What factors predict CS student outcomes?

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External Review

To ensure that this report's contents are rigorous, accurate, and useful to educators and policymakers with varying levels of background knowledge, IWERC solicits feedback from experts. We thank the following reviewers of this report:

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The State of Computer Science in Illinois High Schools Series
Part 4 - What factors predict CS student outcomes?

The purpose of **The State of Computer Science in Illinois High Schools Series** is to analyze the landscape, structures, and pathways of computer science (CS) education in Illinois and to create a baseline by which to measure the expansion of CS education in the coming years. Beginning in the 2023-2024 school year, all districts in the state that serve grades 9-12 must offer every student the opportunity to enroll in a CS course.[1] Because not all districts in the state had CS offerings before this school year, it is imperative we measure capacity for, access to, participation in, and experiences in CS education (i.e., CAPE framework[2,3]) before and after the mandate went into effect. Analyzing trends through the lens of the CAPE framework will highlight progress while identifying existing gaps in providing equitable access and outcomes for all students. The first report of this Series provided an overview of the CS education landscape in the state by analyzing overall participation trends and details about the most enrolled CS courses.[4] The second report analyzed the CS student body, focusing on students from historically marginalized backgrounds, including trends of their participation in general and rigorous coursework and course outcomes.[5] The third report uncovered the characteristics and assignability patterns of high school CS teachers (i.e., how qualified CS teachers are staffed to certain CS courses) to assess the state's capacity to deliver equitable CS education.[6] In this fourth installment of the Series, we investigate the factors predicting student learning outcomes and continued enrollment in CS courses.

Part 4 of The Series

Part 4 of the Series expands upon previous reports that detailed participation trends (Part 1), student demographics (Part 2), and teacher workforce characteristics (Part 3). Specifically, Part 4 examines how student-, teacher-, and course-related factors are associated with disparities in students' outcomes during the 2017-2018 and 2021-2022 school years (labeled as SY 2018 and SY 2022, respectively). Examining disparities in students' learning outcomes across multiple levels helps to identify characteristics and conditions associated with improved learning outcomes in high school CS courses and areas in need of improvement. In this report, we consider student learning outcomes using two measures: (1) students' likelihood of receiving a passing grade in their CS course(s), and (2) their enrollment in a subsequent CS course. This dual measure approach is important because academic outcomes and continued participation reflect distinct but equally meaningful dimensions of students' experiences in CS. While a passing grade indicates mastery of course content, enrolling in a second course signals students' sustained interest, identity development, and access to long-term CS pathways.[a]

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[a] We acknowledge that grades may not be the best indicator for students' knowledge given schools' and districts' varying use of grades. However, no standardized CS test exists that all CS students take. Final course grade was the one common measure we could use as an outcome for nearly all CS students in our dataset. Moreover, we view continuation to subsequent elective CS courses as an indirect indicator of learning which implies a student had enough knowledge and prior success in a previous course to enroll in a second CS course.

Data & Analysis

Consistent with previous reports in this Series, we analyze student coursework data provided by the Illinois State Board of Education (ISBE) for every Illinois high school student who enrolled in at least one CS course between SY 2018 and SY 2022. These data include student characteristics (e.g., gender, race/ethnicity, free or reduced-price lunch eligibility, etc.), CS course characteristics (e.g., course level, type), and corresponding teacher characteristics (e.g., race/ethnicity, professional licensure, CS endorsement, etc.). In this report, we adhere to ISBE and statewide longitudinal data systems disclosure-proofing best practices and round all reported values to the nearest whole number.[7]

The main analyses in this report were conducted using multilevel modeling (MLM), along with descriptives to better understand the population. MLM allows us to assess how student-level characteristics (e.g., gender, race/ethnicity, income status, year in school, etc.), teacher-level characteristics (e.g., licensure, endorsements, race/ethnicity), course-level factors (e.g., course type and rigor), and district differences are associated with student outcomes, both independently and through cross-level interactions.

To examine these relationships, we developed two research questions–each focusing on a different outcome of interest:

1. What factors predict the likelihood of students receiving a passing grade in their CS course when accounting for specific courses, course type, and district characteristics?
2. What factors predict the likelihood of students enrolling in a second CS course when accounting for course and district characteristics?

We believe answering these research questions will help us identify malleable factors related to student learning outcomes that can inform policy and are of interest to Illinois policy discussions surrounding CS education. Factors such as CS endorsement status, teacher diversity, and course characteristics are all aspects that could be related to student outcomes and also aspects that can be changed to better support students (i.e., support for more endorsed teachers, hiring and endorsing teachers of color, and offering various levels of CS coursework). Certainly, non-malleable factors that could relate to student learning outcomes (e.g., race/ethnicity, socioeconomic status, etc.) are of interest as well, but relationships with these factors would suggest a need for more support for certain student populations rather than a claim about the student populations themselves.

We detail the models used to answer the research questions (RQs) below.

Predicting the likelihood of students receiving a passing grade in their CS course

This research question is designed to examine the factors associated with students receiving a passing grade.[b] This analysis builds on, but differs significantly from, the analysis presented in Part 2 of this report series. Part 2 of this report series unveiled disparities in CS outcomes at the student level using descriptive statistics and single-level logistic regression models.[5] We examine RQ1 using three sets of multilevel models. The **overall model** estimates the likelihood that a student receives a passing grade statewide, based on student, teacher, and course characteristics. The second set of models focused on the seven most-enrolled courses, showing the relationship between students receiving a passing grade and teacher and student characteristics within specific course contexts – we call this the **course model** set. The third model, or **district model**, added a district random effect to the course model, allowing us to account for district-level variation and estimate how district-level factors relate to students' CS outcomes. In other words, the overall model tells us how different factors relate to outcomes controlling for course type for the "average" CS course; the course model tells us which specific courses are driving any observed relationships in the overall model; and the district model tells us how different factors relate to outcomes controlling for observed district characteristics. Forgoing either set of controls - course or district - could result in omitted variable bias. Since we cannot include all variables and controls in one model, we run them separately to find consistent patterns (and inconsistent ones). For a more detailed explanation of the models used for this research question, see the Supplemental Materials for Part 4.

Predicting the likelihood of students enrolling in a second CS course

This research question helps us understand which factors predicted whether students enrolled in two or more CS courses during their high school career. Previously, in our first report, we found that about 17.5% of CS students enrolled in two or more CS courses while in high school.[4] Now, we build on that finding by analyzing how student, teacher, and course characteristics (of a student's first course) predict a student's likelihood of taking a second CS course. Ultimately, RQ2 helps us identify key predictors that can support encouraging students to continue enrolling in CS coursework. We examined RQ2 using two complementary multilevel models of two cohorts of student data. The **overall model** estimated the likelihood that a student would take a second CS course anywhere in the state, based on student, teacher, and course characteristics for the specific course students took as their first CS course. This gives us an overall picture of the factors linked to continuation while controlling for course type, but it does not account for differences between districts. The second model, the **district model**, added a district random effect, which allowed us to compare students within the same district and see how continuation patterns vary once district context is considered. Together, these models show both the statewide associations and the ways in which district context is associated with student continuation in CS. Similar to the first research question, forgoing the district controls could result in omitted variable bias. Again, since we cannot include all variables and controls in one model, we run them separately to

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[b] In this analysis, passing grades included A, B, C (including +/-) and failing grades included D, F, W (withdraw), WP (withdraw with credit; including +/-). See the Supplemental Materials for the Series on rationale for these grade categorizations.

find consistent patterns (and inconsistent ones). However, for this research question, a course model is not possible because the specific course that was a student's first CS course is already accounted for in the overall model, unlike the first research question wherein the overall model was for the "average" CS course. For a more detailed explanation of the models used for this research question, see the Supplemental Materials for Part 4.

