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The Middle-to-High School Transition: Key Factors Shaping 9th-Grade Computer Science Enrollment

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Abstract: The increasing demand for computer science (CS) skills underscores the importance of integrating CS education into K–12 curricula to best prepare students for a digitally-driven society. Despite significant progress in expanding access to CS courses, disparities in participation persist, especially among historically underrepresented groups. This study examines the transition from 8th to 9th grade as a pivotal juncture in CS education, analyzing factors linked to 9th-grade CS course-taking among 5,505 students across eight diverse school districts using logistic regression. Findings show that high academic achievers, male students, Asian students, and those with exposure to CS and Algebra 1 in middle school were more likely to enroll in 9th-grade CS courses. Conversely, participation is lower for females, English Language Learners, and students receiving special education services. These results point to persistent barriers to CS participation extending beyond access alone. We discuss practical implications for middle and high schools, emphasizing the need for targeted outreach and early exposure to CS to foster a sense of belonging and applicability of CS. By identifying actionable strategies to address participation gaps, this study provides data-driven recommendations for advancing equity in CS education during the critical middle-to-high school transition.

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1. Introduction

Jobs in computing and related fields are experiencing rapid growth (US Bureau of Labor Statistics, 2024), highlighting the continued and increasing demand for computer science (CS) skills. At the same time, as technology, artificial intelligence (AI), and automation permeate nearly every sector of society, these skills are no longer relevant only for those pursuing careers in software development or technical fields but are seen as critical for all students to become responsible, informed, and productive members of society. Therefore, meaningfully incorporating computer science education (CSE) into K-12 curricula continues to gain momentum as a national priority. As such, broadening participation in CSE is paramount, ensuring that all students, regardless of background, have the opportunity to acquire the skills and knowledge necessary to fully participate in the digital age (CSTA et al., 2023; NASEM, 2024; TeachAI & CSTA, 2024).

Over the past decade, significant investments have been made in K-12 CSE at the local, state, and federal levels. Notable initiatives, such as Computer Science for All, the Computer Science Education Act, the Future of Work, and Broadening Participation in Computing, have contributed to progress in expanding CSE. For instance, while only 45% of public high schools offered foundational computer science in 2019, this figure rose to 60% by 2024 (Code.org, 2024). Although access has improved, disparities persist in both access to and participation in CSE (Fletcher & Warner, 2021; NCES, 2019).

Access to CSE remains uneven across schools. Rural, urban, and smaller high schools, as well as those with higher percentages of economically disadvantaged students, are less likely to offer

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foundational CS. Black/African American, Hispanic/Latinx, and Native American/Alaskan students are less likely to attend schools that offer such courses (Code.org, 2024). We know, however, that increasing CSE access alone does not ensure equitable participation. In the 2023-2024 school year, only 6.4% of high school students in the U.S. enrolled in a foundational computer science course. Despite ongoing efforts to encourage participation, males are still twice as likely to enroll in these courses as females, a statistic that has remained unchanged over the past four years (Code.org, 2024).

Participation among different racial and ethnic groups has also been relatively stable over this period: Black/African American students, Native Hawaiian/Pacific Islander students, multiracial students, and White students are proportionally represented, while Asian students are overrepresented. However, Hispanic/Latinx students remain underrepresented compared to their population, and English Language Learners (ELLs), students with disabilities, and economically disadvantaged students are also underrepresented in CS courses. For example, while 53% of students nationally qualify for free and reduced lunch, they comprise only 38% of foundational computer science classes. This gap points to more than an access issue (Code.org 2024; Fletcher & Warner, 2021; Warner et al, 2022).

To address low CS participation, both overall and particularly among learners from underrepresented groups, recent efforts have increasingly focused on introducing CS instruction at lower grade levels (English, 2017; Madrigal et al., 2020; Wiebe et al., 2019; Weintrop et al, 2018). Research suggests that these early interventions are critical because students are still forming their perceptions of gender roles and career trajectories (Barker & Aspray, 2006; Whitecraft & Williams, 2010) and can benefit from early exposure to CS concepts that encourage continued engagement in high school and beyond (Lee et al., 2023; Denner, 2011; Ryoo et al., 2012). Notably, middle school (MS) CS classrooms tend to reflect a more demographically representative student population than high school CS classrooms (Code.org, 2024). This is likely attributable to the fact that MS CS instruction is often integrated into mandatory curricula, making it not only accessible to a broader range of students, but required.

