AP test without taking the associated course would be counted as participants but would have experienced a different intervention than other students in the group.
- An estimated 100 students participated in specific, comprehensive models of early college programs in Rhode Island, but these students could not be identified in state data systems. These programs, such as P-TECH or Running Start, provide additional student supports and may include an expectation that students will complete a credential. Although these students' participation in dual enrollment or concurrent enrollment is reported, there is no way to distinguish in the state-level data whether they participated in these programs, meaning that the effects of these more comprehensive models cannot be differentiated.
- Data on dual enrollment and concurrent enrollment were available for grades 10-12 but not grade 9 for the study cohort because the state began reliable collection of these data in 2015/16. The study team obtained complete data on participation in early college programs in grades 9-12 from a later cohort for which reliable data were collected (students enrolled in grade 9 in 2015/16) and calculated the number of grade 9 students who participated in dual enrollment or concurrent enrollment that year. In that cohort fewer than 100 grade 9 students (well below 1 percent) participated in these programs. This number serves as a reasonable upper bound on the proportion of students likely to have been incorrectly classified as not participating in these programs because of the missing year of grade 9 enrollment data.
- Although the National Student Clearinghouse (NSC) holds enrollment data on approximately 98 percent of the nation's students at public and private postsecondary institutions (National Student Clearinghouse, 2024), students' data may be missing from NSC records because of institutional or student opt-out or record-matching errors. In this study students with no college enrollment record in NSC were assumed not to have enrolled in college.

Descriptive analysis of program participation rates

Participation rates were calculated for participation in each of the three programs individually and for the combination of concurrent enrollment and AP test-taking. These descriptive analyses were performed on the unmatched sample. About 55 percent of students in the study sample participated in one or more early college programs (see table B1).

Coarsened exact matching

Students in the study sample chose whether to participate in an early college program and were not randomly assigned to participate. Observed differences in outcomes for participants and nonparticipants could be due to characteristics associated with the decision on whether to participate in the program rather than to the programs themselves. To mitigate the influence of any such characteristics, the study team used coarsened exact matching (CEM) to construct a comparison group of students who were similar to participants before the start of high school in terms of measured characteristics (Iacus et al., 2011a, 2011b). While the team examined several characteristics, they aimed to establish baseline equivalence particularly for measures required for meeting What Works Clearinghouse standards with reservations. According to the What Works Clearinghouse review protocol for studies of interventions to support the transition to college (What Works Clearinghouse, 2019), baseline equivalence must be demonstrated for preintervention measures of a continuously scaled measure of academic achievement—in this case, the grade 8 state standardized assessment—and a measure of student socioeconomic status—in this case, eligibility for the National School Lunch Program.

CEM is used to create a matched comparison group in a quasi-experimental study, and it sometimes serves as a better alternative to commonly used propensity score matching (Iacus et al., 2011a). A propensity score is a single aggregate score of all student characteristics on which matching is sought. CEM, in contrast, matches groups of intervention and comparison students within strata. Specifically, for student characteristics that are coded as binary (such as having an IEP), the intervention and comparison students can be specified to match exactly. For student characteristics that are measured continuously (such as math or reading test scores), the scores are coarsened into bins, and intervention and comparison students are matched exactly within each bin. These features give researchers more flexibility to require an exact match on certain binary variables and to control the degree of coarseness in matching on test scores. A many-to-many matching method, CEM groups cases within strata, which contain varying numbers of cases and varying ratios of intervention to comparison cases.

The study team used several specifications of the propensity score estimation model as well as multiple matching approaches incorporating the resulting propensity scores but were unable to attain an acceptable level of baseline equivalence through these methods (that is, a standardized mean difference of less than 0.25 on state standardized assessment scores and eligibility for the National School Lunch Program). Thus, the study team turned to CEM in the hope of exploiting its flexibility in order to create a well-balanced matched sample.

Creating a matched comparison group entailed the following steps. First, the study team checked the prematching baseline balance between students who participated in a given early college program and those who did not participate in any early college program in terms of 10 student characteristics: grade 8 math score on the New England Common Assessment Program (NECAP); grade 8 reading score on NECAP; enrollment in Algebra I in grade 8; eligibility for the National School Lunch Program (an indicator of family socioeconomic status); gender; multilingual learner status; IEP status; race/ethnicity (American Indian/Alaska Native, Asian, Black, Hispanic, Hawaiian Native/Pacific Islander, White, more than one race/ethnicity or multiracial); grade 8 chronic absence (more than 10 percent of school days absent); and grade 8 suspension. The study team evaluated this prematching balance by calculating the difference between intervention and comparison students expressed in the effect size, specifically as Hedges' *g* or Cox's *d* for each available student variable. These calculations were made using formulas provided in the *What Works Clearinghouse Procedures Handbook*, version 4.1 (What Works Clearinghouse, 2020).

The study team then tested several specifications for the CEM model for each early college program and selected final CEM models. Following the What Works Clearinghouse review protocol, the team selected specifications that yielded a baseline standardized mean difference of less than 0.05 on both the math and reading grade 8 state standardized test scores and required an exact match on the student's National School Lunch Program eligibility status (a binary variable). Because the state assessment scores were on a continuous scale, the study team experimented with different degrees of coarseness for the matching bins for these variables that would meet the baseline equivalence criterion. In addition to the baseline measures required by the What Works Clearinghouse review protocol, several other preintervention measures were available that are related to student academic achievement and education progress (see table B3 for the full list of variables). For these other available baseline variables, all of which were binary, the study team tested different specifications requiring an exact match or not. The team attempted to retain as many cases as possible while also achieving baseline equivalence of less than 0.25 as measured by Cox's *d* for these variables. These criteria were met in the final matched samples.

Table B3. Effect size of baseline difference between intervention and comparison groups before and after matching within each program, 2014/15 grade 9 cohort

	Advanced Placement test-taking only		Concurrent enrollment only		Dual enrollment only		Both concurrent enrollment and Advanced Placement test-taking	
Student characteristic in grade 8	Prematch (n = 4,349)	Postmatch (n = 2,609)	Prematch (n = 3,962)	Postmatch (n = 2,886)	Prematch (n = 3,331)	Postmatch (n = 1,651)	Prematch (n = 4,551)	Postmatch (n = 2,518)
NECAP math score (centered mean)	0.88	0.01	0.51	0.01	0.51	0.01	1.10	0.01
NECAP reading score (centered mean)	0.86	0.01	0.48	0.02	0.48	0.01	1.08	0.02
Multilingual learner	-0.34	0.22	0.07	Exact	-0.18	-0.04	-0.24	0.22
Black	-0.05	0.21	-0.08	0.07	0.38	Exact	-0.18	0.04
Hispanic	-0.10	-0.01	0.08	0.17	-0.05	0.07	-0.14	0.10
Asian	0.26	0.05	-0.07	-0.11	-0.93	Exact	0.29	Exact
Female	0.39	Exact	0.31	Exact	0.58	Exact	0.37	Exact
Eligible for the National School Lunch Program	-0.40	Exact	-0.28	Exact	0.04	Exact	-0.55	Exact
Chronically absent[a]	-0.40	Exact	-0.28	-0.17	-0.12	0.04	-0.58	Exact
Took Algebra I in grade 8	0.93	Exact	0.39	0.09	0.43	Exact	1.22	Exact
Has an Individualized Education Program	-1.33	Exact	-0.82	Exact	-0.55	-0.15	-2.12	Exact
Has one or more suspensions	-0.55	Exact	-0.55	Exact	-0.35	0.01	-0.81	Exact

NECAP is New England Common Assessment Program.

Note: The effect size of the difference between intervention and comparison students is expressed as Hedge's *g* for continuous variables (NECAP scores) and Cox's *d* for binary variables (all others). For each program category, students who participated were matched with students who did not participate in any of the programs. Exact match indicates that the groups were constrained to have the same value in the coarsened exact matching procedure.

a. Defined as missing 10 or more days per year.

Source: Authors' analysis of data from the Rhode Island Department of Education.

The matching process required tradeoffs between attaining similarity between the intervention and comparison groups and attaining representativeness of matched intervention students. The proportion of intervention students available for matching who were retained in the matched sample was 79 percent for AP test-taking only, 94 percent for concurrent enrollment only, 90 percent for dual enrollment only, and 71 percent for the combination of concurrent enrollment and AP test-taking. The percentages for each program type were lower because comparison students were selected by design to be similar to intervention students (53 percent of comparison students were retained for AP test-taking only, 67 percent for concurrent enrollment only, 47 percent for dual enrollment only, and 48 percent for the combination of concurrent enrollment and AP test-taking).

The following differences between intervention students who were and those who were not matched should be kept in mind when generalizing the findings. For AP test-taking the matched intervention students were more likely than the unmatched intervention students to attend urban schools (33 percent versus 25 percent) and to be eligible for the National School Lunch Program (37 percent versus 29 percent), were less likely to have an IEP (2 percent versus 6 percent), and had slightly lower average math scores on the grade 8 NECAP (by 7 points). For concurrent enrollment the most notable differences between matched and unmatched intervention students were a higher proportion of White students (75 percent versus 46 percent), a lower proportion of students eligible for the National School Lunch Program (34 percent versus 54 percent), and lower proportions of multilingual learners and students with an IEP. For dual enrollment the intervention sample was much smaller, making comparisons difficult, but there were no notable differences between matched and unmatched intervention students.

Regression

Each research question was answered using generalized regression in the matched sample. For college enrollment and persistence, the outcome was a binary indicator of attaining the outcome. For college level (two-year versus four-year institution), the outcome was a multinomial categorical variable indicating the following mutually exclusive and exhaustive categories: no college enrollment, two-year institution enrollment, or four-year institution enrollment. The intervention was a binary indicator of participation in the given early college program.

The following two-level logistic regression model was used for college enrollment and persistence:

$$\text{Log}\ [P / (1 - P)]_{ij} = b_{0j} + b_{1j}\ (\text{Early College})_{ij} + \sum b_{cj}\ (\text{Student-level Covariates})_{ij} + u_{0j}$$

where P is the probability of a student's attaining the outcome, subscripts i and j refer to individual student i in high school j, b_0 is the population intercept, b_1 is the coefficient for participation in the early college program that represents the intervention effect, $\sum b_c$ is a series of coefficients for student-level covariates, and u is the school random effect. The student-level coefficients were included for baseline measures that exceeded the Hedges' g value of 0.05 for the standardized mean difference between intervention and comparison groups in the given matched sample, as an additional adjustment to reduce selection bias (see the regression coefficients in tables C1–C8, which include those associated with each covariate included in a given model).

The following multinomial regression model was used for college level:

$$\text{Log}\ (P\_2yrCollege / P\_NoCollege) = b_{0j\_2yrCollege} + b_{1j\_2yrCollege}\ (\text{Early College})_{ij} + \sum b_{cj\_2yrCollege}\ (\text{Student-level Covariates})_{ij} + u_{0j\_2yrCollege}$$

$$\text{Log}\ (P\_4yrCollege / P\_NoCollege) = b_{0j\_4yrCollege} + b_{1j\_4yrCollege}\ (\text{Early College})_{ij} + \sum b_{cj\_4yrCollege}\ (\text{Student-level Covariates})_{ij} + u_{0j\_4yrCollege}$$

where *P_OutcomeValue* represents the likelihood of no college enrollment, enrollment in a two-year institution, or enrollment in a four-year institution. The model uses no college enrollment as the base category. Cluster-robust standard errors were used to account for clustering of students within high schools.

Because CEM produces a many-to-many matched sample in which the strata have different numbers of cases and different ratios of intervention to comparison students within each stratum, the study team also adjusted the estimation by a weight to account for the variations across strata (Blackwell et al., 2009).

The models produce results as odds ratios (for the binary outcomes) and relative risk ratios (for the multinomial outcomes). In this study the odds ratios represent the change in the odds of a student's attaining a given outcome, such as enrolling in college within one year of graduation, relative to whether the student participated in the early college program. A statistically significant odds ratio above 1 indicates that participation is related to higher odds of attaining the outcome for a participant in an early college program than for a nonparticipant, and a statistically significant odds ratio below 1 indicates that participation is related to lower odds of attainment for a participant. Relative risk ratios have properties similar to those of odds ratios; the main difference is that the ratios represent the likelihood of a student's attaining a given category of the outcome (for example, enrolling in a four-year institution) as opposed to attaining another category of the outcome (for example, enrolling in a two-year institution).

To make the findings easier to interpret for a nontechnical audience, the study team translated estimated odds ratios and relative risk ratios into predicted probabilities that use the estimated regression coefficients to produce a point estimate of the probability of attaining the outcome conditional on intervention status. Specifically, the study team calculated two predicted probabilities for each student: one under the assumption that the student was treated (participated in an early college program) and the other under the assumption that the student was untreated (did not participate). The predicted probabilities under each scenario were then averaged across all students (Williams, 2012).

To examine the moderating effect of student academic performance at baseline, the main model analyzing program effects was expanded to include its interaction with the intervention indicator. The analysis model is shown below.

The following two-level logistic regression model was used for college enrollment and persistence:

$\text{Log}\,[P / (1 - P)]_{ij} = b_{0j} + b_{1j}\,(\text{Early College})_{ij} + b_{2j}\,(\text{Grade 8 NECAP Score})_{ij} + b_{3j}\,(\text{Early College}) * (\text{Grade 8 NECAP Score})_{ij} + \sum b_{cj}\,(\text{Student-level Covariates})_{ij} + u_{0j}$.

The following model was used for college level:

$\text{Log}\,(P\_2yrCollege\ /\ P\_NoCollege)_{ij} = b_{0j\_2yrCollege} + b_{1j\_2yrCollege}\,(\text{Early College})_{ij} + b_{2j\_2yrCollege}\,(\text{Grade 8 NECAP Score})_{ij} + b_{3j\_2yrCollege}\,(\text{Early College}) * (\text{Grade 8 NECAP Score})_{ij} + \sum b_{cj\_2yrCollege}\,(\text{Student-level Covariates})_{ij} + u_{0j\_2yrCollege}$

$\text{Log}\,(P\_4yrCollege\ /\ P\_NoCollege)_{ij} = b_{0j\_4yrCollege} + b_{1j\_4yrCollege}\,(\text{Early College})_{ij} + b_{2j\_4yrCollege}\,(\text{Grade 8 NECAP Score})_{ij} + b_{3j\_4yrCollege}\,(\text{Early College}) * (\text{Grade 8 NECAP Score})_{ij} + \sum b_{cj\_4yrCollege}\,(\text{Student-level Covariates})_{ij} + u_{0j\_4yrCollege}$.

In the models above, the moderating effect of academic performance at baseline is reflected in b_{3j}, the coefficient for the interaction between intervention and academic performance. The analyses did not find any evidence for such a moderating effect for the outcomes examined except in the case of concurrent enrollment (see tables C13-C20 in appendix C).

Because CEM produces a many-to-many matched sample using bins, an importance weight is used to represent the relative weighting of a given case to meet the matching criteria within the bin. This weight is used in the regression analysis.

Sensitivity analyses

As a sensitivity analysis, two additional specifications of the models were estimated with different covariates (table B4). The direction, magnitude, and significance of the intervention coefficient remained similar in all specifications of the model. The first alternative model included a binary indicator for students enrolled in the Providence Public Schools district, because as the only urban district of its size, it is an outlier in the state and might influence the impact estimates. The second alternative model included grand mean-centered math and reading NECAP scores in grade 8 as covariates, because these indicators of baseline academic achievement are important to attaining baseline equivalence. NECAP scores were not included in the main models because the baseline equivalence check found standardized mean differences smaller than 0.05, but this alternative specification was attempted to see whether the additional adjustment for selection bias would make substantive differences in the impact estimates.

Table B4. Summary of sensitivity analyses with alternative model specifications: Odds ratios from models examining the relationship between participation in early college programs and college outcomes, 2014/15 grade 9 cohort

	Outcome	
Variable	Model 1: College enrollment	Model 2: College persistence
Reported model		
Participation in Advanced Placement test-taking only	2.72 (0.38)***	3.60 (0.42)***
Participation in concurrent enrollment only	2.12 (0.26)***	2.32 (0.23)***
Participation in dual enrollment only	1.85 (0.43)**	1.79 (0.36)**
Participation in both concurrent enrollment and Advanced Placement test-taking	4.09 (0.68)***	7.63 (1.07)***
With Providence Public Schools indicator		
Participation in Advanced Placement test-taking only	2.89 (0.41)***	3.76 (0.45)***
Participation in concurrent enrollment only	2.12 (0.26)***	2.34 (0.23)***
Participation in dual enrollment only	1.86 (0.43)**	1.80 (0.36)**
Participation in both concurrent enrollment and Advanced Placement test-taking	4.19 (0.70)***	7.79 (1.09)***
With New England Common Assessment Program scores		
Participation in Advanced Placement test-taking only	2.57 (0.35)***	3.41 (0.40)***
Participation in concurrent enrollment only	2.08 (0.25)***	2.29 (0.23)***
Participation in dual enrollment only	1.77 (0.41)*	1.74 (0.35)**
Participation in both concurrent enrollment and Advanced Placement test-taking	3.64 (0.59)***	6.90 (0.97)***

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.
Note: Statistical significance refers to a test of whether the odds ratio is different from 1. Numbers in parentheses are standard errors. The sample size is 2,609 for Advanced Placement test-taking only, 2,886 for concurrent enrollment only, 1,651 for dual enrollment only, and 2,518 for the combination of Advanced Placement test-taking and concurrent enrollment. The matched samples were drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018.
Source: Authors' analysis of Rhode Island Department of Education data.

Differences in results for matched and unmatched intervention students

Some intervention students could not be matched and were excluded from the analytic samples. The study team assessed the degree to which matched participants in early college programs were representative of the larger pool of participants in each program (table B5). Differences between matched and unmatched participants should be kept in mind when interpreting results and considering their generalizability, since inferences can be drawn only about the types of students represented in the analytic sample. For example, AP test-taking participants who could not be matched tended to have higher grade 8 academic achievement (as seen in the lower average test scores in table B5); the highest-achieving AP test-taking participants are not as well represented in the analytic sample.

Table B5. Mean baseline characteristics of matched and unmatched intervention students by early college program, 2014/15 grade 9 cohort

Variable	Advanced Placement test-taking only: Unmatched (*n* = 260)	Advanced Placement test-taking only: Matched (*n* = 969)	Concurrent enrollment only: Unmatched (*n* = 48)	Concurrent enrollment only: Matched (*n* = 794)	Dual enrollment only: Unmatched (*n* = 22)	Dual enrollment only: Matched (*n* = 189)	Both concurrent enrollment and AP test-taking: Unmatched (*n* = 410)	Both concurrent enrollment and AP test-taking: Matched (*n* = 1,021)
Student characteristic								
NECAP math score (grade 8)	853.64	846.62	842.00	846.85	844.86	841.43	855.08	848.33
NECAP reading score (grade 8)	863.17	856.22	846.85	852.40	853.73	848.72	866.44	859.39
Has an Individualized Education Program (percent)	5.77	1.55	22.92	6.42	18.18	8.47	3.66	0.49
Multilingual learner (percent)	2.69	3.20	39.58	2.14	0.00	5.29	2.44	2.25
Eligible for the National School lunch Program (percent)	28.85	37.15	54.17	34.13	54.55	62.43	24.88	26.25
Chronically absent[a] (percent)	29.62	23.94	35.42	29.85	22.73	43.92	24.15	19.49
Has one or more suspensions (percent)	8.46	3.61	20.83	4.28	4.55	14.29	5.61	1.57
Female (percent)	61.54	56.55	56.25	53.53	68.18	64.55	57.80	55.04
American Indian/Alaska Native, Asian, Black, Hispanic, or more than one race/ethnicity (percent)	29.62	35.19	54.17	24.81	45.45	51.85	22.93	23.31
School characteristic								
Number of students enrolled (log value)	6.85	6.84	6.90	6.85	6.69	6.74	6.86	6.83
Driving distance to nearest Rhode Island public college (miles)	7.32	7.09	5.87	7.21	6.10	4.17	7.17	7.11
Percentage of students eligible for the National School Lunch Program	33.80	41.21	45.97	34.69	52.97	53.85	33.10	35.77
Percentage of students who are multilingual learners	3.18	5.23	6.97	3.37	2.79	3.29	2.83	4.28
Percentage of students with an Individualized Education Program	10.08	10.68	13.27	12.64	13.88	14.49	11.07	11.88
Suburban locale (percent)	67.69	59.24	35.42	52.14	40.91	22.75	61.95	56.02

NECAP is New England Common Assessment Program.