We use terms such as *predict*, *likelihood*, and *associate* when discussing our findings. We emphasize that the findings are **not causal**. The models rely on statewide coursework records for all students between SY 2018 and SY 2022, representing an observational, population-level snapshot. Although our data include naturally occurring comparison groups (e.g., students who were taught by endorsed vs. non-endorsed teachers), the models do not support causal inference because we lack other sources of variation (e.g., school policies, peer support, etc.) nor did we use a quasi-experimental design. Consequently, this study should be viewed as exploratory and descriptive rather than causal. The associations or relationships reported here represent an essential foundation for generating hypotheses and informing future research designed to draw causal conclusions.

Detailed model estimates for research questions, along with corresponding statistics, are included in the Supplementary Materials. We also provide a full list of the state course codes used in the current analysis, along with additional information on the data sources.

What factors predict the likelihood of students receiving a passing grade in their CS course when accounting for specific courses, course type, and district characteristics?

Part 2 of this Series found significant disparities in CS passing rates for many historically marginalized groups. Specifically, Black/African American students, low-income students, students with English Learner status, and students with disabilities had among the lowest passing rates (less than 70%) compared to their peers who were over 80% passing.[5] This initial analysis, while enlightening, did not consider other factors that may also be associated with varying pass rates. As such, this present analysis incorporates student, teacher, course, and district factors to get a fuller picture of student experiences of achievement in the classroom. Below, we present the descriptive and inferential findings (Tables 1-3) and then move to a discussion of these findings, including the relationships observed between the likelihood of receiving a passing (or failing) grade in a CS course and student, teacher, course, and district factors.

Table 1 shows the descriptive snapshot for SY 2022 of all CS students who received a passing or failing grade in their CS course.

Table 1. Percentage of students receiving a failing or passing grade in CS courses by student, teacher, and course characteristics across all CS courses and all districts (SY 2022).

Student Characteristics	Failing (%)	Passing (%)	Teacher Characteristics	Failing (%)	Passing (%)
Female	17%	83%	Female	18%	82%
Male	18%	82%	Male	18%	82%
AIAN	19%	81%	AIAN	23%	77%
Asian	8%	92%	Asian	16%	84%
Black/African American	29%	71%	Black/African American	26%	74%
Hispanic/Latino	24%	76%	Hispanic/Latino	25%	75%
NHPI	6%	94%	NHPI	5%	95%
Two or More Races	17%	83%	Two or More Races	21%	79%
White	12%	88%	White	16%	84%
EL	31%	69%	CTE licensure	17%	83%
Non-EL	17%	83%	PEL	18%	82%
IDEA	30%	70%	CS Endorsed Teacher	16%	84%
Non-IDEA	16%	84%	Non-CS Endorsed Teacher	20%	80%
FRL	26%	74%	**Course Characteristics**	Failing (%)	Passing (%)
Non-FRL	12%	88%	Remedial Course	18%	82%
Grade 9	18%	82%	General Course	21%	79%
Grade 10	18%	82%	Enriched Course	20%	80%
Grade 11	18%	82%	Honors Course	12%	88%
Grade 12	18%	82%	AP Course	13%	87%
Dual Credit	13%	87%	CTE Course	16%	84%
Overall	**18%**	**82%**			

Note: AIAN refers to American Indian or Alaska Native. NHPI refers to Native Hawaiian or Other Pacific Islander. EL refers to English learners. IDEA refers to Individuals with Disabilities Education Act, or students with disabilities. FRL refers to students eligible for free or reduced-priced lunch. PEL refers to Professional Educators License. CTE refers to Career and Technical Education. AP refers to Advanced Placement courses.

Table 2 shows the descriptive snapshot for SY 2022 of all CS students who received a passing or failing grade for the seven most enrolled CS courses. Notably, Computer Operations and Programming II has the highest passing rate (89%), while Computer Programming has the lowest percentage of students passing (77%), suggesting challenges in student outcomes despite its popularity of enrolling more than 14,000 students annually.[4] More detail about these seven courses and their enrollment patterns are discussed in Part 1 of this Series.[4]

Table 2. Percentage of students receiving a failing or passing grade for the seven most enrolled CS courses (SY 2022).

CS Course	Failing (%)	Passing (%)
AP Computer Science A	13%	87%
AP Computer Science Principles	14%	86%
Computer Programming	23%	77%
Computer Operations and Programming I	14%	86%
Computer Operations and Programming II	11%	89%
Web Page and Interactive Media Development I	18%	82%
Web Page and Interactive Media Development II	16%	84%
Overall	**18%**	**82%**

Table 3 shows the outcomes of the overall, course, and district models created for this research question.

Table 3. Estimated coefficients for the overall model, district model, and course model of student pass rates in CS (SY 2022).