Despite increasing efforts to broaden participation in CS, data consistently show that participation remains closely tied to sociodemographic factors. CS classrooms often fail to represent the diversity of the schools they serve. This disparity is somewhat understandable given the timing of initiatives aimed at diversifying CS pipelines; systemic changes of this size require sustained effort over time. Changes across K-12 systems also take many years to propagate, so it is not possible to observe outcomes of various interventions until long after their onset. A deeper understanding of the various course-taking pathways—both those that intersect with CS and those that do not—is crucial for identifying when, how, and why students choose to engage with CS. Such insights will enable more strategic allocation of resources and further progress toward equitable CS participation.

This paper contributes to the growing body of research by examining the transition from 8th grade to 9th grade as a pivotal decision point in the K–12 CS pipeline. Understanding which students enroll in 9th-grade CS (and related) courses, when available, provides valuable insight into the efficacy of earlier interventions. Specifically, it helps to assess whether these interventions foster a sense of belonging and identity in CS among all students and highlights areas where additional efforts are needed. Furthermore, these findings inform high schools' recruitment strategies by identifying student populations who may require targeted outreach to re-enter or remain on the CS pipeline.

2. Methods

Through a federally funded grant centered on the enhancement of CS and related instruction at the MS level, eight public school districts in a northeastern state provided administrative data from their middle and high schools. Data was considered for all students in grades 6-12 between 2018 and 2024, and included sociodemographic characteristics for each student, along with their courses, marking period grades, and final course grades for each academic year. Data from the eight districts and six academic years were combined into one dataset, retaining student, school, and year

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identifiers. As necessary, variables were standardized to account for variations in individual schools' reporting.

Prior to analysis, racial and ethnic categories with small sample sizes (Indigenous, Multiracial, and Pacific Islander) were recoded to an "Other" category. Similarly, students' gender was recoded as "male" or "non-male" to retain students with other gender identities (supported only by some schools' SISs) and to address their small group size. Several key indicator variables were created to capture student characteristics: English Language Learner (ELL) status, receipt of special education services, economically disadvantaged status, enrollment in Algebra 1 in middle school, and enrollment in a CS and CS-related course in 9th grade. Two composite variables were created for this analysis: (1) the total number of CS and CS-related classes taken in middle school and (2) the average final course grade across all middle school courses. These variables were designed to provide an understanding of students' academic preparation and course-taking patterns that may impact the critical transition from middle to high school.

The unit of analysis in this study was an individual student enrolled in any participating district with available data for both 8th and 9th grades. A total of 5,505 students met this inclusion criteria, and their characteristics are presented in Table 1. The sample comprises a diverse population of students, with a varied racial composition: 46% Hispanic, 34% White, 11% Black, 7% Asian, and 2% Other. Additionally, the sample includes representation from key subgroups: 18% of students receive Special Education services, 9% are ELLs, and 56% are classified as Economically Disadvantaged.

Table 1. Sample Characteristics.

Characteristic	N = 5,505[1]
Gender	
Male	2,860 (52%)
Female	2,642 (48%)
Other	3 (<0.1%)
Race/Ethnicity	
White	1,860 (34%)
Asian	387 (7.0%)
Black	606 (11%)
Hispanic	2,510 (46%)
Indigenous	2 (<0.1%)
Multiracial	123 (2.2%)
Pacific Islander	17 (0.3%)
Sp. Education	992 (18%)
ELL	488 (8.9%)
Economically Disadvantaged	3,104 (56%)
Avg. MS Course Grade	0.89 (0.83, 0.94)[2]
Algebra I in MS	1,563 (28%)

[1] n (%). [2] median (Q1, Q3).