Note: Students who participated in each early college program were matched with students who did not participate in any of the programs. Some students who did not participate in any of the programs were matched multiple times across comparisons.

a. Defined as missing 10 or more days per year.

Source: Authors' analysis of Rhode Island Department of Education data and National Center for Education Statistics (2018).

Cost and cost-effectiveness analysis

Data and methods

The study team collected data from various sources to develop information about the quantities, characteristics, and prices of the resources required to implement each of the three early college programs.

This section details the source or collection methods and purpose for each type of data. For information on how these data were used in the estimation process, see the *Cost estimation process by program and resource category* section.

Focus groups and interviews

To gather information about the resources required and understand the scope of program ingredients (the resources or inputs leveraged to implement a program), the study team conducted interviews with local education agency (LEA) staff across the state. Districts were originally selected using a stratified random sample. First, LEAs were sorted into one of three profiles based on their district National Center for Education Statistics (NCES) locale: urban core, suburban, or rural (National Center for Education Statistics, 2018). Drawing on their knowledge of the districts, RIDE staff members helped the study team make minor adjustments to the profile assignments, such as moving Highlander Charter School to the urban core given its strong similarity to other urban charter schools. The minor reshuffling was accommodated by the study team to better align the profiles with how RIDE views district contexts and their associated resources. The resulting pools of LEAs available in the interview sample for each profile are detailed in table B6.

Table B6. Local education agencies available for selection for focus groups and interviews on the cost of early college programs, by locale profile

Rural	Suburban	Urban core
Chariho	Barrington	Beacon Charter
Coventry	Blackstone Valley Prep	Blackstone Academy
Exeter-West Greenwich	Bristol Warren	Central Falls
Foster-Glocester	Burrillville	Cranston
The Greene School	Cumberland	Highlander Charter School
New Shoreham	Davies Career and Tech	Johnston
	East Greenwich	Metropolitan Regional Career and Technical Center
	East Providence	Newport
	Lincoln	North Providence
	Middletown	Pawtucket
	Narragansett	Providence
	North Kingstown	Trinity Academy for the Performing Arts
	North Smithfield	Village Green Virtual
	Portsmouth	Warwick
	Scituate	West Warwick
	Smithfield	Woonsocket
	South Kingstown	
	Tiverton	
	Westerly	

Note: Local education agencies were assigned to a given profile based on the locale designated by the National Center for Education Statistics, with some adjustment through collaborative discussions with the Rhode Island Department of Education and the agencies themselves. Not all agencies identified in this table were invited to participate or agreed to participate in the study.
Source: Authors' construction based on National Center for Education Statistics (2018).

Some outliers (in terms of program size or school type) were pulled out to be targeted for single-district interviews so that the study team could understand their unique program contexts. From the remaining LEAs in the pool, the study team randomly selected at least 6 LEAs from each profile, initially inviting a total of 24 LEAs for focus groups and 4 LEAs for interviews. This included all six LEAs from the rural profile and roughly two-thirds of LEAs from the other two profiles. Some invited LEAs did not respond or declined to participate, so the study team invited another 5 LEAs from the pool, for a total of 33 LEAs.

A semistructured protocol (included at the end of this appendix) was used to conduct focus group interviews: the study team moved through each set of resources (such as personnel and equipment) to ask about quantities and characteristics. For example, for each program the study team asked about staff involved, the amount of time they spent on the program as hours per week or as a fraction of their overall working time, and any additional qualifications or professional development the staff needed for their role. The focus groups generally consisted of three similar LEAs. Each interview focused on one LEA (though multiple participants from that LEA were present). The same questions were asked in the interviews and focus groups. Responses were recorded for each LEA and program to generate information unique to each LEA (results were not reconciled or averaged). Protocols were tailored to staff role and program. Because this study was retrospective, the interviewers asked the participants to provide information based on their recollection of implementation during the study period (2014/15–2017/18). While most participants spoke to the resources required for successful programs during the study period in general, some provided information on the resources during earlier years of the study period (when programs were growing rapidly) and for the steady-state years. However, not all participants shared information specific to growth in the earlier years, and this was another factor in the decision to focus only on the steady-state years, for which there was more complete information. In a few cases where the participant was not able to speak to the study period, the interviewer used probe questions to ask about the current state and how resources have changed since the study period.

Districts self-selected participants that were best able to speak to the programs during the study period. The exact roles varied by district and program but included principals, coordinators, counselors, academic department chairs, and teachers. The share of participants who were not in their current role or a similar program role during the study period is unknown and may impact response reliability. In some instances where participants were not in a program role during the study period, they were able to use documentation from the study period to supplement their answers. This was most commonly a school's program of studies document, which outlines course offerings and school policies.

Additional data

The Rhode Island Office of the Postsecondary Commissioner (RIOPC) provided unpublished data on dual enrollment and concurrent enrollment fees paid to public colleges in the state (A. Spargo, personal communication, July 24, 2023). These data capture the total amount collected statewide by postsecondary institutions for dual enrollment and concurrent enrollment fees, reported by year, program, and higher education institution. While these fees are a key element in supporting the program, they do not reflect the entire costs (see the key assumptions for each program in the *Cost estimation process, by program and resource category* section). Because the estimated costs reported are restricted to the 2017/18 school year, only fee data from that year were used to estimate this category of costs.

The study team used these fees to capture the cost of activities and resources on the public college side related to implementing these programs. These data were the primary means for estimating the cost on the college side; no interviews with colleges were conducted to collect primary cost data. These fees may include professor and administrator time and, for dual enrollment, the facilities at the public college where the courses are offered.

The RIDE administrative data on the 2014/15 grade 9 cohort used in the impact evaluation were also used in the cost analysis to estimate the number of course sections (see below). The total number of students enrolled in each of the three programs for a given year and district across all grade levels was obtained from the PrepareRI dashboard, which displays administrative data from RIDE and RIOPC (see the *Key limitations* for further discussion) (Rhode Island Department of Education, 2023).

Public price data were also used for consistency and comparability for all personnel and nonpersonnel resources. Rather than using prices directly from a budget or expenditure report for the program, the ingredients method often calls for applying market prices from national sources to reflect the opportunity cost for such goods. These national sources include databases designed especially for this purpose (see Chang & Head, 2022), national government sources such as the Bureau of Labor Statistics, and retailers of college-level books and equipment.

Personnel price

To identify personnel prices, represented as total annual compensation, the study team used information from the interviews and focus groups and documentation on the programs' qualitative requirements for a given resource (such as responsibilities and qualifications necessary for staff and technology specifications) and then matched the requirements with a generic associated resource for which a state market price is available through public databases (see, for example, Chang & Head, 2022). The study team estimated personnel prices mostly by leveraging two public databases: the Bureau of Labor Statistics Occupational Employment Survey and the Bureau of Labor Statistics Employer Costs for Employee Compensation. The School Superintendents Association 2022-2023 Superintendent Salary and Benefits Study was also used as a source of price data. Some prices apply to more than one role because the qualifications and program activities are similar. Table B7 summarizes these sources and the resulting compensation assumptions for each type of personnel role as well as the reporting year of the price, which varies by data source and available years of data. Because the assignment of market prices relies on assumed alignment between state prices and program staff, the study team tested alternative assumed prices for some positions where the state price was less directly aligned with the program role (see table C25 in appendix C).

Table B7. Sources for personnel price assumptions, collection year, and assumed annual price (including base salary and benefits)

Role category	Specific ingredients	Salary source	Benefit rate source	Reporting year	Total annual compensation ($)
District administrator	Finance administrators, dean of students, director of curriculum, and director of special education	BLS-OES, Education Administrators, Kindergarten through Secondary, median	BLS-ECEC, State and local government workers	2019	166,201
Counselor	High school counselors	BLS-OES, Educational, Guidance, and Career Counselors and Advisors, median	BLS -ECEC, State and local government workers, Teachers	2019	91,797
Principal	High school principals	BLS-OES, Education Administrators, Kindergarten through Secondary, median	BLS-ECEC, State and local government workers, Management, professional, and related	2019	166,201
Assistant principal	High school assistant principals, including teaching and learning, assessments, and postsecondary	BLS-OES, Education Administrators, Kindergarten through Secondary, 25th percentile	BLS-ECEC, State and local government workers, Management, professional, and related	2019	140,968
Teacher	Teachers	BLS-OES, Career/Technical Education Teachers, Secondary School, median	BLS-ECEC, State and local government workers, Teachers	2019	122,190

Role category	Specific ingredients	Salary source	Benefit rate source	Reporting year	Total annual compensation ($)
Coordinator	Professional development coordinator, STEM coordinator, CTE coordinator, EEP facilitator, and program liaison	BLS-OES, Instructional Coordinators, median	BLS-ECEC, State and local government workers, Office and administrative support	2019	100,796
Assistant superintendent	Assistant superintendent	AASA-SSBS, Associate Superintendents (1,000-2,999), median	BLS-ECEC, State and local government workers, Management, professional, and related	2022	185,895
Data manager	Data managers	BLS-OES, Database Administrators and Architects, median	BLS-ECEC, State and local government workers, Office and administrative support	2019	162,122
Clerical staff	Administrative support and secretary	BLS-OES, Office Clerks, General, median	BLS-ECEC, State and local government workers, Office and administrative support	2019	65,755
Superintendent	Superintendent	AASA-SSBS, Superintendents, median	BLS-ECEC, State and local government workers, Management, professional, and related	2022	222,767

STEM is science, technology, engineering, and math. CTE is career and technical education. EEP is Early Enrollment Program (concurrent enrollment program between districts and Rhode Island College). BLS-OES is Bureau of Labor Statistics Occupational Employment Survey. BLS-ECEC is Bureau of Labor Statistics Employer Costs for Employee Compensation.

Note: The study team converted all prices to constant dollars in the relevant year of implementation and, after estimating costs, converted the totals to 2022 constant dollars for reporting.

Source: Authors' construction.

Incremental cost

Incremental cost is the reported metric for the cost analysis. This approach is used to isolate the resources beyond those required for the general education program. The incremental approach mirrors the outcome analysis, which estimates the difference in outcomes between participants in an early college program and nonparticipants in the business-as-usual education program. Additional materials needed for a course, such as specific books or computer software (identified through program documentation; see the *Equipment and materials* subsections of the *Cost estimation process, by program and resource category* section for details), are clear examples of resources specific to these early college programs that are incremental costs. Others are not so straightforward—for example, a higher quality computer used for some concurrent enrollment and AP courses in place of a Chromebook used for general education activities. In this case the difference between the cost of a Chromebook and the cost of a more specialized computer represents the incremental cost.

The combination of concurrent enrollment and AP was identified as an intervention group only after the study was in process, based on enrollment data not previously available to the study team. This mode of participation was added to the outcome analysis because of the large share of students participating in both programs. The study team did not have information about any intentional program models that aimed to combine the two separate programs, so it was not possible to collect data about this combined form of early college participation as a distinct program for the cost analysis. Nonetheless, the study team did consider how costs might be affected when students participated in both programs. Specifically, the study team considered two extreme assumptions to illustrate two possible cost profiles for this intervention group. The first assumes that the costs of each program are wholly independent, meaning that the total combined cost is the sum of the costs of each program. The results of this conservative approach can be interpreted as an upper bound. The second is that students experienced the programs in the same classroom setting and that all costs that are not clearly independent are entirely integrated. This approach assumes that costs other than program fees are the average of each LEA's estimated costs in this category across the two programs. This also assumes no overlap in observed participation between the two programs. Thus, the final estimate per student is the total LEA average of nonfee costs added to the fee costs for each program and the sum of this divided by total observed participation across both programs. The results of this approach can be interpreted as a lower bound, given that combined implementation is likely to increase overall efficiency with respect to costs. The results of this exploratory estimation are included in the main report, but detailed estimated costs are not feasible given the limited information available about the actual variations in how students participating in both programs experienced them and the resulting implications for resource use and costs.

Cost perspective

This study defined the set of included costs from a modified state perspective and included all ingredients, direct and indirect, needed to implement the programs across all levels of the system, capturing incremental costs beyond business as usual. Specifically, informed by the Institute of Education Sciences guide *Cost Analysis: A Starter Kit* (Institute of Education Sciences, 2020), the study team defines *state perspective* as meaning all resources used to implement a program that are or may be paid for by the state, districts, or schools. This is in recognition that implementation is being handled by all three levels of the education system and therefore costs from the state, district, and school levels are key to understanding the resources supporting these programs. Importantly, these resources may include those that are not currently paid for by the state but that might be if the programs were expanded to a larger scale (for example, student transportation to dual courses). However, this study did not comprehensively estimate resources required to implement these programs that go beyond the state's role in implementation, such as time spent by parents in supporting their child to succeed.

Analyzing cost-effectiveness

Pairing the results of the outcome analysis with the cost analysis estimates allows for an assessment of cost-effectiveness (also referred to as cost per outcome) and for a comparison of the relative cost-effectiveness of each program. Given that all three programs have similar desired outcomes, each program's estimated effect on these outcomes can be put in common terms, allowing for this comparison. Specifically, a ratio of incremental costs per a standard amount of incremental outcomes can be calculated using the simple formula:

cost-effectiveness ratio (incremental costs [$] / change in outcome) = incremental costs ($) per one unit of incremental outcomes.

To aid in interpreting these ratios, a meaningful change in outcomes is often identified—in this case, an increase in the predicted probability of success of 5 percentage points. Because incremental outcomes are reported as decimal percentage points, this adjustment is made by multiplying the results of the above calculation by 0.05.[1]

Underlying the comparison of outcomes and costs for these three programs is the assumption that the average incremental outcomes for the 2014/15 grade 9 cohort can be extended to the broader population of program participants. This assumption is necessary because the costs apply to all participants, not just the 2014/15 grade 9

[1] The use of this increment of outcomes is not meant to imply that limiting a program budget to the corresponding increments of cost is feasible. Each program has distinct estimated average incremental costs and outcomes, and it is unclear but unlikely that costs could be reduced such that the smaller incremental outcome in the ratio would be realized.

cohort (this issue is discussed further in the *Key assumptions for estimated cross-program costs* section below). However, most of the cohort members who participated in early college programs did so in 2017/18 (78 percent of dual enrollment participants, 71 percent of concurrent enrollment participants, and 82 percent of AP test-takers), and likewise, since it was grade 12 for the cohort, most participants in that year were also part of the cohort. Thus, extending the average cohort incremental outcomes to all participants in 2017/18 is justifiable, and therefore a ratio of these average incremental outcomes to the incremental costs is appropriate.

Comparing the results of these calculations can support policymakers and education leaders in determining which program is most efficient given a common expected outcome.

Cost estimation process, by program and resource category

This section describes the assumptions the study team made to account for missing data and the procedures followed to estimate and assign prices. Several tests of the sensitivity of costs to estimation processes and assumptions are referenced here and presented in appendix C. In addition, given the wide range in some estimated program costs, the sensitivity of mean estimated costs to outliers among the sample of LEAs was also tested, and the results are reported in table C28 in appendix C.

Key assumptions for estimated cross-program costs

Estimation of student/course counts. Program participation data available from the RIOPC's PrepareRI dashboard for the study period are limited to LEA-level unduplicated counts of students for dual enrollment and concurrent enrollment. For AP, LEA-level data for both the total number of tests and number of students who took at least one test are available. Across all programs only data for 2015/16–2017/18 are available, and for estimating costs per participant, only 2017/18 participation data are reflected in the estimated costs.

In this report *student/course count* refers to the duplicated count of students including all courses or tests taken for a given program. For example, a single student taking three dual enrollment courses contributes one to the count of total number of unique students but three to the student/course count.

Because dual enrollment and concurrent enrollment lack student/course counts, the study team assumed that the ratio of unduplicated student counts to student/course counts observed in the cohort data for the outcome analysis was equivalent to the ratio for all participating students. Specifically, the average ratio observed in the cohort data across grades 11 and 12 in the 2016/17 and 2017/18 school years was applied at the LEA level to the unduplicated student counts available in the PrepareRI data for 2017/18. For example, if the average ratio in a given LEA's cohort data was 2.5, indicating an average of 2.5 courses per participant, then a total participation count of 50 would yield an estimated student/course count of 125.

Estimation of total number of courses. Some ingredients in the cost analysis vary at the course level, inclusive of multiple sections for a given course where applicable. Although the scope of the interview and focus group included discussion of the total number of courses offered by participating LEAs during the study period, the gap in time between the study period and data collection, along with inconsistent documentation, resulted in incomplete information about total course offerings.

Therefore, the total number of courses for each program, year, and LEA had to be estimated. The study team relied primarily on the student/course counts and an assumption of course class size to create this estimate. Specifically, a class size of 20.5 was assumed based on the average class size reported for Rhode Island in secondary/high schools for teachers in departmentalized instruction based on 2020/21 data collected through the NCES National Teacher and Principal Survey. This class size was combined with the student/course counts to calculate an estimated number of courses by dividing the student/course count by the assumed class size and then rounding up to the nearest whole number. For example, an LEA with 100 student/courses would have an estimated 5 courses, calculated as 100 divided by 20.5, which rounds to 5 courses. The sensitivity of estimated costs to this process was tested by modeling alternative assumptions, and the results are presented in table C30 in appendix C.

Estimation of total number of teachers. Additionally, some ingredients identified through the cost analysis varied by number of teachers. As with the number of courses, this was discussed in interviews and focus groups, but the information provided was incomplete.

Thus, the number of teachers was estimated for each program, year, and LEA. Specifically, the study team assumed an average of 1.5 course sections per program instructor. This assumption was based on a conservative judgment that, in the earlier years of the programs, instructors each typically taught 1–2 sections for a given course. This approach, including the impact on cost of adjusting the assumption within a reasonable range, is discussed further in the *Sensitivity analysis for alternative estimation assumptions* section in appendix C.

To apply this assumption, the study team divided the estimated total number of courses by 1.5 to calculate an estimated number of teachers. For example, if an LEA had an estimated 6 courses, then the estimated number of teachers was 4 (6 / 1.5). The sensitivity of estimated costs to this process was tested by modeling alternative assumptions, and the results are presented in table C30 in appendix C.

Key assumptions for estimated Advanced Placement costs

Additional data on estimated AP costs, including averages, medians, standard deviations, minimums, and maximums for each resource category and overall, are reported in table 2 of the main report.