		Computer Programming		**AP CS A**		**AP CS P**		**Webpage and Media Development I**		**Webpage and Media Development II**		**Computer Operation and Programming I**		**Computer Operation and Programming II**	
	Overall model	Course model	District model	Course model	District model	Course model	District model	Course model	District model	Course model	District model	Course model	District model	Course model	District model
(Intercept)	2.552 (0.181)***	2.012 (0.333)***	2.020 (0.363)***	2.240 (0.681)**	2.399 (0.636)***	5.478 (1.024)***	5.517 (1.055)***	3.411 (0.487)***	3.437 (0.488)***	2.808 (0.740)***	2.194 (0.701)**	2.677 (0.476)***	2.693 (0.462)***	4.758 (0.918)*	-
Student characteristics															
Female	0.252 (0.038)***	0.326 (0.058)***	0.333 (0.058)***	-0.028 (0.117)	-0.041 (0.116)	0.058 (0.175)	0.060 (0.177)	0.117 (0.122)	0.111 (0.123)	0.499 (0.276)	0.522 (0.270)	0.193 (0.175)	0.185 (0.174)	1.161 (5.958)	-
AIAN	-0.463 (0.269)	-0.650 (0.442)	-0.633 (0.441)	-0.021 (0.846)	-0.008 (0.831)	-	-	0.434 (1.079)	-	-	-	-2.906 (0.712)***	-2.864 (0.705)***	-	-
Asian	0.382 (0.059)***	0.327 (0.131)*	0.300 (0.129)*	0.346 (0.141)*	0.33 (0.138)*	0.465 (0.214)*	0.483 (0.222)*	0.458 (0.200)*	0.400 (0.205)	-0.191 (0.431)	-0.104 (0.421)	0.532 (0.217)*	0.580 (0.216)**	-2.847 (3.032)	-
Black/ African American	-0.791 (0.048)***	-0.905 (0.095)***	-0.863 (0.096)***	-1.042 (0.174)***	-1.019 (0.175)***	-0.788 (0.257)**	-0.77 (0.262)**	-0.687 (0.133)***	-0.664 (0.133)***	-0.741 (0.283)**	-0.699 (0.277)*	-0.781 (0.176)***	-0.774 (0.175)***	-0.55 (5.207)	-
Hispanic/ Latino	-0.482 (0.041)***	-0.422 (0.084)***	-0.397 (0.085)***	-0.608 (0.138)***	-0.616 (0.138)***	-0.740 (0.189)***	-0.716 (0.193)***	-0.536 (0.103)***	-0.545 (0.103)***	-0.579 (0.215)**	-0.539 (0.210)*	-0.381 (0.144)**	-0.383 (0.144)**	-0.969 (5.332)***	-
NHPI	0.743 (0.476)	0.052 (0.510)	0.084 (0.503)	-	-	-	-	-	-	-	-	-	-	-	-
Two or More Race	-0.372 (0.084)***	-0.504 (0.160)**	-0.485 (0.159)**	-0.075 (0.256)	-0.058 (0.252)	0.136 (0.429)	0.148 (0.441)	-0.290 (0.189)	-0.281 (0.188)	-0.488 (0.458)	-0.481 (0.449)	-0.363 (0.271)	-0.360 (0.268)	1.081 (4.116)	-
FRL	-0.432 (0.028)***	-0.216 (0.058)***	-0.212 (0.058)***	-0.369 (0.111)***	-0.401 (0.111)***	-0.257 (0.149)	-0.253 (0.151)	-0.565 (0.080)***	-0.555 (0.080)***	-0.668 (0.166)***	-0.614 (0.162)***	-0.746 (0.113)***	-0.755 (0.113)***	-0.492 (3.261)***	-
Year in School	-0.021 (0.020)	0.021 (0.025)	0.021 (0.025)	-0.124 (0.052)*	-0.119 (0.052)*	0.006 (0.063)	0.002 (0.064)	0.007 (0.035)	0.003 (0.035)	-0.046 (0.081)	-0.024 (0.080)	-0.090 (0.049)	-0.088 (0.049)	0.584 (1.430)	-
IDEA	-0.552 (0.035)***	-0.571 (0.058)***	-0.581 (0.059)***	-1.016 (0.185)***	-1.024 (0.189)***	-0.783 (0.268)**	-0.780 (0.269)**	-0.652 (0.102)***	-0.659 (0.101)***	-0.293 (0.200)	-0.323 (0.196)	-0.613 (0.140)***	-0.598 (0.138)***	-0.278 (4.816)***	-
EL	-0.300 (0.050)***	-0.242 (0.064)***	-0.247 (0.065)***	-0.891 (0.181)***	-0.914 (0.184)***	-0.257 (0.265)	-0.255 (0.266)	-0.397 (0.142)**	-0.393 (0.141)**	-0.462 (0.274)	-0.459 (0.268)	-0.445 (0.207)*	-0.443 (0.205)*	1.149 (7.279)	-
Dual Credit Enrollment	0.189 (0.117)	-	-	0.375 (0.787)	0.375 (0.872)	0.120 (1.164)	0.630 (1.020)	-0.090 (0.301)	-0.380 (1.095)	-0.254 (0.630)	0.170(0.770)	0.345 (0.306)	-0.940 (0.882)	-0.377 (5.803)	-
Teacher characteristics															
Female	-0.060 (0.070)	-0.049 (0.129)	0.024 (0.131)	-0.185 (0.190)	-0.371 (0.188)*	-0.158 (0.261)	-0.143 (0.256)	-0.102 (0.165)	-0.094 (0.154)	-0.127 (0.344)	-0.101 (0.322)	0.163 (0.202)	0.210 (0.196)	-0.393 (0.355)	-
AIAN	0.248 (0.631)	-0.392 (0.862)	-0.352 (0.842)	-	-	-	-	-	-	-	-	-	-	-	-
Asian	0.192 (0.177)	0.233 (0.300)	0.588 (0.308)	0.018 (0.331)	0.008 (0.310)	-0.203 (0.605)	-0.171 (0.594)	-1.941 (1.146)	-1.737 (1.026)	-	-	-0.070 (0.693)	-0.036 (0.740)	-	-
Black/ African American	-0.420 (0.131)**	-0.428 (0.202)*	-0.377 (0.203)	-0.234 (0.374)	-0.142 (0.362)	1.054 (0.806)	1.07 (0.795)	-0.574 (0.399)	-0.300 (0.366)	-0.783 (0.707)	-0.586 (0.675)	-0.744 (0.430)	-0.725 (0.411)	-4.605 (6.820)	-
Hispanic/ Latino	-0.430 (0.135)**	-0.112 (0.180)	0.014 (0.182)	-0.176 (0.375)	-0.200 (0.364)	-1.603 (0.749)*	-1.702 (0.749)*	-1.371 (0.908)	-1.280 (0.823)	-	-	-1.357 (0.869)	-1.376 (0.844)*	-3.93 (2.999)	-

NHPI	0.671 (0.844)	0.681 (1.025)	-0.518 (1.039)	0.659 (1.394)	0.048 (1.258)	-	-	-	-	-	-	-	-	-	-
Two or More Races	-0.022 (0.264)	-0.785 (0.615)	-0.715 (0.602)	-0.103 (0.719)	-0.089 (0.641)	-	-	0.724 (0.657)	0.673 (0.565)	-0.228 (0.861)	-0.216 (0.811)	0.154 (0.688)	0.158 (0.652)	0.077 (19.805)	-
CTE Licensure	0.032 (0.107)	-0.027 (0.206)	0.041 (0.204)	0.879 (0.508)	0.857 (0.464)	-0.824 (0.600)	-0.923 (0.590)	0.055 (0.261)	0.109 (0.246)	-0.088 (0.453)	0.199 (0.430)	0.490 (0.328)	0.335 (0.305)	-1.139 (5.467)	-
PEL Licensure	-0.330 (0.160)*	0.024 (0.300)	0.037 (0.295)	0.774 (0.660)	0.59 (0.602)	-2.723 (0.999)**	-2.670 (1.037)*	-1.267 (0.453)**	-1.300 (0.458)**	0.045 (0.644)	0.283 (0.619)	0.029 (0.500)	0.008 (0.469)	-	-
CS-Endorsed	0.110 (0.077)*	-0.198 (0.141)*	0.037 (0.132)	0.027 (0.177)*	0.12 (0.177)	-0.106 (0.251)	-0.187 (0.257)	0.217 (0.194)*	0.191 (0.171)	-0.110 (0.432)	0.187 (0.397)	0.117 (0.298)*	0.134 (0.293)	-0.478 (0.631)*	-
Course characteristics															
CTE Course	0.122 (0.073)	-	-	-	-	-0.824 (0.600)	-	0.805 (0.510)	-	-1.235 (1.222)	-	0.378 (0.566)	-	0.756 (11.019)	-
AP	0.420 (0.120)**	-	-	0.524 (0.702)	-	-0.392 (0.298)	-	-	-	-	-	-	-	-	-
Enriched	-0.300 (0.212)	-0.222 (0.670)	-	-	-	-	-	0.384 (0.609)	-	1.406 (1.384)	-	1.113 (1.039)	-	-2.071 (13.019)	-
Honors	0.520 (0.121)***	0.400 (0.151)	-	-	-	-	-	-	-	-	-	-	-	-0.900 (10.403)	-
Remedial	1.100 (0.524)*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interactions															
CS Endr Teach × AP	-0.160 (0.279)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CS Endr Teach × Enriched	0.082 (0.711)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CS Endr Teach × Honors	-0.032 (0.855)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CS Endr Teach × Remedial	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Female Student ×Female Teach	-0.050 (0.382)	-0.035 (0.091)	-	0.459 (0.202)*	-	0.206 (0.284)	-	-0.048 (0.167)	-	1.653 (1.258)	-	-0.122 (0.247)	-	-0.638 (9.003)	-
Black Student ×Black Teach	0.341 (0.003)**	0.490 (0.157)**	-	-0.149 (0.447)	-	-1.482 (1.05)	-	0.386 (0.247)*	-	0.142 (0.361)	-	0.061 (0.446)	-	2.693 (13.053)	-
Latino Student ×Latino Teach	0.063 (0.601)	-0.100 (0.132)	-	-0.035 (0.312)	-	0.115 (0.591)	-	0.694 (0.630)	-	0.571 (0.747)	-	0.245 (0.707)	-	-0.741 (10.777)	-
N	43,817	14,281	14,281	6,081	6,081	3,046	3,046	5,828	5,828	1,715	1,715	4,539	4,539	1,361	1,361

Note: Entries are coefficient (logit scale) and standard errors are in parentheses. Significance levels are denoted as (*p < .05), (**p < .01), and (***p < .001). A hyphen (-) indicates the term was not estimated in that specification. This may occur because of small cell sizes or because the model encountered predictor singularity. Interaction terms explained how two factors combine to influence student receiving a passing in a CS course, interaction terms do not tell us the effect of each factor separately. Interaction terms represent how two factors work together to influence whether a student receives a passing grade, as they do not reflect the effect of either factor on its own, thus should not be interpreted alone.