To examine predictors of computer science (CS) and CS-related course enrollment in 9th grade, we applied a binary logistic regression model using the sociodemographic variables described above. For the purposes of this study, "CS courses" were defined as a manually verified subset of courses classified under either category 11 (Communication and Audio/Visual Technology) or category 21 (Engineering and Technology) in the School Courses for the Exchange of Data (SCED) classification system (National Forum on Education Statistics, 2014). Additional predictor variables, discussed above, were included based on prior research and theoretical relevance, such as the relationship between Algebra 1 completion and computer science outcomes (Torbey et al., 2020) and the role of pre-high school exposure to computer science in fostering longer-term CS participation (McGee et al., 2017). To facilitate interpretation of effect sizes, odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. All analyses were conducted using R version 4.4.1 (R Core Team, 2024).

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3. Results

Across the board, only 27% of 9th grade students in the sample (1,463 out of 5,505) enrolled in a CS course, highlighting the persistent challenge in broadening participation in CSE. National data from Code.org (2024) further underscore this issue, showing that only 6.4% of high school students (grades 9-12) took a foundational CS course during the 2023-2024 academic year. This study provides a novel perspective by focusing specifically on 9th grade students, a critical entry point for CSE. However, it is important to note that our model (see Table 2) is predicated on a CS course being available to 9th graders. The following sections thematically interpret these findings, explore their broader implications, and offer recommendations for practice to address disparities in CS course enrollment and accessibility.

Table 2. Fitted Logistic Regression Model.

Characteristic	log(OR)[1]	95% CI[2]	p
Gender (male)	**0.90**	**0.77, 1.0**	**<0.001**
Race/Ethnicity			
White	—	—	
Asian	**0.45**	**0.21, 0.69**	**<0.001**
Black	0.05	-0.19, 0.28	0.7
Hispanic	**0.17**	**0.00, 0.34**	**0.044**
Other	0.36	-0.05, 0.75	0.076
Sp. Education	**-0.27**	**-0.45, -0.10**	**0.002**
ELL	**-0.34**	**-0.59, -0.09**	**0.008**
Economically Disadvantaged	0.08	-0.07, 0.23	0.3
CS-related Courses Taken by Grade 8	**1.1**	**0.69, 1.5**	**<0.001**
Avg. MS Course Grade	**2.3**	**1.2, 3.3**	**<0.001**
Algebra I in MS	0.19	0.03, 0.35	0.022

This table displays results from the logistic regression model, which predicts the binary outcome of whether a student was enrolled in a CS course in 9th grade. A likelihood ratio test against the null model demonstrated a significant improvement in fit (χ^2 = 351.5, p<0.001), suggesting the predictors contribute significantly to explaining the variability in 9th grade CS-related course taking. [1] OR: Odds Ratio; positive log-odds are associated with increases in predicted response. [2] CI: Confidence Interval.

3.1. Sociodemographic Factors

Results from the logistic regression reaffirm well-understood relationships between various sociodemographic factors and participation in CS courses. Male students are much more likely than non-males to take CS courses in 9th grade (log-odds: 0.90, p<0.001); 35% of male students do so, compared to less than 18% of others. This leads to a gender imbalance in 9th grade CS classrooms, where male students outnumber non-males 2:1. Skewed participation leads to skewed representation; cycles like these sustain the reputation of CS classrooms (and later, workplaces) as male-dominated spaces, and females continue to be underrepresented across the CS pipeline in K-12 education (Code.org, 2024), college degrees and workforce participation (Jaccheri et al., 2020).

Similar patterns exist along racial divides: Asian (log-odds: 0.45, p<0.001) students are more likely than their White peers to take CS classes in 9th grade. Nearly 40% of Asian students took a CS course in 9th grade, compared to only 26% of White and Hispanic students and 22% of Black students. The resulting effects on the composition of 9th grade CS classrooms vary based on districts' demographic makeup but will generally create CS classrooms that do not look like school hallways.

Our results also show that ELLs are less likely to take a CS course in 9th grade then their non-ELL peers. On average, 19% of ELL students take a CS course in 9th grade, compared to 27% of non-ELL students. Figure 1 examines these sociodemographic predictors individually and displays the percentage of students from various student groups participating in 9th grade CS courses.