Personnel. The personnel resources reported for AP covered a handful of distinct types of roles. Most meaningful in terms of reported time were course instructors and high school counselors. Instructors were described as spending additional time—time beyond that spent on typical courses—for AP courses primarily on activities outside of the classroom, such as grading, planning, afterschool support, program training, and instruction over the summer. Counselors were described as spending additional time helping AP program students understand the unique aspects of the AP context, ensuring that students met unique eligibility requirements, and participating in additional planning activities and professional learning specific to AP. All LEAs reported instructor time, and all LEAs except for one reported counselor time.

In addition to these two roles, some additional staff time was also reported for principals, assistant principals, career and technical education coordinators, and science, technology, engineering, and math (STEM) coordinators. The activities of staff in these roles were generally administrative and involved periodic management of and support for the unique needs of AP beyond those of a comparable non-AP course. These annual activities included participating in AP-specific planning meetings, executing necessary agreements and paperwork with the College Board, and determining what courses to offer and the appropriate number of sections. Not all LEAs reported these staff time for various roles. All but one reported time for a principal or assistant principal, but only two LEAs reported coordinator roles.

Finally, one LEA also reported an investment of very minimal time by the assistant superintendent and the superintendent. The time reported was less than 1 percent of a full-time position for each role and entailed general oversight of the unique aspects of AP across all schools in the LEA offering AP courses.

Equipment and materials. Through the interview and focus groups most LEAs reported that some AP courses required additional equipment and materials beyond the requirements for a comparable non-AP high school course. These additions included a particular type of software tool or specialized equipment for laboratory projects.

Data from the study period documenting these incremental resources in detail were unavailable, as was complete information about the course offerings and the number of associated participating students.

To fill this gap in the available data and ensure that these costs were accounted for, the study team employed a two-stage estimation process, as discussed in the *Key assumptions for estimated cross-program costs* section above.

First, the available data were used to estimate a typical composition of AP courses by course category and to estimate participation by course category. Specifically, 7 of 12 participating LEAs provided a list of AP courses offered. These courses were grouped into a few course categories (for example, STEM and computer science), and each category's share in the total set of courses was calculated. The results were averaged across LEAs to identify a typical composition of AP courses by category. This share was applied to each LEA's total student/course count to estimate the participation associated with each course category for which these materials costs were relevant.

Second, AP course descriptions from the College Board were used to identify equipment and materials beyond those needed for comparable non-AP courses and to assign each a market price. The study team found College Board course and exam descriptions for each applicable course during the study period. Each description contained a section on selecting and using course materials. The section provides general specifications; teachers are not required to use exact types of textbooks or materials. The study team first identified courses that needed incremental equipment and materials (that is, materials beyond those used for a comparable business-as-usual course). For example, the AP Art and Design course uses computers, editing software, and a textbook that are beyond the common materials for business-as-usual high school art courses. For courses with incremental equipment and materials, the study team averaged three prices from national retailers for each ingredient. In general, textbooks were excluded because there is a comparable high school textbook in each subject, and thus the textbook is not incremental with respect to business-as-usual courses. The exception is art courses, where a textbook is not common for business-as-usual courses and thus is an incremental resource specific to AP. Because data on the types of AP courses Rhode Island students took are limited to broader categories such as STEM, these resources were averaged into a bundle for each course category. After amortization was adjusted for and applied to each LEA based on assumed course participation, the prices of STEM and art course bundles came out to modest average amounts, roughly $40 and $30 per student, respectively, whereas the price of the computer science bundles was lower, at less than $10 per student (table B8).

Table B8. Cost of bundles of incremental equipment and materials for Advanced Placement courses, 2017/18, by course category

Course category	Average price per student ($)	Materials included
Art	30	Textbook, aural software, sound equipment, digital camera, photo editing software
Computer science	<10	Computer
Science, technology, engineering, and math	40	Various, including graphing calculator and lab equipment for physics, chemistry, and biology

Note: Estimated costs are based on incremental estimates per student at the local education agency level, rounded to the nearest $10, reported in 2022 constant dollars, and discounted for present value at 3 percent. Incremental costs refer to the amount beyond the materials cost of a typical course. Costs reflect an average of the materials for several courses.

Source: Authors' analysis of public price data and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

Other resources. The "other resources" category included primarily the fees required to take an AP test. The amount assumed per test was based on a review of AP program guides for each year of the study period and applied to each LEA's total number of tests taken.

In addition to AP test fees, one LEA reported training costs for instructors as a lump sum cost to participate in an annual AP conference for teachers new to the program. The LEA did not report the number of new AP teachers for each year of the study period, so the study team conservatively assumed that each year, about one-fifth of the AP teachers at this LEA were new and participated in the conference.

Key assumptions for estimated concurrent enrollment costs

Additional data used to estimate concurrent enrollment costs, including averages, medians, standard deviations, minimums, and maximums for each resource category and overall, are reported in table 2 of the main report.

Personnel. The personnel required to implement concurrent enrollment varies by LEA. It includes people needed for activities specific to concurrent enrollment beyond the business-as-usual general education curriculum—for example, counseling students for course selection, supporting student registration, coordinating with the public colleges, and instructing students.

Most LEAs reported incrementally increasing staff time for teachers for concurrent enrollment. Although how LEAs used this time varied widely, it could include time spent preparing materials, time spent participating in professional development, and additional time spent grading. Quantities for additional concurrent teacher time are estimated as reported by the LEAs in interviews or focus groups. Some quantities pertained to a specific teacher; others, such as professional development, were reported as applying to each teacher or to each teacher in a specific subject area. Finally, some activities—for example, grading—were reported per course section, so the time for these activities was multiplied by the estimated number of sections.

Lead counselors and counselors generally supported concurrent enrollment students with course selection and registration. Time estimates were reported directly during interviews and focus groups and were applied per counselor employed at the high school—a value also collected through the interviews or document review from the study period.

Some LEAs had coordinator roles; sometimes an early enrollment program coordinator or career and technical education coordinator filled this role. Each time, an estimate was gathered from the interviews and focus groups and applied as time per staff member. The number of staff was reported directly in interviews and focus groups.

Leaders at the school and in the district play a role in concurrent enrollment programming, mainly by supporting data review and strategic decisions about course offerings. Assistant superintendents, principals, and assistant principals played a limited role in concurrent enrollment, and time was reported for these personnel by only a handful of LEAs. Each time estimate was gathered from the interviews and focus groups and applied as time per staff member. The number of staff was reported directly in interviews and focus groups.

Equipment and materials. Limited information was available about equipment and materials for concurrent enrollment because of a lack of information provided by LEAs or public sources. Because both AP and concurrent enrollment require materials that meet the rigor of a college course, the study team leveraged the same price and estimation approach as was undertaken for AP courses. After the estimates were adjusted for amortization and were applied to each LEA based on its assumed course participation in the concurrent enrollment programs, the average prices per student were similar to those for AP. The most notable difference was for art course equipment and materials, which had an average price of $80 per student for concurrent enrollment. STEM materials have a lower average price at $20 per student, while computer science courses are roughly the same average price at less than $10 per student (table B9).

Table B9. Cost of bundles of incremental equipment and materials for concurrent enrollment, 2017/18, by course category

Course category	Average price per student ($)	Equipment and materials included
Art	80	Textbook, aural software, sound equipment, digital camera, photo editing software
Computer science	<10	Computer
Science, technology, engineering, and math	20	Various, including graphing calculator and lab equipment for physics, chemistry, and biology

Note: Estimated costs are based on incremental estimates per student at the local education agency level, rounded to the nearest $10, reported in 2022 constant dollars, and discounted for present value at 3 percent. Incremental costs refer to the amount beyond the materials cost of a typical course. Costs reflect an average of the materials for several courses.
Source: Authors' analysis of public price data and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

One difference from the process for estimating AP costs is that textbooks were included in the cost estimation for concurrent enrollment because they were considered supplementary to a business-as-usual course. Concurrent enrollment is often a specialized offering with no similar course at the high school and therefore is assumed to have particular supplemental materials.

The study team relied on public data from the Integrated Postsecondary Education Data System for the average cost of textbooks per semester in each of the three institution of higher education (IHE) networks in Rhode Island participating in the dual enrollment program for the years of the study. These year-specific prices were divided by four to estimate an average cost per course and semester (under the assumption that a regular course load per semester entails four courses) and multiplied by two for the two semesters in a school year.

The resulting IHE-specific prices were then averaged for each year. The result was multiplied by the student/course count, under the assumptions that all students needed to access books for each course they participated in at the average price per course and that student/course counts are added up across semesters such that a student taking one course per semester would have a student/course count of two for the year.

Transportation and other resources. Fees to public colleges make up most of the "other resource" category and are applicable to all students. To generate an average fee amount, the total fees paid to public colleges for current enrollment, provided to the study team by the (RIOPC), were divided by the number of students enrolled for each year for which data were available (2016/17 and 2017/18). To estimate fees for the year of the study period relevant to this program for which fee data were not provided, 2015/16, the study team assumed the average fee per student across the two available years. The resulting fees were then applied on a per participant basis.

One district described transportation for this program. The LEA used lab space at a local public college every month. Mileage between the high school and this college was calculated using Google Maps, and a standard mileage rate was applied based on one trip per month for the nine months of the school year (Chang & Head, 2022). However, in the end this was a small investment (less than $25 per student), and across all LEAs the unweighted average for transportation in this program was below $2 per student. For that reason transportation costs were not reported for the program.

Key assumptions for estimated dual enrollment costs

Additional data used to estimate AP costs, including averages, medians, standard deviations, minimums, and maximums for each resource category and overall, are reported in table 2 of the main report.

Personnel. The personnel resources reported for dual enrollment included a handful of distinct types of roles. Most meaningful, in terms of typical reported time, were high school counselors and LEA administrative staff. The additional time allocated by high school counselors to support dual enrollment was described as including time for orienting and supporting participants, often liaising with the partner IHE to ensure that program requirements were being met, and in some LEAs tracking student progress and intervening when a student was struggling. Time for general planning and administrative activities related exclusively to dual enrollment was also reported. LEA administrative staff included more senior roles such as district director-level staff and other district administrators, as well as clerical and secretarial roles. In general, the additional time dedicated by these staff to dual enrollment was described as including support for the program process, purchasing, financial management, database management, and coordination of administrative activities. In some LEAs these staff also helped participating students with unique needs succeed in the program. All LEAs reported additional time for high school counselors, whereas only 8 of the 11 LEAs reported time for district administrative staff.

In addition, LEAs reported additional time for school administrators, coordinators, and instructors. School administrators, including principals and assistant principals, were described as providing general administrative support and, in some LEAs, more active support for program planning and implementation through regular meetings with other staff and facilitation of integration with the broader school programming. Coordinator roles were described as supporting program alignment across early college programs and, in some cases, supporting communication with the partner IHE. Finally, in some LEAs instructors were described as providing direct support to participating students to navigate and succeed in the college campus environment as well as providing support for other routine activities, such as registration. Of the 11 LEAs, 7 identified additional time for school administrators, whereas only 3 identified time for coordinators and instructors each.

Finally, one LEA identified additional time for its superintendent and assistant superintendent for supporting the unique aspects of dual enrollment. However, the time reported was less than 1 percent of a full-time position for each role and entailed general oversight across all schools in the LEA offering dual enrollment.

Equipment and materials. The only equipment and materials ingredient identified and estimated for dual enrollment was the cost to purchase course textbooks for all participating students. The study team took the same approach to estimating textbook costs for dual enrollment as it did to estimating costs for concurrent enrollment.

Transportation. Although LEAs participating in interviews and focus groups discussing dual enrollment all mentioned the need for student transportation to and from a participating IHE campus, most did not mention providing for the cost of this transportation comprehensively. Some reported providing bus passes to a subset of participating students based on need, and others mentioned securing a school bus to transport some students. None provided sufficient detail about the typical amount of travel or mode of travel required, whether covered or not, to enable the study team to directly assign an estimated cost based on these discussions.

Therefore, the study team estimated the cost of travel using a consistent process across all LEAs participating in these discussions about dual enrollment. The estimation process proceeded in two stages. First, the mode of transportation was assigned based on the distance from each LEA to the nearest IHE campus. If that distance was less than 5 miles, it was assumed that local public transportation was a viable and primary mode of transportation for students. If the distance was 5 miles or more, it was assumed that a car was used to make the journey.

For local public transportation the assumed cost was that of a monthly Rhode Island Public Transit Authority bus pass for each of the nine months of the school year. For car travel the assumption was the value of the mileage, based on the federal per diem, for three round trips per week in each of the 36 weeks of the school year. For example, if a student's LEA was 10 miles from the nearest IHE campus, the total mileage would be 2,160 miles, calculated as $10 \times 2 \times 3 \times 36 = 2{,}160$. The sensitivity of estimated costs to this process was tested by modeling alternative assumptions, and the results are presented in table C31 in appendix C.

Other resources. For dual enrollment the "other resources" category was made up entirely of IHE fees. As with concurrent enrollment, to generate an average fee amount, the total fees were divided by the number of students enrolled for each year with data (2016/2017 and 2017/18), and the average across available years was used to estimate data for the missing year, 2015/16. The resulting fees were then applied on a per student basis.

Key limitations

The limitations discussed here build on those described in the main report. All limitations are important (to varying degrees) for understanding the results and certain choices the study made that affect the estimated costs.

Generalizability of results

Participation in the LEA interviews and focus groups was low, presenting possible challenges for generalizability across the state. The study team invited 33 LEAs and interviewed 12: 8 traditional LEAs and 4 nontraditional LEAs (such as charter school districts). Half the participating LEAs were in a suburban setting, 42 percent were in urban core settings, and only 1 was in a rural setting. Another participating LEA, originally categorized in the rural group, self-identified as urban based on the students served and their home location and was ultimately recategorized to the urban group.

The study team made extensive efforts to secure participation from more of the invited LEAs through contacts by RIDE and direct emails and phone calls. Several declined or did not respond, noting that spring (when the engagements were held) was a particularly busy time for program staff. Suburban LEAs are slightly overrepresented relative to their number in the state overall.

The presence of several dual enrollment models also affects generalizability. Across the study sample of LEAs offering dual enrollment, some dual enrollment students were served in intensive programs in nontraditional school settings with additional associated staff time (see figures C2 and C3 in appendix C). Although these "high-touch" programs may serve some dual enrollment students statewide, their higher costs may not be generalizable to other less-intensive dual enrollment program models. In the main report table 1 shows the wide range in estimated dual enrollment costs.

Missing cost data

Missing, incomplete, or inconsistent data are often an issue in cost analysis. This issue is particularly challenging when the analysis must rely to some extent on collecting primary information about program resource use from program staff or deals with information about program implementation that took place in the past. Given that documentation about resource use and costs of education programs is typically sparse and incomplete, cost analysis must routinely rely on a combination of available data, reasonable assumptions, and estimation business rules to prepare estimated costs. Cost analysts often choose to use a reasonable set of global assumptions, as opposed to a larger number of site-specific assumptions, which—when applied consistently—result in costs that vary depending on the administrative data available. As such, a detailed summary of these assumptions and estimation procedures and the associated limitations or potential sources of bias is critical (Cost Analysis Standards Project, 2021). This is covered in detail in the *Cost estimation process, by program and resource category* section. The major sources of data, categories of missing data, and procedures used to generate estimated costs are summarized in table B10.

Table B10. Source of quantity estimation, by early college program and resource category

Resource category	Advanced Placement	Concurrent enrollment	Dual enrollment
Personnel	High school full-time equivalents, generated from interviews and focus groups	High school full-time equivalents, generated from interviews and focus groups	High school full-time equivalents, generated from interviews and focus groups
Equipment and materials	Systematic estimation using public data on participation by Advanced Placement course category and suggested course materials from College Board documentation Program course data provided by a subset of participating districts	Systematic estimation based on the same process used for Advanced Placement Systematic estimation for textbooks based on Integrated Postsecondary Education Data System (IPEDS) data	Systematic estimation for textbooks based on IPEDS data
Transportation	na	na	Systematic estimation process based on local education agency mileage from nearest college campus
Fees	College Board documentation	RIOPC administrative data	RIOPC administrative data

na is not applicable. RIOPC is Rhode Island Office of the Postsecondary Commissioner.
Note: All postsecondary costs for concurrent enrollment and dual enrollment, including college personnel time, are assumed to be captured through program fees.
Source: Authors' construction.

For interview and focus group participants, recalling information about staff time and other resources allocated to a program's implementation can be challenging, especially when estimating staff time, which is inherently difficult to track. Additionally, this study added the layer of asking participants to report quantities from several previous years, and at some LEAs the individuals working on these programs during the study period had left by the time the interviews were conducted.

When estimates were difficult to generate for the participants because of the length of time since the study period, the interviewer asked about current practice and how current resources varied from resources used during the study period. As noted, the detailed results by program and resource category describe assumptions that the study team applied in cases where the use of an ingredient was known but the quantity was not and therefore needed to be estimated.

Despite the challenges, participants were able to estimate staff time consistently across LEAs, though as discussed throughout the report, not to a high degree of precision. That said, not all participating LEAs described the same program roles, or even took the same approach to program design. The result of this variation is that specific personnel ingredients are not always relevant to all LEAs and are thus better described as not applicable rather than missing.

For course equipment and materials costs and for facility costs, information provided by interview and focus group participants was less consistent and complete. For equipment and materials, only 7 of 12 participating LEAs provided detailed documentation about the courses offered during the study period, and most could not provide details about the equipment or materials. As a result of the high degree of missingness, the study team opted to establish global estimation business rules and assumptions to estimate costs in this category, which rely on the available sample of course information alongside other public sources of data. These estimation procedures are summarized in table B10 and described elsewhere in this appendix (see the *Cost estimation process, by program and resource category* section).

For facilities costs, most LEAs did not report sufficient detail in this category, and only some reported any incremental costs in this category. In several cases a reported incremental facility type may be reasoned to be specific to a given LEA's preferences and particular implementation context (in other words, course-specific facilities chosen by a given LEA and so forth). In other cases, a reported facility is more likely to be necessary for all LEAs (for example, incremental use of staff office space and so forth), but the particulars of its use were not reported by all LEAs and would thus need to be estimated. Given these issues, the study team omitted this category of resources and acknowledges it as a missing category of costs. It is likely that these programs have incremental costs associated with the use of facilities, but sufficiently reliable estimates could not be generated given the available data.

Additionally, as with any primary collection of data from a sample of the target population with a response rate below the ideal, a nonresponse bias analysis is important to understand the potential biases resulting from a failure to gather information from intended respondents. The results of such an analysis are summarized in appendix D.

As the findings are reviewed, these sources of missing data and potential biases resulting from nonresponse should be kept in mind alongside the details provided about the estimation of specific ingredient costs.

Lack of congruence in enrollment data

There was a mismatch between the student group studied for the outcome analysis and the student group studied for the cost analysis. To generate costs per student, the total cost (gathered at the level of program delivery, which was generally the classroom) was divided by the total number of students served by the program, because many of the resources (such as teachers) are not per student and apply to all participating students. The student-level data for the outcome analysis were collected for a specific cohort: students who entered grade 9 for the first time in the 2014/15 school year. However, students in other grades were participating in the three early college programs alongside this cohort, and the resources described in the interviews cannot be isolated to this cohort specifically; rather, they apply to all students who participated in the programs between 2014/15 and 2017/18. For a denominator that aligns with the analysis level of the costs, the study team used participation data by school from the PrepareRI dashboard.