Student characteristics

Overall, the pattern observed in the SY 2022 snapshot is largely consistent with the trends highlighted in Part 2 of this Series. Significant disparities in final course grades were evident across student groups, including differences by race, gender, income, and disability status. The overall passing rate in SY 2022 was 82%, which is slightly higher than the five-year average of 78.9% reported in Part 2.[5]

As shown in Table 1, descriptive results point to small differences across binary gender (83% passing rate for female students vs. 82% for male students). However, the overall model found that statewide, girls were statistically significantly more likely to pass their CS course compared to their male peers. This means that the gender differences, though small descriptively, persisted statewide overall for CS even after accounting for student, teacher, and course characteristics. Gender differences were also true for the most enrolled course, Computer Programming (see Table 3). For this course, across the state and within individual districts, girls were statistically significantly more likely to pass compared to boys. That said, this trend did not hold across the other six most enrolled courses statewide or within districts, showing no difference in likelihood of passing along gender lines.[c]

According to the descriptive statistics, 92% of Asian students, 71% of Black/African American students, 76% of Hispanic/Latino students, and 83% of students with Two or more races received a passing grade in their CS course, compared to 88% of White students. In the overall statewide model, each of these differences were statistically significant compared to White students (which is the reference group because they are the largest population). This means that, overall in CS, Black/African American and Hispanic/Latino students, and students with Two or more races were statistically significantly less likely to pass their CS course compared to their White peers, while Asian students were more likely to pass compared to their White peers. However, when we accounted for the specific CS course and district differences, we found that these associations were not significant for every course. For example, Asian students were still statistically significantly more likely to receive a passing grade in their CS course compared to White students in five of the seven most enrolled CS courses statewide and within their district. Black/African American and Hispanic/Latino students were also still less likely to receive a passing grade in six of the seven most enrolled CS courses statewide and within their district. This means that the racial disparities observed statewide permeate through individual courses and districts, indicating wide-spread systemic inequities in CS outcomes for Black/African American and Hispanic/Latino students in Illinois CS courses. All other racial groups showed no difference in likelihood of passing when CS course or district differences were accounted.

Descriptively, students identified as English Learners (ELs; 69%), students with disabilities (labeled as IDEA[d]; 70%), and students eligible for free or reduced-price lunch (FRL; 74%) had much lower passing

[c] For interpretation and readability purposes, we interpret model coefficients' direction and not magnitude.
[d] IDEA = Individuals with Disabilities Education Act

rates than their non-EL (83%), non-IDEA (84%), and non-FRL peers (88%). The overall statewide model mirrored these descriptive findings in that EL and low-income students and students with disabilities were all statistically significantly less likely to receive a passing grade in their CS course compared to their peers who are not EL, not low-income, and not disabled, respectively. However, these disparities differed when accounting for specific CS courses or district differences. For example, students with disabilities (IDEA) and EL students were less likely to receive a passing grade in six and four of the seven, respectively, most enrolled CS courses across that state and within their home district. Low-income students were also less likely to receive a passing grade in six of the seven most enrolled CS courses across the state and within their home district. The one course where low-income students did not statistically significantly differ in their outcomes statewide or within their district was in AP Computer Science Principles. Notably, AP Computer Science Principles was created to improve equitable participation in CS for all students and specifically historically marginalized groups.[8] Our findings suggest that in Illinois, the goal of AP Computer Science Principles may be heading in the right direction for at least low-income students, with more progress to be made with other student groups.[e] Nevertheless, these findings mean that disparities based on income, disability, and linguistic lines observed statewide do permeate through individual courses and districts, indicating wide-spread systemic inequities in CS outcomes for these groups as well in CS courses.

Two racial identities (AIAN, NHPI), as well as dual credit enrollment and year in school, were not statistically significantly predictive of students' likelihood of receiving a passing grade in the state overall, across the seven most enrolled courses, or within districts, due to cell size constraints (for the racial identities and dual credit) and similar passing rates (as shown in Table 1 for year in school).

Teacher characteristics

Descriptively, passing rates were similar for students regardless of their teacher's binary gender (as seen in Table 1). Teacher gender was also not a statistically significant predictor for the likelihood of students receiving a passing grade in the overall, course, or district models (as seen in Table 3).

However, according to descriptive statistics, student passing rates were different when disaggregated by teacher race; particularly, students with AIAN, Black/African American, or Hispanic/Latino teachers as well as teachers with Two or more races had lower passing rates (<79%) compared to students with Asian, NHPI, or White teachers (≥84%). In the overall model, students taught by either Black/African American and Hispanic/Latino teachers were statistically significantly less likely to receive a passing grade compared to students with a White teacher. However, this finding should not be interpreted as a reflection of teacher quality or effectiveness. Instead, teachers from racially minoritized backgrounds in general are more likely to teach at schools with higher proportions of students with similar racial

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[e] We did not have access to AP CS Principles or AP CS A exam scores and thus cannot definitively determine mastery of content according to College Board's AP scores.

backgrounds.[9] This pattern likely reflects the ongoing impact of structural racism and resource inequities across schools, such as differences in school resources, available supports, and course offerings typically associated with schools employing larger proportions of teachers of racially minoritized groups (e.g. Black/African American, Hispanic/Latino, etc.). For example, in the course model, students enrolled in Computer Programming across the state were statistically significantly less likely to receive a passing grade in their course if they were taught by a Black/African American teacher. That said, there was no statistically significant difference in the likelihood of receiving a passing grade once district differences were accounted for in the district model. This means that within an individual district, students were no more or less likely to pass Computer Programming based on the race of their teacher. The course and district models showed other relationships for Hispanic/Latino teachers and students' outcomes in various courses, which highlights the complex nature of teacher characteristics and students' likelihood of receiving a passing grade that, in the end, is dependent on the course itself.

In Part 3 of this Series, we explored student-teacher matching and found that girls, Black/African American students, and Hispanic/Latino students had a 45%, 35%, and 18% chance, respectively, of enrolling in a CS course with a teacher of the same gender or race.[6] Previous research has shown that racial or cultural congruence between teachers and students may be linked to improved academic outcomes for students and may help mitigate systemic gaps.[12] As such, we included interaction terms on teacher and student matching binary gender and race in the overall and course models.[f] Interaction terms represent how two factors work together to predict whether a student receives a passing grade, as they do not reflect the relationship of either factor on its own, but rather how their combination moderates the passing rate for students, potentially improving outcomes compared to what would be expected based on either factor alone. For girls, while the overall model found that pairing female students with female teachers did not increase students' likelihood of receiving a passing grade in their CS course, the course model found a statistically significant relationship in AP Computer Science A, where girls state-wide were more likely to receiving a passing grade if their teacher was a women than if their teacher was a man. A positive relationship was also found for Black/African American students. In the overall model, Black/African American students taught by Black/African American teachers were more likely to receive a passing grade compared to Black/African American students taught by White teachers. This relationship also held true for Black/African American students and teachers in Computer Programming and Web Page and Interactive Media Development I. Racial congruence amongst Hispanic/Latino students and teachers was not statistically significant in CS coursework. These findings support that cultural alignment and shared experiences may positively predict classroom interactions and help reduce systemic disparities within CS education, at least in some circumstances. However, because these interaction terms were not present in the district model, it is possible that district differences may be driving part of this relationship between student learning outcomes and gender or racial congruency between students and teachers.

[f] Interaction terms were not included in district models due to cell size constraints.