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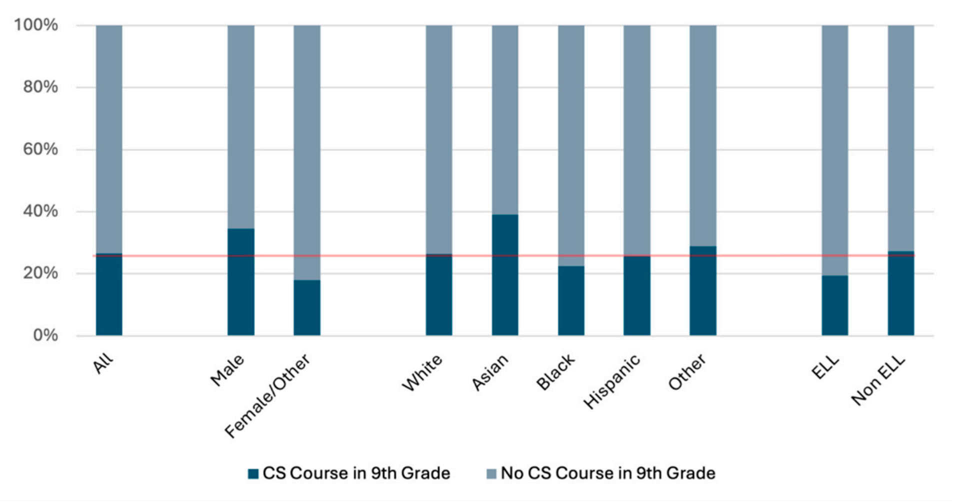

Figure 1. Sociodemographic Characteristics & 9th Grade CS Participation.

3.2. Academic Factors

Our results indicate that participation in various MS courses is linked to CS course participation in 9th grade. Specifically, students that take CS courses in MS are more likely to do so in 9th grade (log-odds: 1.1, $p<0.001$). This finding underscores the importance of early exposure to CS concepts and providing students with early, varied entrance ramps onto the CS pipeline. Additionally, students taking Algebra 1 before high school are more likely to take a CS class in 9th grade (log-odds: 0.19, $p=0.022$); 33% of students that have taken Algebra 1 in MS take a CS course in 9th grade, compared to only 24% of those that take Algebra 1 in HS (see Figure 2).

Beyond MS course participation, results show that overall 9th grade CS course participation is linked to academic achievement in MS. Students with higher overall course grades are more likely to take CS courses in 9th grade (log-odds: 2.3, $p<0.001$), as shown in Figure 3. Although the differences in achievement appear small, they are significant, both statistically ($t=6.167$, $p<0.001$) and contextually (given generally high grades in MS, especially outside of core subject areas, small differences matter). The model also shows that students receiving special education services are less likely to take a CS course in 9th grade (log-odds: -0.27, $p=0.002$), with only 23% of students receiving special education services taking a CS course in 9th grade, compared to 27% of their peers that do not receive these services.

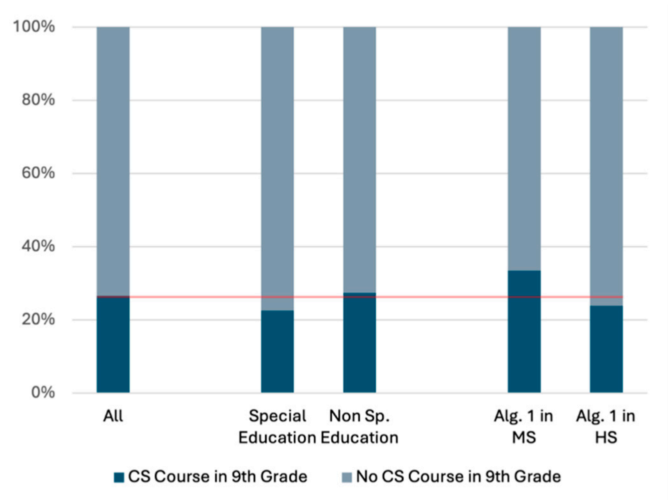

Figure 2. Academic Predictors & 9th Grade CS Participation.