For AP there was a mismatch between the outcome and the cost samples. Data on AP course enrollment were unavailable in statewide data, and student participation was inferred from the number of AP test-takers instead. As a result, the outcomes analysis was able to consider outcomes only for students taking an AP test rather than for all enrolled students. However, for the cost analysis, data were insufficiently detailed to isolate AP resources for test-takers as opposed to all enrolled students. Given the gaps in available data, it is possible to apply test-taker participation only in estimates or calculations relying on student program participation. Thus, the resulting estimated costs per student are biased to the extent that there is a difference between the number of enrolled AP students and the number of AP test-takers (that is, magnitude of bias). Further, the direction of this bias is also unclear, given that it is plausible that in any given LEA not all enrolled students take the test (downward bias) and that some students take the test without enrolling in the course (upward bias). In the judgment of the study team, a downward bias is most likely. But given the uncertainty, no suitable action could be identified to mitigate this issue in the reported estimated costs. See the *Missing cost data* section above for additional limitations related to program data.

Focus group base protocol

Authors note: Due to the nature of the semi-structured interview process, some additional probing or clarifying questions were asked in each engagement. In addition, facilitators stated some clarifications about the scope and purpose of the data collection during the participant orientation to the study and in the opening of the focus/group interview meeting. For example, although the questions as written in this protocol sometimes do not make specific reference to the study period, the introduction section makes clear that all questions relate to the specific study time period. If the time period for a specific answer was unclear, the interviewer would clarify through probing questions whether the answer related to the correct time period.

Opening (5 min)

Having made investments in early college opportunities, Rhode Island state administrators and policymakers want to understand these programs' contributions to the state's educational attainment goals, as well as their relative costs, to inform decision-making.

Rhode Island is collaborating with the Regional Educational Laboratory (REL) Northeast & Islands to study these questions:

- What effects do dual enrollment, concurrent enrollment, and Advanced Placement courses each have on student outcomes, specifically college enrollment within one year of high school graduation, initial enrollment in a four-year rather than a two-year college, and persistence to a second year of college?
- What is the total cost and cost per outcome associated with administration of each of the three early college programs in Rhode Island?

In today's discussion, our goal is to gather comprehensive information related to the second research question about the resources required to implement your dual enrollment, concurrent enrollment, and Advanced Placement programs in the period of 2014/15 through 2017/18. The information gathered during this focus group will be used in combination with program documentation that your district/school provided to generate an estimate of resources required for this program.

Our conversation will focus on the qualities and quantities of resources generally within a few broad categories of resources including **Personnel**, **Facilities**, **Equipment and Materials**, and miscellaneous additional categories such as **Transportation** or **Contracted Services**.

Our discussion will be structured around these categories, but some topics will likely relate to more than one category. There will be room at the end to add any additional information that you feel may help our study.

The overall goal of the discussion is to capture resource information with as much precision *as is reasonable* given that this time period was some years in the past and that certain resources may be inherently difficult to estimate precisely. Throughout our discussion, we just ask that you provide your best estimate of resources, keeping in mind that an imprecise estimate is often better than leaving a resource out entirely. We are interested in all resources required, regardless of who pays for these resources.

Your responses today will be kept confidential and will not be shared with Rhode Island Department of Education (RIDE) staff or any other individuals not involved in the project. REL Northeast & Islands will use the information gathered here, in combination with other sources of data, to identify broad project findings to support a better understanding among policymakers of the relative costs of this program and how it varies across contexts.

REL Northeast & Islands will not be evaluating or publishing individual responses. Nothing you share with us will be used for auditing or compliance purposes, and participation or non-participation in this process will not be shared with RIDE staff. Individual districts and staff members will not be named in connection with your responses in our reports. Aggregate data will be published in a report.

Any concerns before we begin?

Are you OK if we record the interview exclusively for note-taking purposes?

Discussion Ground Rules (5 min)

Before we begin, we'd like to establish a few basic ground rules for our discussion. These include:

- **Take turns responding to questions posed:** The facilitator will call on people to respond as needed, or may simply open the floor for people to signal they would like to respond.
- **Leave space for everyone to participate:** While we would like everyone to have an opportunity to share all of their thoughts, be mindful of how often you are speaking and consider sitting in silence to allow others to join the discussion.
- **Stay on topic:** Please try to stick to the topic raised as much as possible. The facilitator may, from time to time, redirect the discussion if it veers off course.
- **Be specific:** As much as possible, be specific in your responses or when necessary, acknowledge an inability to do so.

Section 1: Program Components (15-20 min)

Before discussing the specific resources required for your dual enrollment, concurrent enrollment, and Advanced Placement programs, it's important to first define the scope of this program and its intended outcomes.

Specifically, we're hoping you can help us to clarify a few key program components, including:

- **Courses Offered** - that is, Which specific AP courses did you offer? Which specific concurrent courses did you offer?
- **Student Audience** - that is, Were any specific student groups targeted for these programs? Were there any students who could not participate and why?
- **Intended Program Outcomes** - that is, What overall student educational outcomes did you intend to effect as a result of the program? What did program success look like?

The goal of this part of the discussion is to identify the commonalities and differences in these program components across your settings and support defining the scope of the rest of our discussion. For example, some AP courses may have happened before the school day starts rather than during the normal school day, thus impacting its resource use. Likewise, some concurrent courses may have been designed to help students gain college credit, while others were designed to give experience for a technical certification or career.

1. To get started, let's begin with the **Courses Offered;** Which AP, dual, and concurrent courses did your district/school offer?
2. Next, let's discuss **Student Audience**; What group or groups of students were targeted for participation in this program? On what factors did a student's participation depend?
3. Finally, for **Intended Program Outcomes**; How did you define program success?

Thanks for helping us identify the commonalities and differences in program components across your settings. We're going to turn next to a discussion of the personnel involved in program implementation.

Section 2: Personnel (25–30 min)

Next, we would like to understand the personnel involved in the implementation of this program. For this important resource category, we're hoping to identify the applicable program roles, the key program responsibilities for each role, and the amount of staff time each role invests in the program over the course of a year. We are especially interested in program resources that are different than would be implemented under business as usual, or incremental in nature. For example, if a personnel role allocates the same amount of time as would be the case for a comparable activity absent the program, this resource would not represent an incremental resource, while a role allocating a different amount of time would.

1. First, I am going to list the roles we have identified for implementation of the AP program.
   a. Teacher, department chair, school counselor, principal, district leader for teaching and learning or postsecondary.
   b. Does anyone have other roles they would like to add? Are there any roles I listed that do not apply to your district/school?
2. Can you please describe the specific personnel roles involved in the implementation of your Advanced Placement programs? In your response can you please include:
   a. each role's program responsibilities;
   b. the minimum required qualifications for each role (e.g., experience, professional credentials, etc.);
   c. the key activities they're involved in; and
   d. the amount of time they spend supporting the program over the course of the year. *Note*: Time can be estimated in full-time equivalents (or the portion of a full-time role) or as the typical number of hours in a given week. If these individuals work during school breaks or the summer, please describe this time as well and how it differs from the school year.

Now let's repeat this process for the concurrent program, and finally for dual enrollment.

3. Is there anything about program personnel that we haven't covered that you would like to share before we move on?

Section 3: Equipment and Materials (15–20 min)

This next section of the discussion will focus on tangible equipment and materials specifically required for the program, such as textbooks or curriculum materials, or technology and other equipment. This would include resources that are shared with other programs or activities, such as a set of tablets or computers available for check-out as needed. As with the Personnel section, we are interested in understanding to what extent these resources are incremental to a comparable business as usual context.

4. Can you please describe the types of equipment or materials that are used for the program? In your response, please include:
   a. the way it is used for the program;
   b. why it's important;
   c. whether it is shared with other programs; and
   d. the estimated quantity of each resource dedicated to the program.

5. Is there anything about program equipment and materials that we haven't covered that you would like to share before we move on?

Section 4: Facilities (10–15 min)

This next section of the discussion will focus on facilities specifically required for the program, such as classroom or office space. We know this program mostly takes place at your high school. We want to drill down into the specific types of facilities required for this program—for example classrooms, science labs, or libraries. This will most likely include facilities that are shared with other programs or activities. As with the prior sections, we are interested in understanding to what extent these resources are incremental to a comparable business as usual context.

6. Can you please describe the types of facilities that are used for the program? In your response, please include:
    a. the way it is used for the program;
    b. why it's important;
    c. whether it is shared with other programs; and
    d. the estimated quantity of each resource dedicated to the program.
7. Is there anything about program facilities that we haven't covered that you would like to share before we move on?

Section 5: Other Resources (10–15 min)

Our final section will cover all other types of resources required for program implementation that do not fit in the previous categories. Some common resources in this catch-all category are transportation costs or contracted services, but any resource not yet covered should be noted. As with the prior sections, we are interested in understanding to what extent these resources are incremental to a comparable business as usual context.

8. Can you please describe any resources in this category that have not already been discussed? In your response, please include:
    a. the way it is used for the program;
    b. why it's important;
    c. whether it is shared with other programs; and
    d. the estimated quantity of each identified resource and, if applicable, the share of its total available use supporting the program.
9. Is there anything about these other resources that we haven't covered that you would like to share before we move on?

Closing (5 min)

Before we close our discussion, we would like to give you all an opportunity to share anything important that we did not yet cover today about the resources required to implement your concurrent enrollment and Advanced Placement programs.

10. Is there anything we missed?

In closing, we want to thank you all for your time and engagement today, and for being willing to share information about your concurrent enrollment and Advanced Placement programs.

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Appendix C. Supporting analysis

This appendix provides more detail from the analyses discussed in the body of the report.

Outcome analysis

This section provides supporting results related to the study's outcome analysis.

Dual enrollment

Tables C1 and C2 provide detailed results from the analyses of student outcomes related to participation in dual enrollment.

Table C1. Odds ratios from models examining the relationship between participation in dual enrollment and college enrollment and persistence, 2014/15 grade 9 cohort

	Outcome	
Variable	Model 1 College enrollment	Model 2 College persistence
Main effects		
Participated in dual enrollment	1.85 (0.43)**	1.79 (0.36)**
Hispanic	0.85 (0.14)	0.80 (0.12)
Has an Individualized Education Program	0.48 (0.08)***	0.73 (0.12)*
Moderating effect of math proficiency		
Participated in dual enrollment	1.36 (0.40)	1.46 (0.40)
Hispanic	1.90 (0.14)	0.84 (0.12)
Has an Individualized Education Program	0.57 (0.10)***	0.85 (0.14)
At least proficient on NECAP math	1.71 (0.22)***	1.59 (0.19)***
At least proficient on NECAP math x intervention	1.89 (0.80)	1.42 (0.48)

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the odds ratio is different from 1. The sample size is 1,651 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The matched sample included 809 students scoring at the proficient level in math on the grade 8 NECAP (102 intervention and 707 comparison) and 842 scoring at the nonproficient level (87 intervention and 755 comparison). Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C2. Relative risk ratios from models examining the relationship between participation in dual enrollment and level of initial college enrollment, 2014/15 grade 9 cohort

	Outcome	
Variable	Two-year college enrollment	Four-year college enrollment
Main effects		
Participated in dual enrollment	1.53 (0.47)	2.95 (0.69)***
Hispanic	1.09 (0.21)	0.52 (0.12)**
Has an Individualized Education Program	0.76 (0.24)	0.23 (0.07)***
Moderating effect of math proficiency		
Participated in dual enrollment	1.30 (0.34)	3.07 (0.73)***
Hispanic	1.21 (0.24)	0.69 (0.17)
Has an Individualized Education Program	0.86 (0.27)	0.32 (0.10)***
At least proficient on NECAP math	1.66 (0.37)*	3.99 (0.85)***
At least proficient on NECAP math x intervention	1.57 (0.75)	1.13 (0.45)

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the relative risk ratio is different from 1. Estimates are from a multinomial logistic regression model in which the outcome of no college enrollment is the reference category. The sample size is 1,635 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. Data on level of college enrollment were missing for 16 students. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Concurrent enrollment

Tables C3 and C4 provide detailed results from the analyses of student outcomes related to participation in concurrent enrollment.

Table C3. Odds ratios from models examining the relationship between participation in concurrent enrollment and college enrollment and persistence, 2014/15 grade 9 cohort

	Outcome	
Variable	Model 1 College enrollment	Model 2 College persistence
Main effects		
Participated in concurrent enrollment	2.12 (0.26)***	2.32 (0.23)***
Asian	1.43 (0.50)	1.60 (0.47)
Chronically absent	0.69 (0.07)***	0.59 (0.50)***
Took Algebra I in grade 8	1.35 (0.17)*	1.43 (0.16)***
Hispanic	1.00 (0.15)	0.98 (0.13)
Black	1.25 (0.29)	1.78 (0.37)**
Moderating effect of math proficiency		
Participated in concurrent enrollment	3.05 (0.63)***	2.73 (0.46)***
Asian	1.40 (0.49)	1.57 (0.46)
Chronically absent	0.70 (0.07)***	0.59 (0.05)***
Took Algebra I in grade 8	1.20 (0.16)	1.28 (0.14)*
Hispanic	1.04 (0.16)	1.01 (0.14)
Black	1.32 (0.31)	1.87 (0.40)**
At least proficient on NECAP math	1.64 (0.18)***	1.53 (0.16)***
At least proficient on NECAP math x intervention	0.56 (0.14)*	0.77 (0.16)

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the odds ratio is different from 1. The sample size is 2,886 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The matched sample included 1,701 students scoring at the proficient level on the grade 8 NECAP (556 intervention and 1,145 comparison) and 1,185 scoring at the nonproficient level (238 intervention and 947 comparison). Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C4. Relative risk ratios from models examining the relationship between participation in concurrent enrollment and level of initial college enrollment, 2014/15 grade 9 cohort

Variable	Outcome: Two-year college enrollment	Outcome: Four-year college enrollment
Main effects		
Participated in concurrent enrollment	1.44 (0.19)**	3.65 (0.47)***
Asian	1.67 (0.96)	1.33 (0.76)
Chronically absent	0.91 (0.14)	0.55 (0.07)***
Took Algebra I in grade 8	1.16 (0.19)	2.11 (0.34)***
Hispanic	1.16 (0.20)	0.65 (0.14)
Black	1.11 (0.30)	0.88 (0.25)
Moderating effect of math proficiency		
Participated in concurrent enrollment	1.98 (0.46)**	5.58 (1.39)***
Asian	1.66 (0.95)	1.32 (0.76)
Chronically absent	0.92 (0.14)	0.57 (0.79)***
Took Algebra I in grade 8	1.06 (0.17)	1.65 (0.25)***
Hispanic	1.22 (0.20)	0.77 (0.17)
Black	1.18 (0.33)	1.08 (0.30)
At least proficient on NECAP math	1.44 (0.23)*	2.75 (0.46)***
At least proficient on NECAP math x intervention	0.59 (0.18)	0.52 (0.16)*

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the relative risk ratio is different from 1. Estimates are from a multinomial logistic regression model in which the outcome of no college enrollment is the reference category. The sample size is 2,864 students clustered in 51 high schools in a matched sample drawn from students who were first-time grade 9 students in Rhode Island public schools in 2014/15 and graduated on time from high school in the state in spring 2018. Data on level of college enrollment were missing for 22 students. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Advanced Placement test-taking

Tables C5 and C6 provide detailed results from the analyses of student outcomes related to participation in Advanced Placement (AP) test-taking.

Table C5. Odds ratios from models examining the relationship between participation in Advanced Placement test-taking and college enrollment and persistence, 2014/15 grade 9 cohort

Variable	Outcome: Model 1 College enrollment	Outcome: Model 2 College persistence
Main effects		
Participated in Advanced Placement	2.72 (0.38)***	3.60 (0.42)***
Multilingual learner	0.47 (0.14)*	1.14 (0.34)
Black	1.62 (0.40)	1.24 (0.24)
Moderating effect of math proficiency		
Participated in Advanced Placement	3.18 (0.79)***	3.85 (0.86)***
Multilingual learner status	0.64 (0.20)	1.44 (0.44)
Black	1.70 (0.43)*	1.27 (0.25)
At least proficient on NECAP math	2.14 (0.32)***	1.75 (0.25)***
At least proficient on NECAP math x intervention	0.79 (0.22)	0.90 (0.22)

* Significant at $p < .05$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the odds ratio is different from 1. No estimates were significant at $p < .01$. The sample size is 2,609 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The matched sample included 1,788 students scoring at the proficient level on the grade 8 NECAP (792 intervention and 996 comparison) and 821 scoring at the nonproficient level (177 intervention and 644 comparison). Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C6. Relative risk ratios from models examining the relationship between participation in Advanced Placement test-taking and level of initial college enrollment, 2014/15 grade 9 cohort

Variable	Outcome: Two-year college enrollment	Outcome: Four-year college enrollment
Main effects		
Participated in Advanced Placement	1.19 (0.16)	4.03 (0.80)***
Multilingual learner	0.58 (0.18)	0.21 (0.07)***
Black	1.18 (0.29)	0.85 (0.25)
Moderating effect of math proficiency		
Participated in Advanced Placement	1.40 (0.42)	5.21 (1.37)***
Multilingual learner	0.76 (0.25)	0.51 (0.18)
Black	1.28 (0.26)	1.08 (0.30)
At least proficient on NECAP math	1.74 (0.29)**	5.28 (1.35)***
At least proficient on NECAP math x intervention	0.81 (0.30)	0.76 (0.28)

** Significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the relative risk ratio is different from 1. No estimates were significant at $p < .05$. Estimates are from a multinomial logistic regression model in which the outcome of no college enrollment is the reference category. The sample size is 2,600 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. Data on level of college enrollment were missing for nine students. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Combination of Advanced Placement test-taking and concurrent enrollment

Tables C7 and C8 provide detailed results from the analyses of student outcomes related to participation in the combination of AP test-taking and concurrent enrollment.

Table C7. Odds ratios from models examining the relationship between participation in the combination of Advanced Placement test-taking and concurrent enrollment and college enrollment and persistence, 2014/15 grade 9 cohort

Variable	Outcome: Model 1 College enrollment	Outcome: Model 2 College persistence
Main effects		
Participated in the combination of Advanced Placement test-taking and concurrent enrollment	4.09 (0.68)***	7.63 (1.07)***
Hispanic	0.88 (0.19)	0.99 (0.18)
Multilingual learner	0.55 (0.23)	1.16 (0.45)
Moderating effect of math proficiency		
Participated in the combination of Advanced Placement test-taking and concurrent enrollment	3.76 (1.27)***	6.61 (2.06)***
Hispanic	0.94 (0.20)	1.00 (0.18)
Multilingual learner	0.82 (0.35)	1.53 (0.62)
At least proficient on NECAP math	2.35 (0.46)***	1.85 (0.34)***
At least proficient on NECAP math x intervention	1.02 (0.38)	1.12 (0.37)

*** Significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the odds ratio is different from 1. No values were significant at $p < .05$ or $p < .01$. The sample size is 2,518 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The matched sample included 1,842 students scoring at the proficient level on the grade 8 NECAP (909 intervention and 933 comparison) and 676 scoring at the nonproficient level (112 intervention and 564 comparison). Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C8. Relative risk ratios from models examining the relationship between participation in the combination of Advanced Placement test-taking and concurrent enrollment and level of initial college enrollment, 2014/15 grade 9 cohort

Variable	Outcome: Two-year college enrollment	Outcome: Four-year college enrollment
Main effects		
Participated in the combination of Advanced Placement test-taking and concurrent enrollment	1.04 (0.25)	7.04 (1.91)***
Hispanic	1.20 (0.28)	0.39 (0.11)**
Multilingual learner	0.56 (0.19)	0.30 (0.12)**
Moderating effect of math proficiency		
Participated in the combination of Advanced Placement test-taking and concurrent enrollment	1.71 (0.51)	8.29 (3.13)***
Hispanic	1.34 (0.30)	0.50 (0.13)**
Multilingual learner	0.80 (0.29)	0.71 (0.38)
At least proficient on NECAP math	2.25 (0.52)***	5.32 (1.83)***
At least proficient on NECAP math x intervention	0.53 (0.22)	0.82 (0.41)

** Significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the relative risk ratio is different from 1. No values were significant at $p < .05$. Estimates are from a multinomial logistic regression model in which the outcome of no college enrollment is the reference category. The sample size is 2,505 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. Data on level of college enrollment were missing for 13 students. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Effect sizes for outcome analyses

Tables C9 and C10 report the effect sizes from each analysis of program effects on college outcomes, expressed in a metric commonly used by the What Works Clearinghouse (Cox index).