Passing rates for students taught by teachers holding a Professional Educator License (PEL; 82%) and a Career and Technical Educator (CTE) license (83%) were nearly identical to the state-wide passing rate (82%). The overall model indicated that students taught by a teacher holding a PEL were statistically significantly less likely to receive a passing grade in their CS course compared to students taught by a teacher without a PEL. This relationship was also true for two courses (AP Computer Science Principles and Web Page and Interactive Media Development I) both at the state-wide course level and within districts. While our models indicate a statistically significant association between holding a PEL and lower passing rates, its interpretation is practically limited due to its predictive power. The significance of a predictor in a statistical model depends not only on how theoretically relevant it is, but also on how distinctive and informative it is within the data.[12] Given that most teachers hold a PEL (over 92% as found in Part 3[6]), this finding likely reflects broader structural factors rather than individual qualifications. In other words, because the PEL is so common, it does not offer much discriminating power in the model, even if it appears to have a statistically significant negative relationship with student outcomes.

As shown in Table 1, passing rates were slightly better for students taught by a CS-endorsed teacher (84%) compared to those taught by a non-CS endorsed teacher (80%). This relationship held in the overall model where students were statistically significantly more likely to receive a passing grade in their CS course if their teacher had a CS endorsement. This relationship also held in three courses (AP Computer Science A, Web Page and Interactive Media Development I, and Computer Operations and Programming I) for the course model, meaning students were more likely to receive a passing grade in these courses if their teacher had a CS endorsement. However, the district model rendered this relationship not statistically significant, meaning that within districts CS endorsements did not play a role in predicting student outcomes. Inversely, in two courses (Computer Programming and Computer Operations and Programming II), students were statistically significantly *less* likely to receive a passing grade in their course if their teacher held a CS endorsement, according to the course model. Similar to the courses above, the district model rendered this relationship not statistically significant after accounting for district differences.[g] Taking all three models together, there is a positive correlation between the CS endorsement and students' likelihood of receiving a passing grade, but the models suggest it is due to differences in other correlated district characteristics rather than the endorsement. This may be due to district offerings, such as teacher supports like professional development that may serve a similar role to the endorsement in certain courses or districts (depending on course depth and quality), or it may signal differences in whether or not districts require the CS endorsement to teach CS.

Course characteristics

In terms of course characteristics, the descriptive data showed the highest passing rates among CS students enrolled in honors (88%) and AP (87%) CS courses, followed closely by those in CS CTE courses

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[g] The district model for Computer Operations and Programming II did not converge so we are unable to determine if district differences account for differences in student outcomes for that course.

(84%). In contrast, students in remedial CS coursework had a passing rate of 82%, students in enriched CS coursework had a passing rate of 80%, and students in general CS courses had a passing rate of 79%, indicating some disparities in outcomes based on course rigor and type.

According to the overall model (see Table 3), students enrolled in AP, honors, or remedial coursework were statistically significantly more likely to receive a passing grade in their CS course compared to students enrolled in general CS coursework. Students enrolled in enriched CS coursework were just as likely to receive a passing grade as their peers in general CS coursework, and students enrolled in CS CTE coursework were just as likely to receive a passing grade as their peers in non-CTE CS coursework, according to the overall model. In other words, the overall model found that course type and rigor did account for some differences in students' likelihood of receiving a passing grade for the "average" CS course. Conversely, the course model did not reveal any statistically significant predictors indicating that course differences did not account for any differences observed in students' likelihood of passing based on the rigor or type of their specific CS course. The district model did not account for course type or rigor and thus did not add to our findings here.[h]

In the overall model, we included interaction terms on course level (e.g., AP, honors, etc.) and teacher endorsements to explore the relationship between the two. None of these interaction terms resulted in a statistically significant relationship, meaning that for our data there was no relationship between students' likelihood of receiving a passing grade and the level of CS course in which they were enrolled combined with their teacher's qualifications.

Summary

For student characteristics, we observed statewide disparities in CS passing rates that permeate through individual courses and districts for Black/African American, Hispanic/Latino, low-income, and EL students, as well as students with disabilities, indicating a need for systemic change. For teacher characteristics, student-teacher matching for girls and Black/African American students showed statistically significantly higher likelihoods of receiving passing grades in their CS courses overall and in specific CS courses, indicating cultural and representative alignment may help to mitigate systemic barriers for equitable outcomes. We also found that CS endorsements gave students a better chance of passing courses, though district differences may mitigate some of these advantages for specific courses. For course characteristics, students enrolled in AP, honors, or remedial coursework were statistically significantly more likely to receive a passing grade in their CS course compared to their peers in general CS coursework, indicating some disparities based on course rigor and type.

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[h] Course characteristics were not included in the district model for two reasons. First, if we included both course and district characteristics in the model, it would complicate interpretation and course predictor estimates would not be stable. Second, the model would face multicollinearity issues because some districts only offer one CS course.

What factors predict the likelihood of students enrolling in a second CS course when accounting for course and district characteristics?

Previously, Part 1 of this Series provided a snapshot of Illinois high school students, reporting that 17.5% enrolled in more than one CS course,[4] that offered an overview across all available records at a single point in time. In the present analysis, we focus on two full cohorts of students during SY 2018 through SY 2022. Cohort 1 (about 42,000 students) was in grade 9 during SY 2018 and grade 12 in SY 2021. Cohort 2 (about 43,000 students) was in grade 9 during SY 2019 and grade 12 in SY 2022. This cohort-based approach enables a more accurate estimate of continuation by excluding students with incomplete enrollment histories, thereby better exploring what factors are associated with students' likelihood of taking multiple CS courses. Going forward, we discuss both cohorts collectively, as our research approach focused on describing this population generally and not examining differences among cohorts.

For these cohorts, more than 30% of students enrolled in their first CS course during grade 9 with the remaining spread mostly evenly across grades 10 through 12 (see Table 4). This is higher than the grade level distribution we reported earlier in Part 1 of this Series, where grade 9 enrollment was between 20-25%.[13–16] Of all students in the cohorts, 36% of students enrolled in two or more CS courses during their high school career, a markedly higher percentage (more than doubled) compared to the snapshot taken across all students in Part 1.[4] Here, the majority of students enrolled in their second CS course during grades 11 (30%) or 12 (39%). About one quarter of students enrolled in their second CS course during grade 10 and a small 8% of students enrolled in both their first and second CS course in grade 9. Students who took two or more CS courses did so across different semesters but could do so in the same school year. These results suggest that students entering CS in earlier grades generally have more time to continue, as continuation rates increase linearly with earlier entry into CS.

Table 4. Percentage of cohort students enrolling in first and second CS courses by grade.

	Grade 9	Grade 10	Grade 11	Grade 12
Enrollment of 1st CS course	31%	22%	23%	24%
Enrollment of 2nd CS course	8%	23%	30%	39%

Table 5 shows descriptive data for students in our dataset who completed their entire high school careers between SY 2018 and 2022, comparing those who enrolled in only one CS course to those who took two or more. It is important to note that all predictor variables (i.e., student, teacher, and course demographics) were captured at the time of students' initial CS course enrollment.

Table 5. Percentage of CS students enrolling in one or two or more CS courses between SY 2018-2022 by student, teacher, and course characteristics.

Student Characteristics	Enrolled in only 1 course (%)	Enrolled in 2 or more courses (%)	**Teacher Characteristics**	Enrolled in only 1 course (%)	Enrolled in 2 or more courses (%)
Female	76%	24%	Female	65%	35%
Male	58%	42%	Male	63%	37%
AIAN	66%	34%	AIAN	74%	26%
Asian	44%	56%	Asian	61%	39%
Black/African American	78%	22%	Black/African American	73%	27%
Hispanic/Latino	72%	28%	Hispanic/Latino	82%	18%
NHPI	63%	37%	NHPI	50%	50%
Two or More Races	62%	38%	Two or More Races	60%	40%
White	57%	43%	White	60%	40%
EL	77%	23%	CTE licensure	61%	39%
Non-EL	63%	37%	PEL	58%	42%
IDEA	75%	25%	CS Endorsed Teacher	60%	40%
Non-IDEA	62%	38%	Non-CS Endorsed Teacher	71%	29%
FRL	72%	28%	**Course Characteristics**	Enrolled in only 1 course (%)	Enrolled in 2 or more courses (%)
Non-FRL	57%	43%	Remedial Course	93%	7%
Dual Credit	48%	52%	General Course	68%	32%
			Enriched Course	53%	47%
			Honors Course	60%	40%
			AP Course	55%	45%
			CTE Course	50%	50%
Overall	**64%**	**36%**			

Note: This table shows only students who ever enrolled in any CS course. For example, of all girls who enrolled in a CS course during these years, 76% enrolled in one course versus 24% enrolled in two or more. AIAN refers to American Indian or Alaska Native. NHPI refers to Native Hawaiian or Other Pacific Islander.