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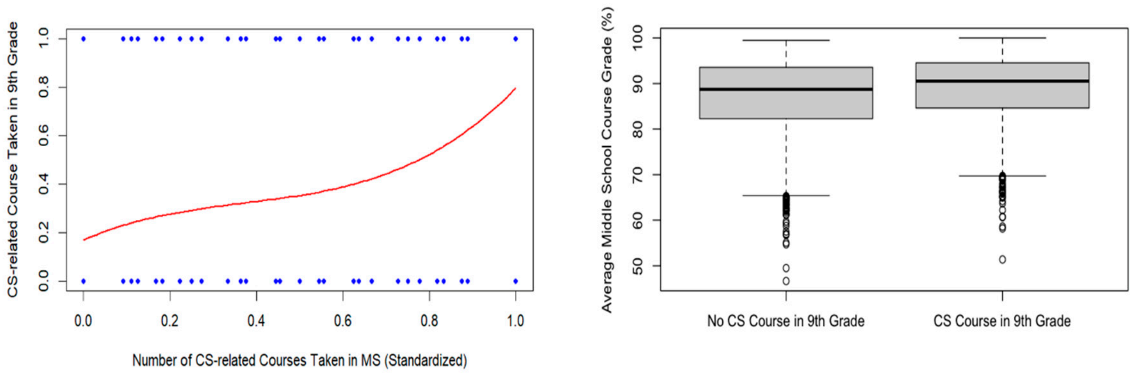

Figure 3. Middle School Academics & 9th Grade CS Participation.

4. Discussion

High school is often the first time where students can select to take a relatively small number of courses from a much larger catalog of options. In recent years, there has been tremendous progress in refining the structure and content of introductory CS courses, as well as ensuring that a CS course is contained in the course catalog for as many students as possible. Despite these efforts, overall CS participation remains: (a) generally low, although 60% of high schools nationally offer a foundational CS course, up from 35% in 2017, only 6.4% of high school students are taking these courses (Code.org, 2024), and (b) consistently inequitable, with CS participation remaining even lower for females and students requiring additional learning supports (i.e., English language and Special Education) and linked to students' racial identities.

Simultaneously, there have been advances in understanding what constitutes inclusive, culturally responsive CS instruction, and how putting these strategies to practice can increase the retention of CS learners regardless of their background. However, these strategies are often presented as generalized frameworks or broad guidance. Further, students generally need to be in the CS classroom to benefit from this work. The bottom line: despite demonstrable progress in increasing access to, participation in CS, especially for historically underrepresented students, remains low.

Schools and practitioners stand to benefit from more specific guidance, as school-dependent and age-linked factors often dictate what strategies are applicable and stand to be successful. This paper offers such guidance through a critical examination of CS course participation for students transitioning into 9th grade, a strategically selected, narrow focus. We offer this analysis as a narrow exploration of CS course-taking that can provide concrete guidance to both middle and high schools, providing data-based evidence to guide resource allocation and strategic planning. Given the well-understood importance of the 9th grade transition, schools can use this juncture to continuously monitor CS participation to gauge the success of their ongoing efforts and more intentionally plan interventions to advance their work.

For instance, our results show that CS participation in 9th grade remains low, especially for female and non-Asian students. As such, middle schools can ensure that all 8th graders are aware of options available to them during the course selection process. Coordinating efforts with high schools could include sending representatives – both students and teachers - to 8th grade classrooms to actively promote CS courses. Given gendered and racial differences in participation, schools must also consider the selection of appropriate messengers and the differentiated messages they deliver. Middle schools are well positioned to carry out this work, as a greater percentage of all students take CS courses (due to smaller pools of elective courses or required course rotations); at the same time, high schools must be prepared to "pick up" that work once students reach 9th grade. If, for

instance, efforts at the middle school show promise in reducing racial participation gaps in 9th grade CS classes, high schools can focus on inviting female students to the fold in 10th grade. Our results, and the success of these proposed initiatives, are predicated on the availability of CS courses

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for 9th graders; for schools lacking such offerings, adjustments to elective schedules, reevaluation of exclusionary pre-requisites, or opening sections of CS courses to incoming students may be necessary.