Table C9. Summary of effect sizes (Cox index) from main effects models examining the relationship between participation in each early college program and college enrollment and persistence, 2014/15 grade 9 cohort

	Outcome	
Intervention	College enrollment	College persistence
Dual enrollment only	0.37**	0.35**
Concurrent enrollment only	0.46***	0.51***
Advanced Placement test-taking only	0.61***	0.78***
Combination of Advanced Placement test-taking and concurrent enrollment	0.85***	1.23***

** Significant at $p < .01$; *** significant at $p < .001$.

Note: No values were significant at $p < .05$. Analyses were performed on a set of matched samples drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The sample sizes are 1,651 for dual enrollment only, 2,886 for concurrent enrollment only, 2,609 for Advanced Placement test-taking only, and 2,518 for the combination of Advanced Placement test-taking and concurrent enrollment.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C10. Summary of effect sizes (Cox index) from main effects models examining the relationship between participation in each early college program and level of initial college enrollment, 2014/15 grade 9 cohort

	Outcome	
Intervention	Two-year college enrollment	Four-year college enrollment
Dual enrollment only	0.26	0.66***
Concurrent enrollment only	0.22**	0.78***
Advanced Placement test-taking only	0.11	0.84***
Combination of Advanced Placement test-taking and concurrent enrollment	0.02	1.18***

** Significant at $p < .01$; *** significant at $p < .001$.

Note: No values were significant at $p < .05$. Estimates are from multinomial logistic regression models in which the outcome of no college enrollment is the reference category. Analyses were performed on a set of matched samples drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The sample sizes are 1,635 for dual enrollment only, 2,864 for concurrent enrollment only, 2,600 for Advanced Placement test-taking only, and 2,505 for the combination of Advanced Placement test-taking and concurrent enrollment. Data on level of initial college enrollment were missing for 16 students who participated in dual enrollment only, 22 students who participated in concurrent enrollment only, 9 students who participated in Advanced Placement test-taking only, and 13 students who participated in the combination of Advanced Placement test-taking and concurrent enrollment.

Source: Authors' analysis of Rhode Island Department of Education data.

Tables C11-C14 provide a summary of all program effects in the metric used in the main body of this report, predicted probabilities.

Table C11. Summary of predicted probabilities from models examining the relationship between participation in each early college program and college enrollment and persistence, 2014/15 grade 9 cohort

	Outcome	
Intervention	College enrollment	College persistence
Dual enrollment only		
Intervention	0.79 (0.04)**	0.64 (0.03)**
Comparison	0.69 (0.03)	0.51 (0.03)
Concurrent enrollment only		
Intervention	0.84 (0.02)***	0.69 (0.02)***
Comparison	0.72 (0.02)	0.51 (0.02)
Advanced Placement test-taking only		
Intervention	0.88 (0.02)***	0.77 (0.03)***
Comparison	0.74 (0.02)	0.52 (0.03)
Combination of Advanced Placement test-taking and concurrent enrollment		
Intervention	0.94 (0.01)***	0.88 (0.02)***
Comparison	0.79 (0.02)	0.54 (0.03)

** Significant at $p < .01$; *** significant at $p < .001$.

Note: A statistically significant estimate indicates that the difference in marginal predicted means between intervention and comparison groups is different from 0. No values were significant at $p < .05$. Analyses were performed on a set of matched samples drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The sample sizes are 1,651 for dual enrollment only, 2,886 for concurrent enrollment only, 2,609 for Advanced Placement test-taking only, and 2,518 for the combination of Advanced Placement test-taking and concurrent enrollment. For each outcome the model included several predictors specific to each intervention group. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C12. Summary of predicted probabilities from models examining the moderating effect of math proficiency on the relationship between participation in each early college program and college enrollment and persistence, 2014/15 grade 9 cohort

	Outcome	
Intervention	College enrollment	College persistence
Dual enrollment only		
Not proficient on NECAP math		
Intervention	0.69 (0.05)	0.54 (0.06)
Comparison	0.63 (0.03)	0.46 (0.03)
Proficient on NECAP math		
Intervention	0.87 (0.04)**	0.72 (0.05)**
Comparison	0.74 (0.02)	0.56 (0.05)
Concurrent enrollment only		
Not proficient on NECAP math		
Intervention	0.85 (0.02)***	0.67 (0.03)***
Comparison	0.66 (0.02)	0.45 (0.03)
Proficient on NECAP math		
Intervention	0.84 (0.02)***	0.71 (0.03)***
Comparison	0.76 (0.02)	0.54 (0.02)
Advanced Placement test-taking only		
Not proficient on NECAP math		
Intervention	0.84 (0.03)***	0.71 (0.04)***
Comparison	0.64 (0.03)	0.43 (0.04)
Proficient on NECAP math		
Intervention	0.90 (0.02)***	0.79 (0.02)***
Comparison	0.78 (0.02)	0.55 (0.03)
Combination of Advanced Placement test-taking and concurrent enrollment		
Not proficient on NECAP math		
Intervention	0.88 (0.03)***	0.81 (0.04)***
Comparison	0.67 (0.04)	0.44 (0.04)
Proficient on NECAP math		
Intervention	0.94 (0.01)***	0.89 (0.02)***
Comparison	0.82 (0.02)	0.57 (0.03)

** Significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the difference in marginal predicted means between intervention and comparison groups is different from 0. No values were significant at $p < .05$. Analyses were performed on a set of matched samples drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The sample sizes are 1,651 for dual enrollment only, 2,886 for concurrent enrollment only, 2,609 for Advanced Placement test-taking only, and 2,518 for the combination of Advanced Placement test-taking and concurrent enrollment. For each outcome the model included several predictors specific to each intervention group. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C13. Summary of predicted probabilities from models examining the relationship between participation in each early college program and level of initial college enrollment outcome, 2014/15 grade 9 cohort

	Outcome		
Intervention	No college enrollment	Two-year college enrollment	Four-year college enrollment
Dual enrollment only			
Intervention	0.15 (0.01)***	0.39 (0.04)	0.45 (0.04)***
Comparison	0.27 (0.02)	0.45 (0.01)	0.28 (0.03)
Concurrent enrollment only			
Intervention	0.10 (0.02)***	0.32 (0.02)***	0.57 (0.02)***
Comparison	0.21 (0.02)	0.46 (0.02)	0.33 (0.03)
Advanced Placement test-taking only			
Intervention	0.07 (0.01)***	0.22 (0.02)***	0.71 (0.03)***
Comparison	0.17 (0.02)	0.42 (0.04)	0.41 (0.04)
Combination of Advanced Placement test-taking and concurrent enrollment			
Intervention	0.04 (0.01)***	0.12 (0.01)***	0.84 (0.02)***
Comparison	0.13 (0.02)	0.41 (0.04)	0.46 (0.05)

*** Significant at $p < .001$.

Note: A statistically significant estimate indicates that the difference in marginal predicted means between intervention and comparison groups is different from 0. No values were significant at $p < .05$ or $p < .01$. Analyses were performed on a set of matched samples drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The sample sizes are 1,635 for dual enrollment only, 2,864 for concurrent enrollment only, 2,600 for Advanced Placement test-taking only, and 2,505 for the combination of Advanced Placement test-taking and concurrent enrollment. Data on level of initial college enrollment were missing for 16 students who participated in dual enrollment only, 22 students who participated in concurrent enrollment only, 9 students who participated in Advanced Placement test-taking only, and 13 students who participated in the combination of Advanced Placement test-taking and concurrent enrollment. For each outcome the model included several predictors specific to each intervention group. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C14. Summary of predicted probabilities from models examining the moderating effect of math proficiency on the relationship between participation in each early college program and level of initial college enrollment, 2014/15 grade 9 cohort

	Outcome		
Intervention	No college enrollment	Two-year college enrollment	Four-year college enrollment
Dual enrollment only			
Not proficient on NECAP math			
Intervention	0.23 (0.03)**	0.42 (0.05)	0.35 (0.05)***
Comparison	0.35 (0.03)	0.47 (0.03)	0.17 (0.02)
Proficient on NECAP math			
Intervention	0.08 (0.03)**	0.38 (0.05)	0.53 (0.05)**
Comparison	0.19 (0.02)	0.43 (0.03)	0.37 (0.03)
Concurrent enrollment only			
Not proficient on NECAP math			
Intervention	0.11 (0.03)***	0.39 (0.03)*	0.61 (0.02)***
Comparison	0.28 (0.02)	0.49 (0.03)	0.38 (0.03)
Proficient on NECAP math			
Intervention	0.09 (0.01)***	0.29 (0.02)***	0.49 (0.04)***
Comparison	0.18 (0.02)	0.44 (0.02)	0.22 (0.02)
Advanced Placement test-taking only			
Not proficient on NECAP math			
Intervention	0.15 (0.03)***	0.35 (0.04)**	0.50 (0.04)***
Comparison	0.30 (0.03)	0.50 (0.03)	0.19 (0.02)
Proficient on NECAP math			
Intervention	0.06 (0.01)***	0.19 (0.02)***	0.75 (0.03)***
Comparison	0.14 (0.03)	0.40 (0.04)	0.46 (0.05)
Combination of Advanced Placement test-taking and concurrent enrollment			
Not proficient on NECAP math			
Intervention	0.09 (0.03)***	0.26 (0.05)***	0.64 (0.06)***
Comparison	0.29 (0.03)	0.47 (0.03)	0.24 (0.03)
Proficient on NECAP math			
Intervention	0.03 (0.01)***	0.10 (0.01)***	0.87 (0.01)***
Comparison	0.11 (0.02)	0.40 (0.05)	0.48 (0.06)

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the difference in marginal predicted means between intervention and comparison groups is different from 0. Analyses were performed on a set of matched samples drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The sample sizes are 1,635 for dual enrollment only, 2,864 for concurrent enrollment only, 2,600 for Advanced Placement test-taking only, and 2,505 for the combination of Advanced Placement test-taking and concurrent enrollment. Data on level of initial college enrollment were missing for 16 students who participated in dual enrollment only, 22 students who participated in concurrent enrollment only, 9 students who participated in Advanced Placement test-taking only, and 13 students who participated in the combination of Advanced Placement test-taking and concurrent enrollment. For each outcome the model included several predictors specific to each intervention group. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Academic proficiency moderation analyses with reading scores instead of math scores

Tables C15-C22 provide results from the analyses of academic proficiency at the start of high school that used grade 8 reading assessment scores instead of math scores.

Table C15. Odds ratios from models examining the moderating effect of reading proficiency on the relationship between participation in dual enrollment and college enrollment and persistence, 2014/15 grade 9 cohort

Variable	Outcome: Model 1 College enrollment	Outcome: Model 2 College persistence
Participated in dual enrollment	0.97 (0.36)	1.01 (0.36)
Hispanic	0.89 (0.14)	0.83 (0.12)
Has an Individualized Education Program	0.54 (0.09)***	0.79 (0.13)
At least proficient on NECAP reading	1.23 (0.19)	1.14 (0.17)
At least proficient on NECAP reading x intervention	2.45 (1.05)*	2.08 (0.81)

* Significant at $p < .05$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the odds ratio is different from 1. No values were significant at $p < .01$. The sample size is 1,651 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C16. Relative risk ratios from models examining the moderating effect of reading proficiency on the relationship between participation in dual enrollment and level of initial college enrollment, 2014/15 grade 9 cohort.

Variable	Outcome: Two-year college enrollment	Outcome: Four-year college enrollment
Participated in dual enrollment	0.64 (0.19)	2.68 (0.94)**
Hispanic	1.22 (0.26)	0.69 (0.18)
Has an Individualized Education Program	0.85 (0.25)	0.34 (0.11)**
At least proficient on NECAP reading	1.25 (0.27)	3.35 (1.02)***
At least proficient on NECAP reading x intervention	3.81 (1.36)***	1.42 (0.58)

** Significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the relative risk ratio is different from 1. No values were significant at $p < .05$. The sample size is 1,635 students clustered in 51 high schools in a matched sample drawn from students who were first-time grade 9 students in Rhode Island public schools in 2014/15 and graduated on time from high school in the state in spring 2018. Data on level of college enrollment were missing for 16 students. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C17. Odds ratios from models examining the moderating effect of reading proficiency on the relationship between participation in concurrent enrollment and college enrollment and persistence, 2014/15 grade 9 cohort

	Outcome	
Variable	Model 1 College enrollment	Model 2 College persistence
Participated in concurrent enrollment	3.35 (1.02)***	2.78 (0.71)***
Asian	1.37 (0.48)	1.55 (0.45)
Chronically absent	0.69 (0.07)**	0.58 (0.05)***
Took Algebra I in grade 8	1.28 (0.17)	1.37 (0.15)**
Hispanic	1.06 (0.16)	1.02 (0.14)
Black	1.30 (0.31)	1.81 (0.38)**
At least proficient on NECAP reading	1.78 (0.26)***	1.63 (0.23)**
At least proficient on NECAP reading x intervention	0.58 (0.19)	0.81 (0.22)

** Significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the odds ratio is different from 1. No values were significant at $p < .05$. The sample size is 2,886 students clustered in 51 high schools in a matched sample drawn from students who were first-time grade 9 students in Rhode Island public schools in 2014/15 and graduated on time from high school in the state in spring 2018. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C18. Relative risk ratios from models examining the moderating effect of reading proficiency on the relationship between participation in concurrent enrollment and level of initial college enrollment, 2014/15 grade 9 cohort

	Outcome	
Variable	Two-year college enrollment	Four-year college enrollment
Participated in concurrent enrollment	2.22 (0.93)	7.64 (3.13)***
Asian	1.63 (0.93)	1.27 (0.72)
Chronically absent	0.90 (0.14)	0.54 (0.08)***
Took Algebra I in grade 8	1.10 (0.18)	1.89 (0.30)***
Hispanic	1.27 (0.22)	0.79 (0.17)
Black	1.20 (0.32)	1.03 (0.28)
At least proficient on NECAP reading	1.64 (0.27)**	4.02 (0.88)***
At least proficient on NECAP reading x intervention	0.59 (0.26)	0.43 (0.20)

** Significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the relative risk ratio is different from 1. No values were significant at $p < .05$. The sample size is 2,864 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. Data on level of college enrollment were missing for 22 students. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C19. Odds ratios from models examining the moderating effect of reading proficiency on the relationship between participation in Advanced Placement test-taking and college enrollment and persistence, 2014/15 grade 9 cohort

	Outcome	
Variable	College enrollment	College persistence
Participated in Advanced Placement	3.54 (1.31)**	4.43 (1.48)***
Multilingual learner	0.60 (0.19)	1.41 (0.43)
Black	1.66 (0.41)*	1.25 (0.24)
At least proficient on NECAP reading	2.01 (0.42)***	1.85 (0.38)**
At least proficient on NECAP reading x intervention	0.72 (0.28)	0.78 (0.27)

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the odds ratio is different from 1. The sample size is 2,609 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C20. Relative risk ratios from models examining the moderating effect of reading proficiency on the relationship between participation in Advanced Placement test-taking and level of initial college enrollment, 2014/15 grade 9 cohort

	Outcome	
Variable	Two-year college enrollment	Four-year college enrollment
Participated in Advanced Placement	1.61 (0.75)	7.72 (2.99)***
Multilingual learner	0.75 (0.26)	0.42 (0.16)*
Black	1.22 (0.28)	0.93 (0.27)
At least proficient on NECAP reading	1.75 (0.39)*	6.49 (1.82)***
At least proficient on NECAP reading x intervention	0.70 (0.36)	0.49 (0.22)

* Significant at $p < .05$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the relative risk ratio is different from 1. No values were significant at $p < .01$. The sample size is 2,600 students clustered in 51 high schools in a matched sample drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. Data on level of college enrollment were missing for nine students. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C21. Odds ratios from models examining moderating effect of reading proficiency on the relationship between participation in the combination of Advanced Placement test-taking and concurrent enrollment and college enrollment and persistence, 2014/15 grade 9 cohort

Variable	Outcome: Model 1 College enrollment	Outcome: Model 2 College persistence
Participated in the combination of Advanced Placement test-taking and concurrent enrollment	8.06 (4.69)***	7.49 (3.52)***
Multilingual learner	0.94 (0.20)	0.99 (0.18)
Hispanic	0.81 (0.37)	1.67 (0.70)
At least proficient on NECAP reading	2.69 (0.82)**	2.10 (0.63)*
At least proficient on NECAP reading x intervention	0.47 (0.28)	0.99 (0.47)

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the odds ratio is different from 1. The sample size is 2,518 students clustered in 51 high schools in a matched sample drawn from students who were first-time grade 9 students in Rhode Island public schools in 2014/15 and graduated on time from high school in the state in spring 2018. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Table C22. Relative risk ratios from models examining the moderating effect of reading proficiency on the relationship between participation in the combination of Advanced Placement and concurrent enrollment and level of initial college enrollment, 2014/15 grade 9 cohort

Variable	Outcome: Two-year college enrollment	Outcome: Four-year college enrollment
Participated in the combination of Advanced Placement test-taking and concurrent enrollment	1.36 (0.59)	20.36 (13.02)***
Multilingual learner	0.93 (0.36)	0.67 (0.34)
Hispanic	1.36 (0.31)	0.46 (0.13)*
At least proficient on NECAP reading	2.53 (0.70)**	8.16 (3.25)***
At least proficient on NECAP reading x intervention	0.72 (0.38)	0.32 (0.22)

* Significant at $p < .05$; ** significant at $p < .01$; *** significant at $p < .001$.

NECAP is New England Common Assessment Program.

Note: A statistically significant estimate indicates that the relative risk ratio is different from 1. The sample size is 2,505 students clustered in 51 high schools in a matched sample drawn from students who were first-time grade 9 students in Rhode Island public schools in 2014/15 and graduated on time from high school in the state in spring 2018. All estimates are relative risk ratios. Numbers in parentheses are standard errors. Data on level of college enrollment were missing for 13 students. Statistical significance refers to a test of whether the relative risk ratio is different from 1.

Source: Authors' analysis of Rhode Island Department of Education data.

Cost and cost-effectiveness analysis

This section provides additional detail and sensitivity analyses conducted as part of the cost and cost-effectiveness analysis. Topics covered include information about early college program participation, details about the range and spread of estimated program costs, and the results of additional analyses testing the sensitivity of costs to key assumptions and estimation processes.

Tables C23 and C24 provide detailed results for the cost per outcome reported for each program in the main report.