Table 6 shows the outcomes of the overall and district models created for this research question. Below, we use the descriptive and inferential findings from Tables 5 and 6, respectively, to discuss the relationships observed between the likelihood of enrolling in a second CS course and student, teacher, course, and district factors.

Table 6. Estimated coefficients from overall and district models predicting student continuation into a second CS course, SY 2018–2022.

	Overall Model	District model
(Intercept)	-0.411 (0.344)	-1.16 (0.347)***
Student characteristics		
Female	-0.659 (0.021)***	-0.779 (0.12)***
AIAN	-0.170 (0.188)	-0.154 (1.052)
Asian	0.401 (0.039)***	0.632 (0.205)***
Black/African American	-0.332 (0.045)***	-0.589 (0.221)***
Hispanic/Latino	-0.120 (0.034)**	-0.244 (0.196)**
NHPI	0.103 (0.242)	-0.026 (1.292)
Two or More Races	-0.110 (0.072)	-0.100(0.338)
FRL	-0.060 (0.022)*	-0.18 (0.118)*
Year in School	-0.049 (0.010)***	-0.072 (0.039)
IDEA	-0.249 (0.027)***	-0.385 (0.186)*
EL	-0.358 (0.045)***	-0.437 (0.257)***
Dual Credit	0.150 (0.104)	0.252 (0.183)
Teacher characteristics		
Female	0.034 (0.088)	0.049 (0.122)
AIAN	1.301(0.052)	0.027(0.947)
Asian	-0.045 (0.214)	-0.030 (0.255)
Black/African American	0.102 (0.174)	-0.229 (0.208)
Hispanic/ Latino	-0.052 (0.212)	-0.692 (0.251) ***
NHPI	1.402 (1.331)	0.239 (1.381)
Two or More Races	0.110 (0.424)	0.492 (0.470)
CTE Licensure	0.549 (0.150)***	0.371 (0.170)*
PEL Licensure	0.988 (0.222)	-0.230 (0.272)
CS Endorsed	0.442 (0.143)***	0.282 (0.116)*
Latino Student ×Latino Teach	-	-
Black Student ×Black Teach	-0.012 (0.039)	-0.008 (0.162)
Female Student ×Female Teach	-0.0976 (0.022)	0.012 (0.001)
Course characteristics		
CTE	1.280 (0.466) **	-
AP	-0.522 (0.902)	-
Enriched	0.271(0.132)*	-
Honors	0.610 (0.078)***	-
Remedial	-2.308 (0.602)***	-
N	85,158	85,158

Note: Entries are coefficient (logit scale) and standard errors are in parentheses. Significance levels are denoted as (* $p < .05$), (**$p < .01$), and (*** $p < .001$). A hyphen (-) indicates the term was not estimated in that specification. This may occur because of small cell sizes or because the model encountered predictor singularity.

Student characteristics

As shown in the population descriptives in Table 5, female students had much lower enrollment rates into a second course (24%) compared to their male peers (42%). By race/ethnicity, Asian students had the highest continuation rates (56%), followed closely by White students (43%), while AIAN (34%), Hispanic/Latino (28%), and Black/African American (22%) students had lower than average rates (36%). Students eligible for free or reduced-price lunch (28%), students receiving IDEA services (25%), and students identified as English Learners (23%) demonstrated low enrollment rates into a second CS course compared to their non-low-income, non-EL, non-disabled peers. Additionally, students enrolled in dual credit during their first CS course demonstrated a notably higher continuation rate (52%) than the overall sample.

The overall model and district model (Table 6) mirror many of these findings and reveal persistent disparities by student identity, with several historically marginalized groups facing lower odds of enrolling in a second CS course. For both models, female students, English Learners, IDEA students, FRL-eligible students, Black/African American students, and Hispanic/Latino students, were all statistically significantly less likely to continue CS coursework compared to their male, non-EL, non-IDEA, non-FRL, and White peers, respectively. This means that these student groups were less likely to continue CS coursework across all course levels in the state (as shown by the overall model) and were less likely to continue CS coursework within their own district (district model) when compared to their peers. In contrast, Asian students were more likely to enroll in a second CS course compared to their White peers across all course levels in the state and within their own district.

We note that such disparities should not be attributed solely to students' individual interests or willingness to persist; rather, they reflect broader systemic inequities. In particular, the pronounced gaps in continuation for girls and Black/African American students suggests the need to examine how CS learning environments may differentially support or discourage these students from pursuing further CS study even after they have taken the first step into their high school CS career.[17,18]

The timing of students' initial CS coursework was statistically significant in the overall model, but not statistically significant in the district model. Statewide, students who took their first CS course earlier in high school had higher odds of enrolling in a second CS course. This may be because districts where students tend to enroll earlier also have more course offerings, advising, or other differences that support subsequent enrollment or districts may have concentrations of students with prior CS knowledge or higher CS interest. Indeed, when we compare students with similar characteristics within the same district, we do not see differences in subsequent enrollment based on the timing of students' first CS course. Statewide findings here complement findings from Part 1 and the descriptives earlier in this section that indicate over half of all students who enrolled in a CS course during these five years were in grades 11 or 12, indicating students in these years would not have as much of a chance for continued enrollment as others.[4] Expanding early and equitable access to rigorous CS can be critical for building foundational skills, confidence, and ongoing interest, potentially mitigating some systemic barriers identified among underrepresented groups and helping more students stay engaged in the CS pipeline throughout their high school career.[19]

Several racial identities (AIAN, NHPI, and Two or more races) as well as dual credit enrollment were not statistically significantly predictive of students' continuation in CS coursework in the state overall nor within districts. Each of these student characteristics had small N sizes, which may be contributing to their lack of statistical power despite higher-than-average continuation rates (particularly for dual credit enrollment).

Teacher characteristics

Descriptively, teacher characteristics at the time students took their first CS course further revealed some differences in continuation rates. For example, only 18% of students taught by Hispanic/Latino teachers and 27% of students taught by Black/African American teachers enrolled in a second CS course, which is well below the overall continuation rate of 36%. Although the continuation rate is higher for students taught by White teachers (40%), it is important to keep in mind that the majority of students in the dataset were taught by a White teacher (see Part 3 of this Series for more information on the CS teacher workforce by race/ethnicity). For the inferential models, the relationship between likelihood of enrolling in a second CS course and students having a Hispanic/Latino teacher (or a teacher of any race or gender) was not statistically significant in the overall model and as such continuation rates statewide do not vary by teacher race. However, within districts, Hispanic/Latino teachers were the only gender or racial group to be associated with a lower likelihood of CS continuation. Variation in continuation rates by teacher race and ethnicity should not be interpreted as measures of individual teacher effectiveness. Instead, they may reflect how racialized staffing patterns, resource allocation, and other district contexts intersect with students' opportunity to learn. Moreover, Hispanic/Latino teachers were much more likely to be assigned to teach general CS courses than any other course level or type (see Table 32 in Supplemental Materials), which, as will be noted in the next section, is less likely to have students continue onto subsequent CS course taking.