Similarly, academic influences throughout a student's MS education can predict their likelihood to participate in 9th grade CS. Specifically, the perception of CS courses as inherently challenging to students, teachers, guidance counselors, and parents remains a barrier that needs to be addressed. This may be due, in part, to overrepresentation of analytical domains in introductory computer science (Amiel & Blitz, 2022), or the fact that AP CS Principles, although designed as an introductory course, carries an AP designation. Although advanced CS concepts require foundational knowledge and can be demanding, this characteristic is not unique to CS, and introductory CS courses have no reason to be more challenging than introductory courses in other subject areas.

CS courses maintain the reputation that they require strong math skills, an interest in math, or a natural aptitude for analytical thinking. This, and the apparent complexity and difficulty of CS concepts, creates unnecessary barriers that may deter students who are not among the top academic performers. Educational systems still have work to do in appropriately levelling CS concepts and addressing misconceptions about the scope and broad applicability of the discipline. This work is especially important considering that introductory CS courses provide students with skills and knowledge that are needed by all students. As society continues to change, more and more people in the workforce stand to benefit from analytical and computational thinking skills. Further, non-instructional strategies are needed to address low participation: waiting until students are in the CS classroom to address these misconceptions is too late, because these very misconceptions are keeping students from being in CS classrooms.

Internal competition and systematic conflicts within middle school academic structures also require attention. Leaners that require additional supports, namely ELLs and Special Education students, find themselves disadvantaged not only because of the cultural and linguistic barriers they face in CS instruction (Lei & Allen, 2022; Hagiwara & Rodriguez, 2021), but also due to lost instructional time and inadequate supports in these classes (Blitz et al., 2025). Similarly, technical domains of CS use many concepts that are taught in Algebra 1 courses, but courses that explore these domains are offered before all students have taken Algebra 1. School systems regularly offer differentiated tracks for MS mathematics (explaining why some, but not all, students take Algebra 1 in MS), but analogous tracks frequently do not exist for CS.

Both middle and high schools may not be able to offer appropriately leveled CS learning experiences for a number of reasons. Available resources may not support separate sections of courses for learners that require instructional support, instruction and materials in other languages, or time for individual educators to spend time developing differentiated instruction. While bringing CS concepts to learners with diverse needs is an open area of research, schools can effectively manage factors within their control, such as ensuring that service delivery models do not interfere with (or worse, counteract) leaners' early exposure to CS, and providing supports to learners in these settings so they are positioned not only to be successful in the courses, but to understand that CS is a discipline they are able and welcomed to explore further.

5. Conclusion

This study's resulting model validates well-understood inequities in CS along sociodemographic factors, while also maintaining that these key factors are still in play when narrowing the focus to the transition between middle school and 9th grade. We also discuss the ways in which this model offers concrete guidance for middle and high schools, such as addressing root causes of the reputation of CS as a challenging, mathematics-adjacent subject area or giving attention to emergent tension points in the CS pipeline for learners that are not on advanced mathematics tracks or require additional instructional supports.

Recent efforts have made considerable progress in both increasing students' access to CS courses; however, this study (among others) show that there is still much work to be done within an intermediate step: inviting all learners to participate in the CS opportunities available to them. We offer the analysis of 9th grade CS course participation (and by extension, the MS to HS transition) as an important juncture that enables schools to assess the cumulative results of CS exposure and outreach efforts through 8th grade, understand what efforts are needed to invite learners to the CS pipeline after 9th grade, and take repeated measures to understand the impacts of their efforts and plan accordingly.

5.1. Limitations & Future Work

As presented in this paper, 9th grade CS participation remains low, resulting in class imbalance within course taking data that can make stable inference challenging. Additionally, this study is restricted to students that have the option to take a CS course in 9th grade, which we acknowledge is not a reality for many leaners, especially those from the very groups that remain underrepresented in CS. Further research into CS course pathways and their intersection with broader pathways is warranted, and this paper presents early findings in a series of research on this topic.

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