Table C23. Detailed results of cost per student analysis, by outcome and program, 2017/18

Outcome and cost metric	Advanced Placement (AP)	Concurrent enrollment	Dual enrollment	Combination of AP and concurrent enrollment: Implemented separately	Combination of AP and concurrent enrollment: Integrated implementation
Enroll in college within one year of high school graduation					
Average unweighted annual incremental cost (dollars)	900	1,600	6,400	2,500	900
Predicted increase in probability of outcome (percentage points)	14	12	11	14	14
Incremental cost per outcome associated with an increase in probability of 5 percentage points (dollars)	300	700	2,900	900	300
Persist in college for 24 months after high school graduation					
Average unweighted annual incremental cost (dollars)	900	1,600	6,400	2,500	900
Predicted increase in probability of outcome (percentage points)	25	19	13	34	34
Incremental cost per outcome associated with an increase in probability of 5 percentage points (dollars)	200	400	2,500	400	100
Enroll in a four-year college					
Average unweighted annual incremental cost (dollars)	900	1,600	6,400	2,500	900
Predicted increase in probability of outcome (percentage points)	30	24	17	39	39
Incremental cost per outcome associated with an increase in probability of 5 percentage points (dollars)	100	300	1,900	300	100

Note: For outcome estimates the sample sizes for enrollment within one year and persistence are 1,651 students for dual enrollment, 2,886 students for concurrent enrollment, 2,609 students for AP, and 2,518 students for the combination of AP and concurrent enrollment, and the sample sizes for enrollment in a four-year college are 904 students for dual enrollment, 1,663 students for concurrent enrollment, 1,645 students for AP, and 1,699 students for the combination of AP and concurrent enrollment. For estimated costs the sample sizes are 10 local education agencies (LEAs) for dual enrollment and 7 LEAs for AP and concurrent enrollment. Estimated costs are based on incremental estimates per student at the LEA level, rounded to the nearest $100, reported in 2022 constant dollars, and discounted for present value at 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of data from the Rhode Island Department of Education and authors' calculations based on data from LEA interviews and focus groups, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

Table C24. Total early college program estimated incremental cost per local education agency (LEA), 2017/18 (dollars)

Measure	Advanced Placement (n = 7)	Concurrent enrollment (n = 7)	Dual enrollment (n = 10)
Number of students served per LEA × student incremental cost per LEA			
Median	164,300	147,400	41,900

Note: Estimated costs are based on LEA incremental estimates per student, rounded to the nearest $100, reported in 2022 constant dollars, and discounted for present value at 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

Key drivers of variation in the cost of early college programs

Differences in program models and contexts result in estimated costs per student for the early college programs that vary widely across local education agencies (LEAs). The reported estimated costs reflect average costs across a sample of diverse LEA contexts, especially with respect to specific program models and education context—for example, student populations served, school type, and locale. These differences in LEA program models and contexts help explain the variation in estimated costs across these settings. Estimated AP costs are the most sensitive to changes in class size and teacher course load, given the tendency for this program to have a larger overall number of students.[2] Although fluctuations in these factors are unlikely to change how AP costs compare with those of the other two programs, they may change AP costs enough to affect how administrators plan for implementation (see tables C29 and C30 later in the appendix).

Finally, the difference in one category of costs, program fees, is another important factor contributing to the higher cost of dual enrollment, despite the large variation in the other costs. Dual enrollment tuition and fees are paid to the public college to cover the costs associated with the student taking the course there (including instructor time, administration, and facilities use). Concurrent enrollment fees are much more modest, likely because most concurrent enrollment activities occur at the high school rather than the public college. Importantly, program fees do not vary by site within each program. For example, fees per student are the same for all dual enrollment sites (see figure 4 in the main report).

All three early college programs require more staff time for activities such as administration and student support than the business-as-usual scenario (a typical high school course)

Through the interview and focus group process the study team captured information on the personnel required to implement the early college programs. Though program staff rarely reported adding additional positions to support a particular early college program, most reported having increased staff time to implement these programs. This additional staff time may have taken place outside contract hours or in place of other activities during the workday.

For example, all three programs required additional counselor and administrator time for activities such as counseling, assisting with student registration, and data reporting. School leaders reported that AP and concurrent enrollment required additional time for teacher planning and grading to incorporate more rigorous materials and provide more frequent and advanced feedback than is typical for a comparable high school course. This incremental staff time is summarized in figure C1, organized into two broad staff categories: instructional and counseling (high school teachers and high school counselors) and administrative and clerical (all other positions). Staff time is measured in full-time equivalents (FTEs), which reflect the time spent on the activities as the share of a full-time position. For example, an FTE of 0.10 would equate to 10 percent of a full-time position, or 4 hours of a 40 hour work week.[3]

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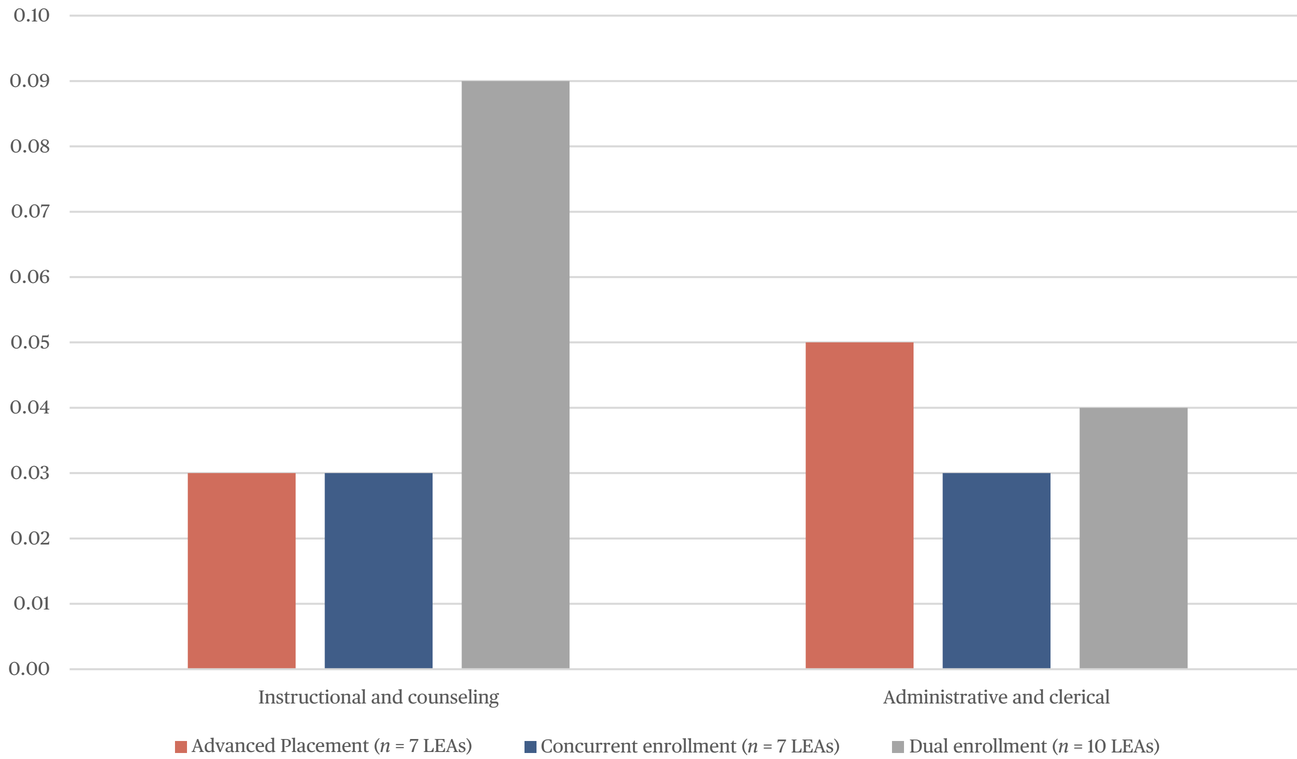
[2] For example, with 10 students there is almost certainly only one teacher and one course section regardless of what class size and teacher course load is assumed, whereas for a program with more than 800 students, whether the class size is assumed to be 20 or 25 and teacher course load is assumed to be one or two will make more of a difference.

[3] Also, estimated staff time is reported here per individual, and depending primarily on program size, the total number of individuals in a given role may be larger or smaller, resulting in differences in total staff time.

Figure C1. Additional staff time for instructional and counseling positions was higher for dual enrollment than for the other two early college programs, whereas administrative and clerical staff time was consistent across all three programs

Estimated average additional staff time per individual (full-time equivalents)



LEA is local education agency.

Note: The staff categories reflect groups defined by the role that LEAs reported. The instructional and counseling category includes high school teachers and counselors, and the administrative and clerical category includes all other identified roles, which generally consist of district and school administrative staff and clerical support. Average staff time reflects the average additional full-time equivalents beyond the time normally spent on comparable programming, reported per individual for staff in each category among LEAs in each program sample. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data.

For AP the additional time estimated for staff who held either administrative or clerical positions—an average of 0.05 FTE per individual—was slightly higher than the additional 0.03 FTE per individual estimated for staff who were either instructors or high school counselors (see figure C1). These FTEs equate to approximately one or two hours per week on average. In contrast, for concurrent enrollment, on average, administrative and clerical staff allocated the same amount of time as instructors and counselors, roughly 0.03 FTE per individual. These figures represent incremental personnel time for the steady-state implementation of these programs; interviews and focus groups suggest that estimates would be higher when a school is expanding concurrent enrollment.[4] Finally, in contrast to the other two programs, dual enrollment instructors and counselors allocated much higher amounts of time per individual on average than did administrative and clerical staff (0.09 FTE compared with 0.04 FTE).[5]

[4] The cost and personnel estimates reflect the resources required for the three programs in their steady-state implementation, not in an expansion phase. Therefore, the estimated costs do not reflect the investment required for programs to expand course offerings or partnerships with local colleges. Responses from the interviews and focus groups suggest that concurrent enrollment courses required more staff time in their first year than in later years, for activities such as developing articulation agreements with the colleges.

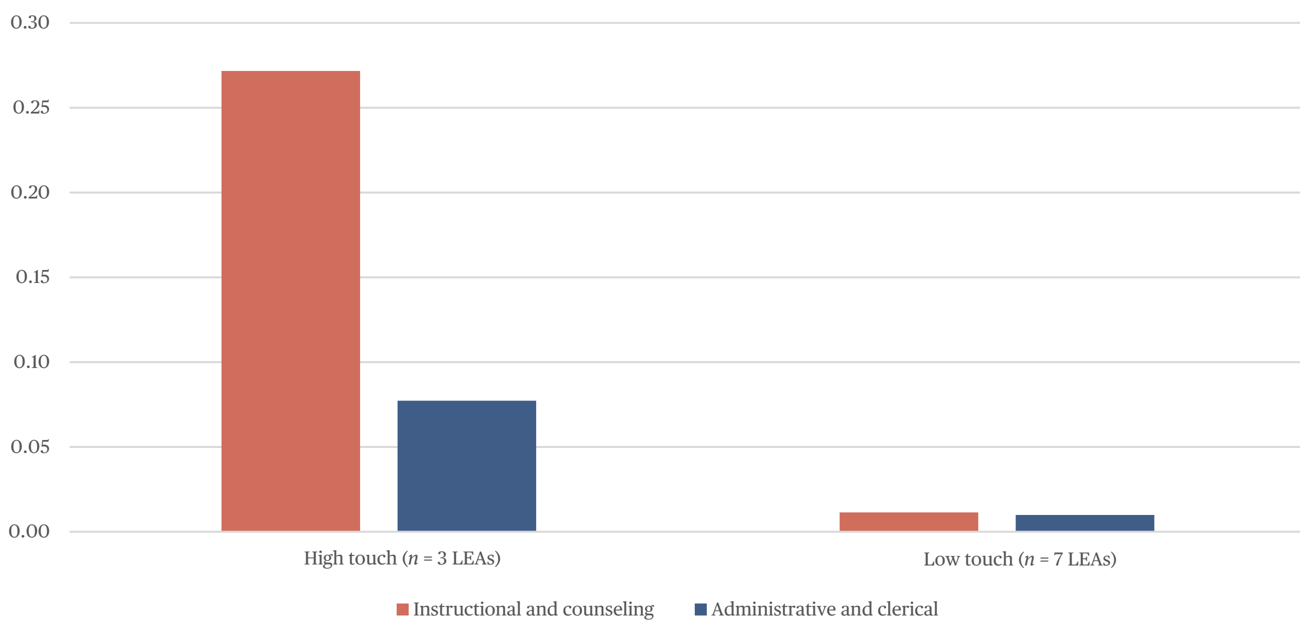
[5] For both concurrent and dual enrollment a portion of the postsecondary fees pay for staff time at the college to run the program.

For dual enrollment, unlike the other two programs, there was a wide range of K-12 personnel costs, reflecting variation in how the LEAs in the sample designed and implemented their programs. Some reported large amounts of direct staff support to participating students in addition to program administration and coordination activities, whereas others reported primarily the latter. The programs with more staff support, which are referred to here as "high-touch," include those with personnel at or above 0.05 FTE for a given individual, on average, for both types of roles. In practical terms this means that any given person working in this program role was generally working two or more hours a week on program activities and responsibilities.[6] The programs with less staff support, referred to as "low-touch," were those below the 0.05 FTE threshold.

The low-touch approach was reported in about two-thirds of the sample (seven LEAs), and the high-touch approach was reported in the remaining third (three LEAs). For low-touch LEAs average staff time per individual was 0.01 FTE for both staff groups. For high-touch LEAs average staff time per individual was much higher, at 0.08 FTE for administrative and clerical staff and 0.27 FTE for instructors and counselors (figures C2 and C3).

Figure C2. Additional staff time for dual enrollment varied by the type of program model that local education agencies (LEAs) reported, with larger allocations of time in the "high-touch" model than in the "low-touch" model across staff types

Estimated average additional staff time per individual (full-time equivalents)

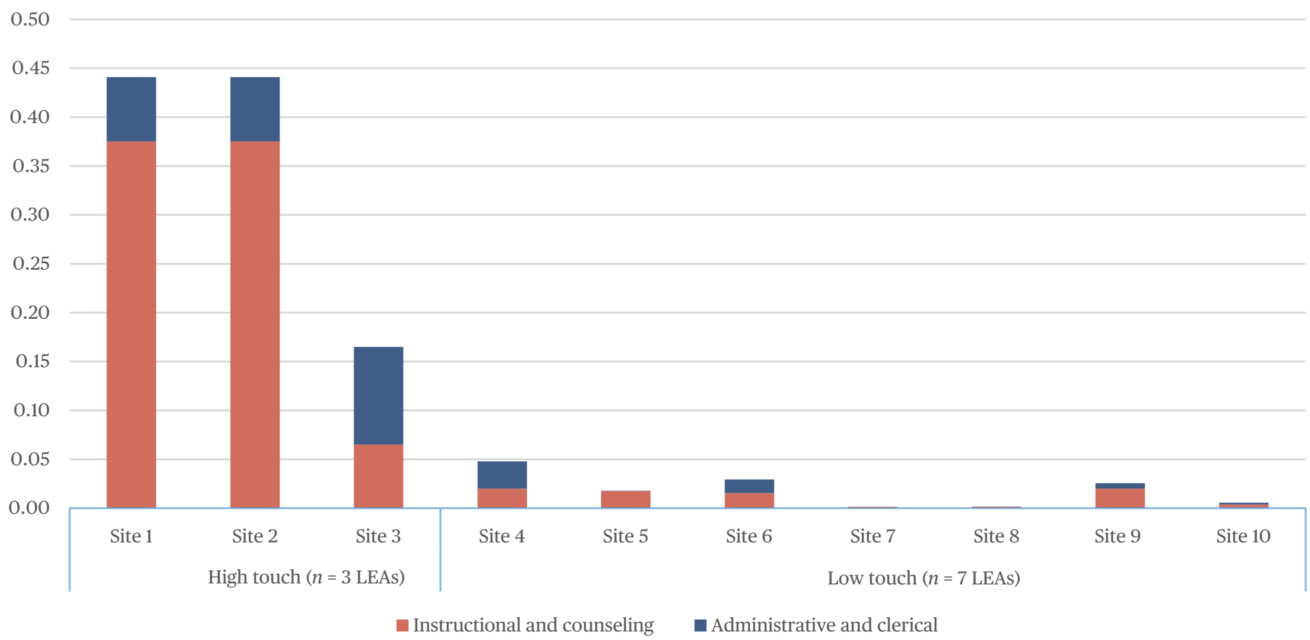


Note: The staff categories reflect groups defined by the role that LEAs reported. The instructional and counseling category includes high school teachers and counselors, and the administrative and clerical category includes all other identified roles, which generally consist of district and school administrative staff and clerical support. The program models reflect differences in program staff roles that LEAs reported, with three "high-touch" LEAs reporting more extensive additional program activities for staff and seven "low-touch" LEAs reporting more limited additional staff responsibilities. Average staff time reflects the average additional full-time equivalents reported per individual for staff in each category among LEAs in each program sample. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.
Source: Authors' analysis of LEA interview and focus group data.

[6] This threshold was determined through a holistic process that used both qualitative and quantitative data. The interview and focus group process surfaced a distinct difference between some LEAs that had minimal personnel dedicated to the program, while others applied a fair amount of staff time. Pairing this qualitative finding with the reported FTE estimates, the study team visually identified an FTE quantity where there is a practically meaningful threshold between low-touch and high-touch at 0.05 FTE (see figure C3 for reported LEA-level personnel time above and below this threshold).

Figure C3. Local education agencies (LEAs) with "high-touch" models of dual enrollment allocated more staff time to the program than agencies with "low-touch" models

Estimated average additional staff time per individual (full-time equivalents)



Note: The staff categories reflect groups defined by the role that LEAs reported. The instructional and counseling category includes high school teachers and counselors, and the administrative and clerical category includes all other identified roles, which generally consist of district and school administrative staff and clerical support. The program models reflect differences in program staff roles that LEAs reported, with three "high-touch" LEAs reporting more extensive additional program activities for staff and seven "low-touch" LEAs reporting more limited additional staff responsibilities. Average staff time reflects the average additional full-time equivalents reported per individual for staff in each category among LEAs in each program sample. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data.

Estimated personnel costs are likely not directly funded by the early college programs but nonetheless are resources required for successful implementation. Staff typically conduct these incremental activities outside of contract hours (including on the weekends and in the summer), or the activities displace other non-early college program activities (for example, a teacher whose regular teaching duties are displaced by time required to proctor an AP test). In accordance with the standard practice in cost analysis, program personnel time resulting from additional responsibilities beyond business as usual is a key type of cost.