Unlike the previous research question on passing rates, neither the overall model nor the district model showed that racial or gender congruence in student-teacher pairings (interaction terms) statistically significantly predicted continued enrollment in CS. This may be due in part to the fact that enrolling in a second CS course also reflects students' own choices and motivation to continue, which are shaped by individual interests and opportunities. At the same time, between-district differences captured through the district model, such as course availability, scheduling, advising, and graduation requirements can also play an influential role in shaping continuation.

Students taught by CS-endorsed teachers were more likely to take a second CS course (40%) compared to those taught by non-endorsed teachers (29%). Similarly, students whose teachers held a CTE license showed a continuation rate of 39%, a rate higher than the statewide continuation rate of 36%. In the overall model and district model, both CTE licensure and CS endorsements were statistically significant predictors of students' continued enrollment. This means that statewide and within districts, students taught by teachers with a CTE licensure or a CS endorsement were more likely to enroll in subsequent CS coursework compared to students taught by teachers without CTE licensure or a CS endorsement, respectively. This suggests pairing students with qualified teachers may expand student opportunities to continue in CS.

To further examine the relationship between teacher qualifications and student continuation in CS during the SY 2018–2022 period, we examined how modeled estimations of teachers' CS endorsements and students' identity characteristics associated with continuation outcomes (see Table 33 in the Supplemental Materials).[i] Overall, on average, teacher endorsements were generally associated with increased odds of continued enrollment, but the magnitude varied considerably across student identity groups compared to the same student groups without a CS-endorsed teacher. For many historically marginalized student groups including Black/African American, Hispanic/Latino, EL, and low-income students, being taught by a CS-endorsed teacher was the difference between being slightly more likely to enroll in a subsequent CS course compared to being slightly less likely to continue in CS when paired with a non-CS-endorsed teacher.

Students taught by teachers who hold a PEL had an enrollment rate in a second CS course of 42% (higher than the statewide continuation rate of 36%), but the fact that most teachers hold a PEL limits its ability to differentiate variation in continuation rates. This should not be interpreted as a lack of impact, but rather as a reflection of how widely held credentials may offer limited explanatory power in understanding disparities in student outcomes. This is further explained by the lack of statistical significance of PEL as a predictor of continuation in either the overall model or the district model.

Course characteristics

Descriptively, course characteristics were also associated with differences in continued CS enrollment. As shown in Table 5, students who began their CS pathway in honors (40%), enriched (47%), AP (45%), and CTE (50%) courses were more likely to take a second CS course than those whose initial experience was in general (32%) or remedial (7%) CS courses.

In the overall model, course-level factors continued to show strong statistical associations with students' likelihood of enrolling in a second CS course. Students whose first CS experience was in an honors, enriched, or CTE course were statistically significantly more likely to continue compared to students whose first CS experience was in a general or non-CTE course, suggesting that rigorous initial course experiences may foster sustained student engagement. Other possible explanations from unobserved

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[i] These modeled estimations in Table 33 of the Supplemental Materials were calculated by the resulting coefficients from the overall multi-level model as a way to quantify and better understand the relationship between teacher endorsement status, student characteristics, and students' likelihood of continuing CS. These terms were *not* interaction terms entered into the overall or district models themselves and are, therefore, estimations.

characteristics could be that students enrolling in honors, enriched, or CTE coursework for their first CS course may have higher motivation or interest in CS. Furthermore, as identified in Parts 1 and 2 of this Series, CS CTE courses have a variety of pathways to other CS coursework, and this variation may contribute to differences in how students experience their first CS course and persist in CS coursework through these natural "feeder" CS CTE courses.[4,5] In contrast, students who began in remedial CS courses were statistically significantly less likely to continue. This disparity may reflect differences in course level, as remedial courses are defined by ISBE as less rigorous than general, enriched, or honors courses. While less rigor does *not* imply lower quality or instructional value, students in remedial courses may have fewer opportunities to engage with advanced CS content, which could be associated with a lower likelihood of enrolling in a second CS course. These patterns suggest that students' initial placement, particularly into more rigorous course types, may influence their likelihood of continued engagement in CS. This gap highlights substantial differences in students' opportunities to continue in CS, which may reflect broader inequities in how course types align with access to sustained CS learning pathways. AP CS course enrollment as their first course was not associated with an increase or decrease in the chances of enrolling in a second CS course. This may be due to AP course-taking later in a student's high school career (where two-thirds of all AP exam takers are in either their junior or senior year[19]) when we know students are less likely to enroll in a second CS course (as noted previously in this section).

Because the overall model indicates that enrolling in rigorous coursework can substantially shape continued CS participation, we estimated combinations of course level (i.e., rigor) and students' identity characteristics associated with the likelihood of enrolling in a second CS course (see Table 34 in Supplemental Materials).[j] On average, Hispanic/Latino, FRL-eligible, Black/African American, and EL students who initially took an enriched course had higher estimated odds of continuing compared to the reference group.[k] Female students in enriched courses, however, were less likely to continue, suggesting that even when enrolled in some rigorous coursework, gender disparities persist. Similarly, many student groups who began with an honors-level course demonstrated positive outcomes on average. However, starting in a remedial CS course was negatively associated with continued enrollment across all analyzed student groups. As we found in Part 2 of this series, historically marginalized student groups, particularly Black/African American, IDEA, and FRL-eligible students, were disproportionately placed or enrolled into remedial CS courses and remain underrepresented in more rigorous course options such as honors, enriched, and AP CS coursework.[5] Alternative explanations may include district differences (not modeled

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[j] These modeled estimations in Table 34 of the Supplemental Materials were calculated by the resulting coefficients from the overall multi-level model as a way to quantify and better understand the relationship between course rigor level, student characteristics, and students' likelihood of continuing CS. These terms were not interaction terms entered into the overall or district models themselves and are, therefore, estimations.

[k] The reference group here is a White, male, non-IDEA, non-EL, non-FRL student taught by a non-CS-endorsed, White, male teacher without a PEL in a general level CS course.

here) where some districts that offer remedial CS may be less likely to offer additional or advanced CS courses.

An interaction term of CS endorsement and course level was modeled in the overall model but was not found to be statistically significant, indicating that statewide there is no observable relationship between endorsement status, course level, and the likelihood of students enrolling in a second CS course.

Course-level characteristics were only included in the overall model but not the district model. As such, we cannot speak to the differences of course level characteristics within districts. See the Supplemental Materials for Part 4 for more information on inclusion of characteristics in our inferential models.

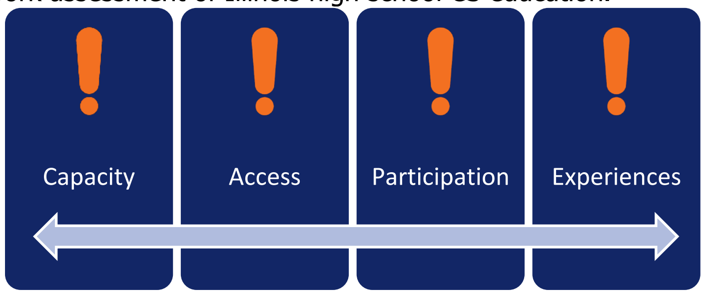
Summary

Collectively, the likelihood of students enrolling in a second CS course varies by individual student, teacher, and course characteristics with and without accounting for district differences. For student characteristics, girls, English Learners, IDEA students, FRL-eligible students, Black/African American students, and Hispanic/Latino students were all statistically significantly less likely to continue CS coursework compared to their male, non-EL, non-IDEA, non-FRL, White peers both statewide and within districts, indicating broader systemic inequities in CS education. For teacher characteristics, both CTE licensure and CS endorsements were statistically significant predictors of students' continued enrollment both statewide and within districts. For course characteristics, students whose first CS experience was in an honors, enriched, or CTE course were more likely to continue in CS coursework, emphasizing that rigorous initial course experiences may foster sustained student engagement. However, it is unclear how differences in district offerings, advising practices, and other factors may play a role in course level and type predicting student continued CS enrollment.