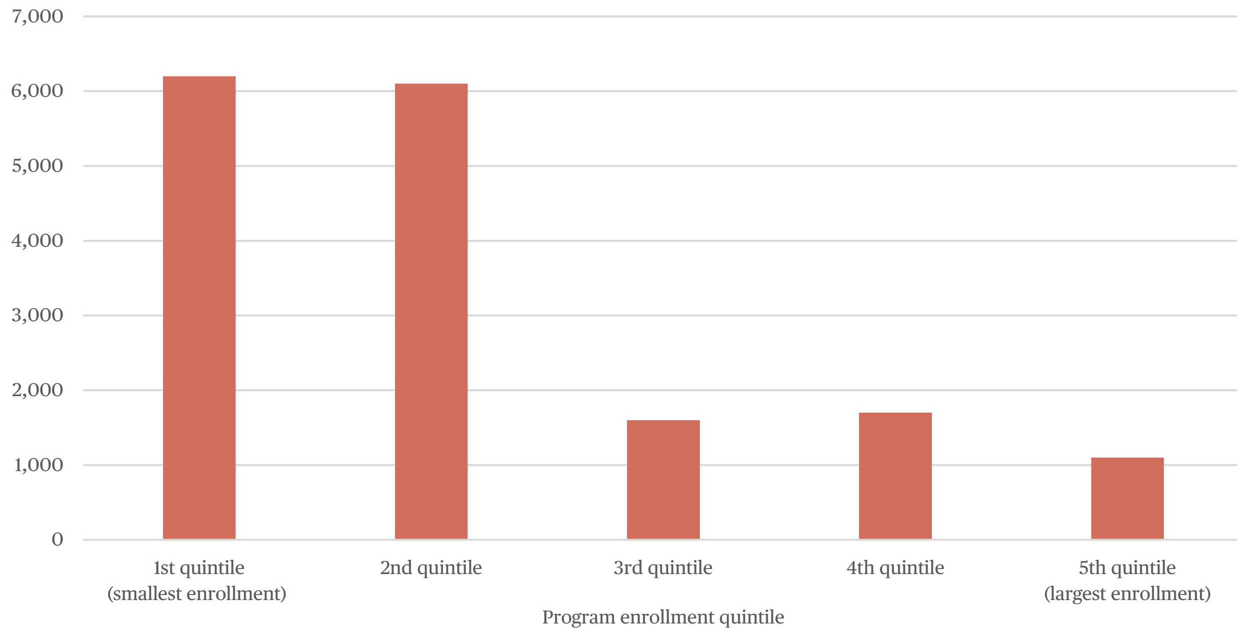
Across the three early college programs the cost per student tends to decline as programs increase in enrollment, providing suggestive evidence of economies of scale in early college programs in general

Across programs, estimated average cost per student varied systematically with the number of participants, or the program scale. Specifically, the cost per student declines as program scale increases, with a large drop in average cost for programs in the third quintile of program enrollment or higher. This result aligns with a general pattern observed in education costs: as scale increases, unit costs decline and gradually level out (Andrews et al., 2002). These results are across program types; early college program scale varied systematically across the study sample during the study period (2014/15–2017/18) (figure C4).[7]

[7] In the current study sample the smallest sizes are found in dual enrollment and the largest in AP. This pattern is observed in the overall population of LEAs providing these three programs during the study period. More balanced variation in program scale within each program type would be needed to understand trends for each program separately.

Figure C4. Program scale is a considerable source of variation in estimated average cost per student across early college programs, 2017/18

Estimated average annual incremental cost per student (dollars)



Note: The sample size is 11 local education agencies (LEAs). The size quintiles reflect counts of participating students: 1st quintile = 1-15, 2nd quintile = 16-140, 3rd quintile = 141-325, 4th quintile = 326-618, 5th quintile = 619 or more. Within each group the sample is not necessarily evenly divided across the possible range. Estimated average costs are participant-weighted averages of estimates per student at the LEA level, rounded to the nearest $100, reported in 2022 constant dollars, and discounted for present value at of 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

Additional participation and cost data

Participation in early college programs in general during the study period varied systematically by program (calculated by dividing LEA-program observations across all years of the study period into quintiles by program size and reviewing the number of LEAs in each quintile by program). Dual enrollment is generally clustered in the bottom three quintiles of program enrollment, meaning that most dual enrollment programs are small, whereas AP is more common in the top two quintiles (table C25). Concurrent enrollment is generally well represented across quintiles, with the largest concentration in the third and fourth quintiles.

Table C25. Frequency counts of local education agencies across all years of the study period, by enrollment quintile and early college program, 2014/15-2017/18

Program enrollment quintile	Advanced Placement	Concurrent enrollment	Dual enrollment
1st quintile (smallest enrollment)	7	9	11
2nd quintile	4	1	22
3rd quintile	5	11	11
4th quintile	12	15	0
5th quintile (largest enrollment)	17	9	1

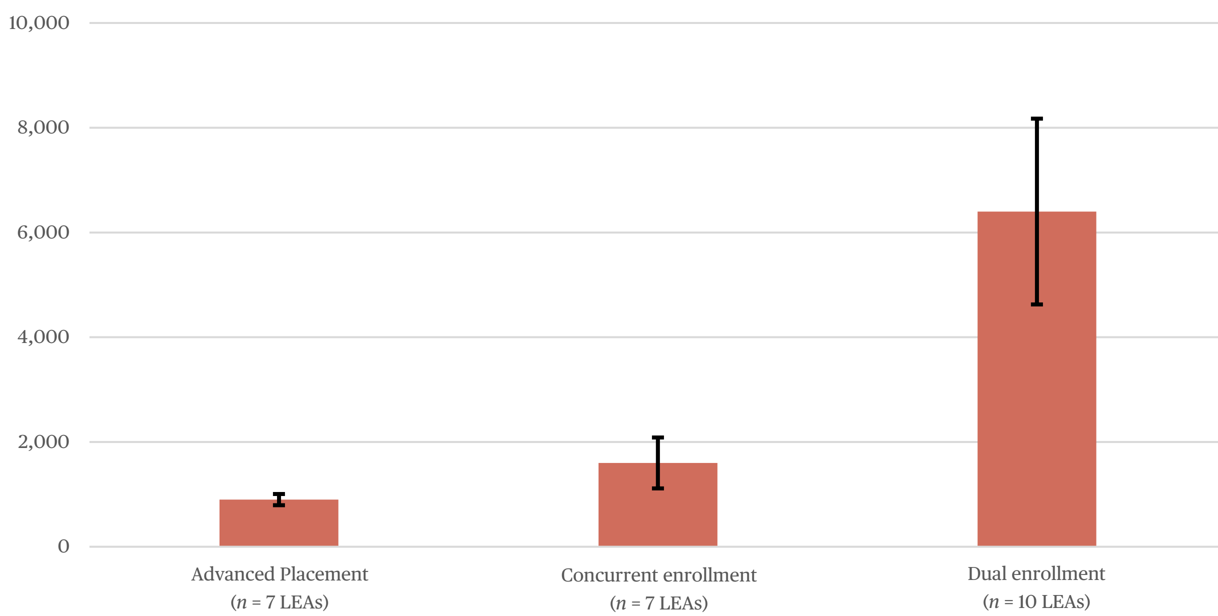
Note: 1st quintile includes programs with enrollment of 0.33-3.67 students, 2nd quintile includes programs with 4-13.33 students, 3rd quintile includes programs with 13.67-63.33 students, 4th quintile includes programs with 66-124.33 students, and 5th quintile includes programs with 131.66 .66-1,094.33 students. Student counts can contain decimals because they are averages over the study period.

Source: Authors' analysis of Rhode Island Department of Education data.

With respect to the overall estimated program costs per student, it may be helpful to consider the range of uncertainty bounding the estimated average for each program, represented by the 95 percent confidence interval. The size of the 95 percent confidence interval around the average cost is approximately $200 for AP, $1,000 for concurrent enrollment, and $3,500 for dual enrollment (figure C5). Further, no programs have overlapping confidence intervals, though the intervals for AP and concurrent enrollment are very close. The lack of overlap suggests that the true program costs likely differ in the way suggested by the averages, especially the difference between dual enrollment and the other two programs, though true average costs may be closer or farther apart than the estimates.

Figure C5. The estimated average annual costs per student for each early college program reflect different levels of uncertainty but are distinct from each other, 2017/18

Estimated average annual incremental cost per student with 95 percent confidence interval (dollars)



LEA is local education agency.

Note: Estimated average costs are unweighted averages of estimates per student at the local education agency (LEA) level, rounded to the nearest $100, reported in 2022 constant dollars, and discounted for present value at 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

Table C26 provides a breakdown of the estimated costs, showing the average share of cost per participant by resource category and program. The "other resources" category includes primarily program fees, which for AP are testing fees and for dual enrollment and concurrent enrollment are fees paid to the institution of higher education to cover personnel and other costs at the postsecondary level.

Table C26. Share of estimated average annual incremental cost per participant, by resource category and program, 2017/18 (percent)

Resource category	Advanced Placement (*n* = 7 LEAs)	Concurrent enrollment (*n* = 7 LEAs)	Dual enrollment (*n* = 10 LEAs)
Personnel	75	41	27
Equipment and materials	7	40	19
Transportation	na	na	18
Other resources	19	19	36

na is not applicable.

LEA is local education agency.

Note: The estimated average costs on which the percentages are based are unweighted averages of estimates per student at the LEA level, rounded to the nearest $100, reported in 2022 constant dollars, and discounted for present value. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program. Totals may not sum to 100 because of rounding.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

Sensitivity analysis for alternative estimation assumptions

The study team reviewed the assumptions made with respect to assigned market prices for program staff and tested alternative assumptions for key positions. Ultimately, these alternative assumptions resulted in small differences in mean program costs in standard deviation units for all programs (table C27).

Table C27. Sensitivity analysis for alternative assumptions of personnel market prices, by program, 2017/18

Alternative assumption and program	Baseline cost per student: Mean (dollars)	Baseline cost per student: Standard deviation	Alternative mean cost per student (dollars)	Difference in cost per student (standard deviation units)
Change assistant principal price from education administrators, kindergarten through secondary–25th percentile ($138,682) to education administrators, kindergarten through secondary–median ($163,505)				
Advanced Placement	944	145	951	0.04
Concurrent enrollment	1,607	656	1,610	0.01
Dual enrollment	6,405	2,861	6,406	0.00
Change director price from education administrators, kindergarten through secondary–median ($163,505) to school admin–75th percentile ($185,688)				
Advanced Placement	944	145	951	0.00
Concurrent enrollment	1,607	656	1,607	0.00
Dual enrollment	6,405	2,861	6,405	0.00

Note: The sample size is 11 local education agencies (LEAs). Estimated average costs are unweighted averages of estimates per student at the LEA level, reported in 2022 constant dollars, and discounted for present value at 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

As described in the main report, the study team removed one LEA's estimate for dual enrollment because it was an outlier, defined here as an estimate that was more than two standard deviations above or below the estimated mean program cost. Because of the large variation in LEA costs within early college programs, the study team tested the sensitivity of costs to the removal of outliers from the final estimates. The difference in estimated mean program cost resulting from removing this outlier LEA was 0.59 standard deviation and approximately $1,700 per participant (table C28). This analysis reflects the impact the outlier would have on the average if it had been included and illustrates the importance of its removal to mitigate the issue.

Table C28. Sensitivity analysis for including outliers, by program, 2017/18

Alternative assumption and program	Baseline cost per student: Mean (dollars)	Baseline cost per student: Standard deviation	Alternative mean cost per student (dollars)	Difference in cost per student (standard deviation units)
Includes outliers two standard deviations above or below the mean				
Advanced Placement	944	145	944	0.00
Concurrent enrollment	1,607	656	1,607	0.00
Dual enrollment	6,405	2,861	8,101	0.59

Note: The sample size is 11 local education agencies (LEAs). Estimated average costs are participant-weighted averages of estimates per student at the LEA level, reported in 2022 constant dollars, and discounted for present value at 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

As described above, assumed class size is based on the state average from the National Center for Education Statistics National Teacher and Principal Survey for secondary/high schools. The average class size in Rhode Island for high schools is 20.5 students. Class size may differ by school or course, so the study team tested how costs change when the assumed class size is increased or decreased by 25 percent. These changes have small impacts on cost.

When assumed class size is reduced by 25 percent to 15.375 students, the change in mean estimated cost is largest for AP—a 0.38 standard deviation increase in cost over the baseline estimate—because it has such a small range of costs across LEAs (table C29). The change is smaller for concurrent enrollment, representing a 0.14 standard deviation increase over the reported estimate. When assumed class size is increased by 25 percent to 25.625 students, costs decrease by a magnitude similar to the increase when class size is reduced. The largest decline is for AP: 0.23 standard deviation. The decline is more modest for concurrent enrollment: 0.09 standard deviation. Changing the class size assumption does not have an impact on the estimated dual enrollment cost.

These sensitivity analyses suggest that the costs of the AP program are particularly sensitive to changes in class size. As practitioners use these estimates to shape their implementation of these programs, they may consider the cost implications associated with larger or smaller classes, particularly related to personnel. Policymakers and administrators should note that the cost range shown in these sensitivity analyses shows that AP programs with low participation or underenrolled course areas may require additional funds per student because fixed resources, such as assigned teachers, are spread over fewer participants.

Table C29. Sensitivity analysis for alternative assumptions of class size, by program, 2017/18

Alternative assumption and program	Baseline cost per student: Mean (dollars)	Baseline cost per student: Standard deviation	Alternative mean cost per student (dollars)	Difference in cost per student (standard deviation units)
Assumes max class size is 25 percent smaller than the NCES average for secondary departmentalized instruction				
Advanced Placement	944	145	1,000	0.38
Concurrent enrollment	1,607	656	1,700	0.14
Dual enrollment	6,405	2,861	6,405	0.00
Assumes max class size is 25 percent larger than the NCES average for secondary departmentalized instruction				
Advanced Placement	944	145	911	-0.23
Concurrent enrollment	1,607	656	1,551	-0.09
Dual enrollment	6,405	2,861	6,405	0.00

NCES is National Center for Education Statistics.

Note: The sample size is 11 local education agencies (LEAs). Estimated average costs are participant-weighted averages of estimates per student at the LEA level, reported in 2022 constant dollars, and discounted for present value at 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

As described in the *Cost estimation process, by program and resource category* section in appendix B, the number of sections per program and per LEA were assumed by taking a conservative approach of one to two sections per teacher based on the study team's review of documentation from early years of the study period. This approach results in an assumption of 1.5 sections per teacher. Changing this assumption changes the course load for each teacher and therefore changes the number of total teachers needed to run the program. Because some costs, for example certification and training, are per teacher rather than per section, changing this assumption changes the costs. Changing this assumption has the biggest impact on programs with higher training and supplemental outside-of-classroom time for teachers.

When the assumed number of sections per teacher is changed to one, costs increase, because more teachers are needed to cover all the courses. Per teacher activities such as training and summer preparation time are multiplied over more teachers, thereby increasing costs. The increase is modest for all programs and largest for AP (1.22 standard deviation), followed by concurrent enrollment (0.06 standard deviation) and dual enrollment (0.05 standard deviation) (table C30). When the assumed number of sections per teacher is increased to two, costs decrease because fewer teachers are needed. The decline is largest for AP (0.61 standard deviation), followed by concurrent enrollment (0.03 standard deviation) and dual enrollment (0.02 standard deviation).

These sensitivity estimates suggest that the costs of these programs are responsive to changes in the number of sections offered. Increasing the number of sections per teacher (rather than adding teachers) can improve efficiencies, especially for AP. Improved efficiencies may not be possible in districts where demand for a certain subject does not exceed one class. Similarly, efficiency in some areas, such as summer planning time, may improve for only one specific course, whereas efficiency in others, such as AP training, could yield time savings for the school if a teacher teaches two different subjects.

Table C30. Sensitivity analysis for alternative assumptions of number of course sections per teacher, by program, 2017/18

Alternative assumption and program	Baseline cost per student: Mean (dollars)	Baseline cost per student: Standard deviation	Alternative mean cost per student (dollars)	Difference in cost per student (standard deviation units)
Assumes one section per teacher to estimate number of teachers				
Advanced Placement	944	145	1,122	1.22
Concurrent enrollment	1,607	656	1,647	0.06
Dual enrollment	6,405	2,861	6,537	0.05
Assumes two sections per teacher to estimate number of teachers				
Advanced placement	944	145	856	-0.61
Concurrent enrollment	1,607	656	1,587	-0.03
Dual enrollment	6,405	2,861	6,338	-0.02

Note: The sample size is 11 local education agencies (LEAs). Estimated average costs are unweighted averages of estimates per student at the LEA level, reported in 2022 constant dollars, and discounted for present value at 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates in one program.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

Transportation is a resource specific to dual enrollment. As described in appendix B, the study team set thresholds for public transportation and, for those unable to use public transportation, made assumptions about the number of miles per week per student. To demonstrate how costs change under different assumptions, the study team tested alternative assumptions about the number of times per week students need transport to the college campus and about the use of public transportation to reach the college campus. This sensitivity estimation does not impact travel estimates for concurrent enrollment, which were for specific courses at specific LEAs.

For the reported estimates, the study team assumed that dual enrollment students traveled to the college campus three days per week. The study team tested alternative assumptions of travel two and five days per week. When travel is reduced to two days per week, the total cost decreased 0.09 standard deviation from the reported estimates (table C31). Decreases will be larger in districts that are farther from public college campuses, though their overall total transportation costs will be higher. When travel is increased to five days a week, the cost increased by 0.19 standard deviation per student.

The study team also tested an alternative assumption about public transportation, extending the cutoff for passes rather than driving to schools that are 10 or fewer miles from the closest public college campus. This shift changes the estimate from being based on driving to receiving a Rhode Island Public Transit Authority pass in a handful of the study sample districts. This assumption decreases costs by an average of 0.04 standard deviation, a decrease that would be higher in schools that are close to 10 miles away from a public college (see table C31). Switching to the transit passes for schools between 5 and 10 miles from the college campus has a smaller impact than switching to a two day per week travel schedule.

Table C31. Sensitivity analysis for alternative transportation costs for dual enrollment, 2017/18

Alternative assumption	Baseline cost per student: Mean (dollars)	Baseline cost per student: Standard deviation	Alternative mean cost per student (dollars)	Difference in cost per student (standard deviation units)
Assumes 2 days per week for transportation by car	6,405	2,861	6,139	-0.09
Assumes 5 days per week for transportation by car	6,405	2,861	6,935	0.19
Extends public transit transportation radius to 10 miles	6,405	2,861	6,278	-0.04

Note: The sample size is 11 local education agencies (LEAs). Estimated average costs are unweighted averages of estimates per student at the LEA level, reported in 2022 constant dollars, and discounted for present value at 3 percent. Estimates that were two standard deviations above or below the mean for each program were considered outliers and are excluded from the reported estimates. This resulted in the removal of one LEA's estimates.

Source: Authors' analysis of LEA interview and focus group data, public price datasets, and enrollment and fee data from the Rhode Island Office of the Postsecondary Commissioner.

Reference

Andrews, M., Duncombe, W., & Yinger, J. (2002). Revisiting economies of size in American education: Are we any closer to a consensus? *Economics of Education Review, 21*(3), 245-262. https://doi.org/10.1016/S0272-7757(01)00006-1

Appendix D. Other analyses

This appendix provides the results of additional exploratory analyses. These are not intended to be central findings of the report but exploratory analyses to help readers better understand the results.

Multiyear participation: Additional analyses of dosage

The results reported in the main report classify students as intervention students if they participated in an early college program at least once. However, it is important to consider that students may participate in early college programs multiple times. Some students may take multiple courses or AP tests in the same school year, whereas other students may take multiple courses or AP tests in multiple school years. This section describes the proportion of students participating in multiple programs and presents exploratory correlational analyses of the relationship between dosage and student outcomes.

Participation in multiple courses or AP tests

Analyzing different dosages of early college programs would require the identification of a matched comparison group with adequate baseline equivalence for each dosage level, which was beyond the scope of this study. However, the study team conducted a set of exploratory correlational analyses using the existing matched samples (consisting of students experiencing any level of dosage in a given early college program and a matched comparison group with students who had not participated in any early college program). These analyses used regression models to estimate the effect of the intervention in the same form as the main analyses for this report but replaced the single indicator for participation in an early college program with two indicators: one for participation in a single course or test and one for participation in more than one course or test. Within the matched analytic samples used to estimate program impacts, it was more common for AP and dual enrollment students to participate in multiple programs, whereas the majority of concurrent enrollment participants participated in a single course (table D1).

Table D1. Participation in multiple programs in matched samples, by early college program 2014/15 grade 9 cohort

	Advanced Placement only		Concurrent enrollment only		Dual enrollment only	
Participation category	Number of students	Percent of total	Number of students	Percent of total	Number of students	Percent of total
Participated in one program	376	39	526	66	67	35
Participated in two or more programs	593	61	268	34	122	65
Total	969	100	794	100	189	100

Note: The sample is limited to intervention students included in the outcome analysis after matching.

Source: Authors' analysis of data from the Rhode Island Department of Education.

For AP and concurrent enrollment the correlational exploratory analyses found stronger positive relationships between program participation and college outcomes for students who took two or more courses or tests than for those who took a single course or test. For example, the increase in the probability of enrolling in college on time was 19 percentage points for students who took two or more concurrent enrollment courses, compared with 8 percentage points for students who took a single course. For dual enrollment the difference was more pronounced: 17 percentage points for students who took two or more dual enrollment courses, compared with no statistically significant effect for students who took a single course. The patterns were similar for the college persistence outcome. These exploratory findings suggest that early college dosage merits further study.

Dosage based on enrollment in multiple years

The timing of participation for students who participated in multiple early college programs—in a single year or over multiple years—has particular implications for the cost-effectiveness analysis (see the next section). Some students who participated in multiple programs did so over more than one year of high school. In the matched analytic samples most concurrent enrollment students (81 percent) and dual enrollment students (72 percent) completed their early college program experiences in a single year, whereas 50 percent of AP test-takers did (table D2).

Table D2. Participation in multiple years in matched samples, by early college program, 2014/15 grade 9 cohort

Participation	Advanced Placement only		Concurrent enrollment only		Dual enrollment only	
	Number of students	Percent of total	Number of students	Percent of total	Number of students	Percent of total
Participated in one year	485	50	640	81	136	72
Participated in two or more years	484	50	154	19	53	28
Total	969	100	794	100	189	100

Note: The sample is limited to intervention students included in the outcome analysis after matching.
Source: Authors' analysis of data from the Rhode Island Department of Education.

In terms of the difference the timing makes for the intervention effect estimates, a similar exploratory analysis was conducted on the matched sample, using one indicator for single-year participation (regardless of the number of courses or tests) and a second indicator for multiyear participation. Results from these multilevel logistic regression models provide suggestive evidence that additional years of participation were associated with larger positive effects on outcomes than single-year participation. For example, participating in concurrent enrollment in two or more years was associated with a 19 percentage point increase in the probability of college enrollment, compared with a 9 percentage point increase for a single year of participation. As with multicourse participation, dual enrollment in a single year had no statistically significant relationship with the outcomes, whereas more than one year of dual enrollment had positive relationships with outcomes. Because a student who participated in a program in more than one year necessarily also took more than one course or test, the similarity between the exploratory findings for multiyear participation and multiple course participation is expected.

Estimated costs of multiyear program participation

The estimated costs in the main report capture the average annual cost for the year 2017/18 to reflect the cost of one year of programming in the steady-state implementation of each early college program. This is an interpretable cost metric that gives decisionmakers an idea of the investment required per student per year. However, it may be useful to think about the estimates over the length of participation in the program rather than for a single year. This strategy is important because some students participate for more than one year (as discussed in the previous section), so an annual cost may not reflect the full cost of participation for the average student.

The average number of years of participation varied by program (table D3). The results refer to all students in the study cohort rather than only those in the matched analytic samples. For the purpose of cost estimation, the student counts were based on those who participated in a given program at all, regardless of whether they also participated in another early college program.

Table D3. Average length of participation, by program, 2014/15 grade 9 cohort

Number of years enrolled program	Any Advanced Placement (*n* = 2,857)	Any concurrent enrollment (*n* = 2,406)	Any dual enrollment (*n* = 420)
Percent of all early college program participants enrolled			
One year	44	74	82
Two years	42	25	15
Three years	12	1	3
Four years	2	na	na
Years of participation			
Mean	1.71	1.27	1.21

na is not applicable.

Note: Data on dual enrollment and concurrent enrollment for before 2014/15 were unavailable, meaning that it was not possible to determine the number of students participating in these programs for all four years of high school. The sample is limited to intervention students included in the outcome analysis after matching.

Source: Authors' analysis of data from the Rhode Island Department of Education.

The design and development stage of these early college programs during the study period presented some challenges for calculating a cost per student or a total cost over the full length of program participation. There are no consistent statewide rules that define length of participation, which varies by student, program, and site. Therefore, the time horizon of the intervention is not clearly defined. The rapid scale-up of some programs during the study period also complicates looking across the four years because costs per student appear higher in earlier years simply because the programs were in an early, small phase.

Because these costs may be of interest, the study team conducted an exploratory estimation of the cost over the typical length of participation for each program. However, because these analyses are exploratory and rely on data with the limitations described above, they are included here as supplementary analyses rather than reported in the main findings, and results should be interpreted with caution. An approximation of the cost over the average length of participation in the program can be calculated for the cost analysis sample using annual costs per student and the duplicated number of students who participated in each program in each year. The study team used the cohort data for local education agencies (LEAs) in the cost analysis sample to generate the count of students who participated in each year category (that is, one, two, three, or four years of participation) for each program and LEA. Within each year category the annual cost was multiplied by the number of students and the number of years of participation. These results were summed to generate a total cost per program that captured students' multiyear participation in each LEA and program. This total was divided by the total number of students who participated in the program across all four years to generate a new cost per student. Finally, the multiyear estimates per student for each LEA were averaged to generate unweighted program-level results (table D4).

Table D4. Incremental cost for average length of participation, by program, 2017/18 (dollars)

Measure	Advanced Placement (n = 7)	Concurrent enrollment (n = 7)	Dual enrollment (n = 10)
Incremental cost per student			
Average	1,500	1,900	7,400
Median	1,500	1,500	6,700
Standard deviation	200	700	3,100
Minimum	1,200	1,200	3,600
Maximum	1,900	2,900	12,200
Number of students served × incremental cost per student, per local education agency			
Median	263,300	174,000	41,900

Source: Authors' analysis of data from the Rhode Island Department of Education.

Understandably, the costs capturing average length of participation are higher than the annual costs for all three programs. AP has the longest average participation (1.7 years), and under the alternate multiyear assumption the cost per student increases by roughly $600, or 66 percent. The additional costs for concurrent and dual enrollment are much more modest as a percentage of the estimated annual costs because students on average do not participate in these programs for more than a year. Considering these multiyear results, AP's cost inches closer to that of concurrent enrollment because of student participation over more years.

Moderating effect of student economic disadvantage

Although this study did not include a research question about the moderating effects of student economic disadvantage, the findings led the study team to explore the topic. Given the higher cost per outcome of dual enrollment, the team was interested in whether there was any evidence that dual enrollment might have different effects for students experiencing economic disadvantage (as indicated by eligibility for the National School Lunch Program). A previous Regional Educational Laboratory Northeast & Islands study of early college programs in Rhode Island addressed this question in terms of all three early college programs taken together and found no evidence of a moderating effect (Shields et al., 2021).

A term representing the interaction between intervention status and economic disadvantage status was entered into the regression models for each program category, and predicted probabilities were estimated for each intervention-by-economic disadvantage group using marginal means, following the same methods described in appendix B for the academic proficiency moderation analyses.

Both students who are economically disadvantaged and those who are not are predicted to enroll and persist in college at higher rates if they participate in concurrent enrollment or AP (table D5). The result for dual enrollment is more nuanced. Among economically disadvantaged students, those who participate in dual enrollment have higher predicted probabilities of attaining college outcomes than nonparticipants. However, no difference was found among non-economically disadvantaged students. The sample size for non-economically disadvantaged dual enrollment participants was small (n = 71), making precise estimation more difficult.

Table D5. Summary of predicted probabilities from models examining the moderating effect of student economic disadvantage on the relationship between participation in an early college program and outcomes, by program, 2014/15 grade 9 cohort

	Outcome	
Intervention and economic disadvantage status	College enrollment	College persistence
Advanced Placement test-taking only		
Not eligible for NSLP		
Intervention (*n* = 609)	0.89 (0.02)***	0.80 (0.02)***
Comparison (*n* = 832)	0.79 (0.02)	0.58 (0.03)
Eligible for NSLP		
Intervention (*n* = 360)	0.89 (0.02)***	0.76 (0.03)***
Comparison (*n* = 808)	0.74 (0.02)	0.51 (0.03)
Concurrent enrollment only		
Not eligible for NSLP		
Intervention (*n* = 523)	0.88 (0.02)***	0.76 (0.02)***
Comparison (*n* = 1,097)	0.77 (0.02)	0.56 (0.02)
Eligible for NSLP		
Intervention (*n* = 271)	0.79 (0.03)***	0.62 (0.03)***
Comparison (*n* = 995)	0.67 (0.02)	0.47 (0.02)
Dual enrollment only		
Not eligible for NSLP		
Intervention (*n* = 71)	0.85 (0.04)	0.74 (0.06)
Comparison (*n* = 610)	0.79 (0.02)	0.60 (0.03)
Eligible for NSLP		
Intervention (*n* = 118)	0.75 (0.05)*	0.57 (0.06)*
Comparison (*n* = 852)	0.63 (0.03)	0.46 (0.03)
Combination of Advanced Placement test-taking and concurrent enrollment		
Not eligible for NSLP		
Intervention (*n* = 753)	0.96 (0.01)***	0.92 (0.01)***
Comparison (*n* = 760)	0.84 (0.02)	0.60 (0.03)
Eligible for NSLP		
Intervention (*n* = 268)	0.88 (0.02)***	0.81 (0.03)***
Comparison (*n* = 737)	0.71 (0.03)	0.48 (0.03)

* Significant at $p < .05$; *** significant at $p < .001$.

NSLP is National School Lunch Program.

Note: A statistically significant estimate indicates that the difference in marginal predicted means between intervention and comparison groups is different from 0. No values were significant at $p < .01$. Analyses were performed on a set of matched samples drawn from first-time grade 9 students in Rhode Island public schools in 2014/15 who graduated on time from high school in the state in spring 2018. The sample sizes are 2,609 students for Advanced Placement test-taking only, 2,886 students for concurrent enrollment only, 1,651 students for dual enrollment only, and 2,518 students for the combination of Advanced Placement test-taking and concurrent enrollment. For each outcome the model included several predictors specific to each intervention group. Numbers in parentheses are standard errors.

Source: Authors' analysis of Rhode Island Department of Education data.

Nonresponse bias analysis (cost and cost-effectiveness analysis)

Because cost data could not be collected for the entire target population of the cost analysis, a nonresponse bias analysis was conducted. LEAs in the study population were initially categorized into profiles defined primarily by their locale (see appendix B). Excluding the one outlier LEA,[8] of the 32 LEAs from which the collection of cost data was attempted, 11 ultimately participated in the data collection process–an overall sample response rate of 34.4 percent, with rates within programs and LEA locale profiles ranging from 8.3 percent to 38.5 percent (table D6). Because of the low response, taking a closer look at the analytic sample relative to the target population is important for assessing whether the sample varies with respect to key covariates from the population.

Table D6. Local education agency (LEA) counts and sample response rates for the cost and cost-effectiveness analysis, by program and locale profile, 2022/23

Program and locale profile	Number of LEAs from which the study team attempted to collect data	Number of LEAs from which data were collected	Response rate (percent)
Advanced Placement	28	7	25.0
Urban core	9	1	11.1
Suburban	14	5	35.7
Rural	5	1	20.0
Concurrent enrollment	30	7	23.3
Urban core	12	1	8.3
Suburban	13	5	38.5
Rural	5	1	20.0
Dual enrollment	30	10	33.3
Urban core	12	4	33.3
Suburban	14	5	35.7
Rural	4	1	25.0
Any early college program	32	11	34.4

Source: Authors' analysis of Rhode Island Department of Education data.

To assess the extent of bias resulting from the level of nonresponse, the study team identified five key covariates likely to be associated with program costs. These included average LEA student demographics among high schools that reflect distinct subgroups of students with unique and greater needs, and as a result, distinct resource needs. Also included is the average LEA student-teacher ratio among high schools, a reflection of the overall investment in personnel resources, which is very likely relevant to the use of personnel resources for early college programs. Institute of Education Sciences (2020) guidance suggests that a difference of 0.05 standard deviation between the mean for the target population and the mean for the final analytic sample suggests the presence of bias.

The results of the nonresponse bias analysis suggest that for several key covariates, bias is likely to be present if the results are assumed to reflect the overall target population. Differences are especially significant for the mean percentages of students eligible for the National School Lunch Program and of students of color, which show large differences across all three programs and within several profiles. In general, the sample tends to reflect LEAs serving smaller percentages of students eligible for the National School Lunch Program and larger percentages of students of color across all programs. Moreover, student-teacher ratios tend to be lower in the

[8] This outlier was excluded because it had an estimated cost per student that was more than two standard deviations above the sample mean.

study sample than in the population, with one notable exception being comparisons within the rural LEA profile across all three programs.

Table D7. Results of the nonresponse bias analysis for Advanced Placement primary cost data collection, by local education agency (LEA) locale profile and covariate

Locale profile and covariate	Mean for LEAs with data on cost per participant[a]	Mean for target population (standard deviation)	Difference (standard deviation units)
Urban core			
Eligible for the National School Lunch Program (percent)	0.36	0.49 (0.17)	-0.79
Multilingual learners (percent)	0.06	0.09 (0.09)	-0.38
Students with an Individualized Education Program (percent)	0.19	0.19 (0.04)	0.10
Students of color (percent)	0.69	0.44 (0.27)	0.94
Student-teacher ratio	11.88	13.14 (1.44)	-0.88
Number of LEAs	1	14	
Suburban			
Eligible for the National School Lunch Program (percent)	0.16	0.2 (0.14)	-0.30
Multilingual learners (percent)	0.02	0.02 (0.02)	-0.05
Students with an Individualized Education Program (percent)	0.15	0.15 (0.03)	-0.05
Students of color (percent)	0.85	0.81 (0.19)	0.22
Student-teacher ratio	12.19	12.58 (1.94)	-0.20
Number of LEAs	5	19	
Rural			
Eligible for the National School Lunch Program (percent)	0.13	0.14 (0.04)	-0.15
Multilingual learners (percent)	0.00	0.03 (0.06)	-0.44
Students with an Individualized Education Program (percent)	0.13	0.14 (0.04)	-0.26
Students of color (percent)	0.91	0.89 (0.07)	0.33
Student-teacher ratio	12.83	10.77 (3.13)	0.66
Number of LEAs	1	5	
Overall			
Eligible for the National School Lunch Program (percent)	0.18	0.3 (0.21)	-0.56
Multilingual learners (percent)	0.02	0.05 (0.07)	-0.40
Students with an Individualized Education Program (percent)	0.15	0.16 (0.04)	-0.19
Students of color (percent)	0.84	0.68 (0.28)	0.56
Student-teacher ratio	12.24	12.55 (2.04)	-0.15
Number of LEAs	7	38	

a. Excludes one LEA because its estimate was considered an outlier (it was two standard deviations above the sample mean).
Source: Authors' analysis of data from National Center for Education Statistics (2018).

Table D8. Results of the nonresponse bias analysis for concurrent enrollment primary cost data collection, by local education agency (LEA) locale profile and covariate

Locale profile and covariate	Mean for LEAs with data on cost per participant[a]	Mean for target population (standard deviation)	Difference (standard deviation units)
Urban core			
Eligible for the National School Lunch Program (percent)	0.36	0.51 (0.19)	-0.81
Multilingual learners (percent)	0.06	0.09 (0.09)	-0.38
Students with an Individualized Education Program (percent)	0.19	0.19 (0.04)	0.10
Students of color (percent)	0.69	0.44 (0.27)	0.94
Student-teacher ratio	11.88	13.08 (1.5)	-0.80
Number of LEAs	1	16	
Suburban			
Eligible for the National School Lunch Program (percent)	0.16	0.16 (0.08)	-0.03
Multilingual learners (percent)	0.02	0.02 (0.01)	-0.10
Students with an Individualized Education Program (percent)	0.15	0.15 (0.02)	-0.08
Students of color (percent)	0.85	0.86 (0.07)	-0.12
Student-teacher ratio	12.19	12.26 (1.59)	-0.05
Number of LEAs	5	17	
Rural			
Eligible for the National School Lunch Program (percent)	0.13	0.14 (0.04)	-0.15
Multilingual learners (percent)	0.00	0.03 (0.06)	-0.44
Students with an Individualized Education Program (percent)	0.13	0.14 (0.04)	-0.26
Students of color (percent)	0.91	0.89 (0.07)	0.33
Student-teacher ratio	12.83	10.77 (3.13)	0.66
Number of LEAs	1	5	
Overall			
Eligible for the National School Lunch Program (percent)	0.18	0.31 (0.22)	-0.58
Multilingual learners (percent)	0.02	0.05 (0.07)	-0.40
Students with an Individualized Education Program (percent)	0.15	0.17 (0.04)	-0.44
Students of color (percent)	0.84	0.69 (0.28)	0.53
Student-teacher ratio	12.24	12.41 (1.9)	-0.09
Number of LEAs	7	38	

a. Excludes one LEA because its estimate was considered an outlier (it was two standard deviations above the sample mean).

Source: Authors' analysis of data from National Center for Education Statistics (2018).

Table D9. Results of the nonresponse bias analysis for dual enrollment primary cost data collection, by local education agency (LEA) locale profile and covariate

Locale profile and covariate	Mean for LEAs with data on cost per participant[a]	Mean for target population (standard deviation)	Difference (standard deviation units)
Urban core			
Eligible for the National School Lunch Program (percent)	0.52	0.55 (0.19)	-0.13
Multilingual learners (percent)	0.05	0.09 (0.08)	-0.50
Students with an Individualized Education Program (percent)	0.15	0.18 (0.05)	-0.66
Students of color (percent)	0.44	0.38 (0.28)	0.21
Student-teacher ratio	12.99	12.93 (1.48)	0.04
Number of LEAs	4	18	
Suburban			
Eligible for the National School Lunch Program (percent)	0.12	0.18 (0.11)	-0.51
Multilingual learners (percent)	0.01	0.02 (0.01)	-0.53
Students with an Individualized Education Program (percent)	0.14	0.15 (0.02)	-0.33
Students of color (percent)	0.86	0.84 (0.13)	0.13
Student-teacher ratio	12.13	12.4 (1.57)	-0.17
Number of LEAs	5	19	
Rural			
Eligible for the National School Lunch Program (percent)	0.13	0.14 (0.05)	-0.12
Multilingual learners (percent)	0.00	0.00 (0.00)	0.00
Students with an Individualized Education Program (percent)	0.13	0.13 (0.02)	-0.01
Students of color (percent)	0.91	0.92 (0.01)	-0.67
Student-teacher ratio	12.83	12.14 (0.77)	0.90
Number of LEAs	1	4	
Overall			
Eligible for the National School Lunch Program (percent)	0.29	0.33 (0.24)	-0.19
Multilingual learners (percent)	0.03	0.05 (0.07)	-0.32
Students with an Individualized Education Program (percent)	0.14	0.16 (0.04)	-0.42
Students of color (percent)	0.70	0.65 (0.31)	0.15
Student-teacher ratio	12.54	12.6 (1.47)	-0.04
Number of LEAs	10	41	

a. Excludes one LEA because its estimate was considered an outlier (it was two standard deviations above the sample mean).
Source: Authors' analysis of data from National Center for Education Statistics (2018).

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