Can we assess equity in Illinois high school CS education using the CAPE framework?

This fourth report continued our analysis of the CAPE framework (Figure 1), with a specific focus on the **experience** component of Illinois high school CS education. This report highlights three key findings: (1) We observed statewide disparities in CS passing and continuation rates that permeate through individual courses and districts for Black/African American, Hispanic/Latino, low-income, and EL students, as well as students with disabilities, indicating a need for systemic change; (2) On average, students taught by CS-endorsed teachers demonstrated higher rates of passing and a greater likelihood of enrolling in additional CS courses, though district differences may account for some of these advantages; (3) Girls and Black/African American students paired with teachers of the same gender and/or race were associated with increased odds of passing their CS course, suggesting the value of culturally and/or gender affirming instructional contexts. Together, these findings emphasize the need to view student outcomes holistically, considering how teacher qualifications, student support structures, and course rigor intersect to shape learning experiences. Expanding access to CS-endorsed teachers, promoting diversity and cultural responsiveness in the teaching workforce, and ensuring early and equitable access to rigorous CS coursework pathways are all potential levers for achieving equitable CS education statewide.

Figure 1. CAPE Framework assessment of Illinois high school CS education.



Much like the other reports in this Series, while we found improvements in various aspects of CS education in the state, there is still much room for improvement for equitable student experiences in CS education. This non-causal analysis, however, is not without limitations. First, due to limitations in data access, we did not include AP test scores in this report, which can provide an additional lens on learning outcomes and disparities in advanced learning opportunities to complement the coursework data. Second, our models are limited by the nature of coursework data; we do not account for other factors that may be linked with student outcomes, such as prior CS exposure, students' computing identity, sense of belonging, classroom climate, or access to out-of-school learning resources. These unmeasured variables may potentially shape student learning outcomes and persistence in CS. Additionally, our model does not incorporate teachers' CS identity, content knowledge, or pedagogical skill beyond the presence of a formal endorsement or license. It is possible that some teachers without the CS endorsement may possess strong pedagogical content knowledge in CS and substantial experience in the field but may be in the process of obtaining a CS endorsement or have not yet pursued the formal credential due to institutional, procedural, or personal factors. Future research should explore these areas with additional student-level and teacher-level data acknowledging how structural and contextual factors can obscure or amplify opportunities for all students.

What's coming next?

This was the fourth report in **The State of Computer Science in Illinois High Schools Series**. The fifth (and final) report of this Series will examine capacity for, access to, participation in, and experiences in CS education by high school districts across the state. We will also highlight Cases of Excellence of CS education: districts around the state that sustain robust, equitable CS education programs for their students.

References

1. Public Act 101-0654 - The Education and Workforce Equity Act, No. HB2170, Illinois Legislative Assembly (2021). https://www.ilga.gov/legislation/101/HB/PDF/10100HB2170lv.pdf
2. Fletcher, C. L., & Warner, J. R. (2021). CAPE: a framework for assessing equity throughout the computer science education ecosystem. *Communications of the ACM*, *64*(2), 23–25. https://doi.org/10.1145/3442373
3. Warner, J. R., Fletcher, C. L., Martin, N. D., & Baker, S. N. (2022). Applying the CAPE framework to measure equity and inform policy in computer science education. *Policy Futures in Education*, 14782103221074468. https://doi.org/10.1177/14782103221074467
4. Chen, Y., & Werner, S. M. (2024). *The State of Computer Science in Illinois High Schools Series: Part 1 - What is the landscape of CS coursework?* Illinois Workforce and Education Research Collaborative (IWERC), Discovery Partners Institute, University of Illinois. https://dpi.uillinois.edu/applied-research/iwerc/current-projects/cs-ed-research/
5. Werner, S. M., & Chen, Y. (2024). *The State of Computer Science in Illinois High Schools Series: Part 2 - What are the characteristics of the CS student body?* Illinois Workforce and Education Research Collaborative (IWERC), Discovery Partners Institute, University of Illinois. https://dpi.uillinois.edu/applied-research/iwerc/current-projects/cs-ed-research/
6. Werner, S. M., & Chen, Y. (2025). *The State of Computer Science in Illinois High Schools Series: Part 3 - What are the characteristics of the CS teacher workforce?* Illinois Workforce and Education Research Collaborative (IWERC), Discovery Partners Institute, University of Illinois. https://dpi.uillinois.edu/wp-content/uploads/2025/03/IWERC-Report_IL-HS-CS-Teachers.pdf
7. Institute of Education Sciences, & National Center for Education Statistics. (2010). *SLDS techinical brief: Guidance for statewide longitudinal data systems (SLDS)*. https://nces.ed.gov/pubs2011/2011603.pdf
8. College Board. (2023). *AP Computer Science Principles: Course and Exam Description*. https://apcentral.collegeboard.org/media/pdf/ap-computer-science-principles-course-and-exam-description.pdf
9. Spiegelman, M. (2020). *Race and Ethnicity of Public School Teachers and Their Students* (No. NCES 2020103). NCES. https://nces.ed.gov/use-work/resource-library/report/data-point/race-and-ethnicity-public-school-teachers-and-their-students?pubid=2020103
10. Egalite, A. J., Kisida, B., & Winters, M. A. (2015). Representation in the classroom: The effect of own-race teachers on student achievement. *Economics of Education Review*, *45*, 44–52. https://doi.org/10.1016/j.econedurev.2015.01.007
11. Redding, C. (2019). A teacher like me: A review of the effect of student–teacher racial/ethnic matching on teacher perceptions of students and student academic and behavioral outcomes. *Review of Educational Research*, *89*(4), 499–535. https://doi.org/10.3102/0034654319853545
12. Kutner, M. H., Nachtsheim, C. J., Wasserman, W., & Neter, J. (2004). *Applied Linear Regression Models* (4th Edition). McGraw Hill Higher Education. https://www.scirp.org/reference/referencespapers?referenceid=1668293
13. Erete, S., Thomas, K., Nacu, D., Dickinson, J., Thompson, N., & Pinkard, N. (2021). Applying a Transformative Justice Approach to Encourage the Participation of Black and Latina Girls in Computing. *ACM Transactions on Computing Education*, *21*(4), 1–24. https://doi.org/10.1145/3451345
14. Werner, S. M., & Blazquez, R. (2024). *The pathways and experiences of Illinois computer science undergraduate students series: Part 1 – Towards an "uplifting environment": Understanding supports and barriers for students in Illinois computer science college programs*. Illinois Workforce and Education Research Collaborative (IWERC), Discovery Partners Institute, University of Illinois. https://dpi.uillinois.edu/applied-research/iwerc/current-projects/cs-ed-research/

15. Rankin, Y. A., Thomas, J. O., & Erete, S. (2021). Black Women Speak: Examining Power, Privilege, and Identity in CS Education. *ACM Transactions on Computing Education*, *21*(4), 1–31. https://doi.org/10.1145/3451344
16. Master, A., Cheryan, S., & Meltzoff, A. N. (2016). Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology*, *108*(3), 424–437. https://doi.org/10.1037/edu0000061
17. Hur, J. W., Bhuyan, J., Wu, F., Thomas, C., Wang, C.-H., Jiang, L., & Koong, K. (2023). Promoting Underrepresented Minority Students' Interest in Computer Science: Motivation and Sustained Interest. *Society for Information Technology & Teacher Education International Conference*, 979–984. https://par.nsf.gov/servlets/purl/10408473
18. Sivilotti, P. A. G., & Demirbas, M. (2003). Introducing middle school girls to fault tolerant computing. *SIGCSE Bulletin*, *35*(1), 327–331. https://doi.org/10.1145/792548.611999
19. CollegeBoard. (2023). *Beyond Your Campus: AP Participation Continues to Increase in 2023*. https://highered.collegeboard.org/recruitment-admissions/policies-research/beyond-your-campus/ap-participation-increase

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