



When Demand Outpaces Supply: Flexible Staffing and the Making of Maryland's High School CS Teacher Workforce

Jiseung Yoo

University of Maryland College Park

David Blazar

University of Maryland College Park

Jing Liu

University of Maryland College Park

U.S. high schools have rapidly expanded computer science (CS) education over the past decade, resulting in increased pressure to staff classrooms with qualified teachers. This study examines how Maryland high schools responded to rising CS enrollment from school year 2012-13 through 2023-24, focusing on the growth and compositional changes of the CS teacher workforce. CS demand significantly outpaced teacher growth, which was responded by schools via increasing class sizes, recruiting new teachers, and reallocating in-service teachers. Teachers shifting into CS from other subjects outnumbered new entrants, with new entrants more likely to hold CS-specific endorsements and conditional licenses while shifters transitioning from STEM subjects with traditional credentials. Flexible staffing has helped schools meet rapid demand, but frequent movement in and out of CS roles raises concerns about sustained expertise and long-term capacity building.

VERSION: May 2026

Suggested citation: Yoo, Jiseung, David Blazar, and Jing Liu. (2026). When Demand Outpaces Supply: Flexible Staffing and the Making of Maryland's High School CS Teacher Workforce. (EdWorkingPaper: 26-1469). Retrieved from Annenberg Institute at Brown University: <https://doi.org/10.26300/1dy0-hf07>

When Demand Outpaces Supply: Flexible Staffing and the Making of Maryland's High School CS Teacher Workforce

Jiseung Yoo, David Blazar, Jing Liu

University of Maryland College Park

Abstract

U.S. high schools have rapidly expanded computer science (CS) education over the past decade, resulting in increased pressure to staff classrooms with qualified teachers. This study examines how Maryland high schools responded to rising CS enrollment from school year 2012-13 through 2023-24, focusing on the growth and compositional changes of the CS teacher workforce. CS demand significantly outpaced teacher growth, which was responded by schools via increasing class sizes, recruiting new teachers, and reallocating in-service teachers. Teachers shifting into CS from other subjects outnumbered new entrants, with new entrants more likely to hold CS-specific endorsements and conditional licenses while shifters transitioning from STEM subjects with traditional credentials. Flexible staffing has helped schools meet rapid demand, but frequent movement in and out of CS roles raises concerns about sustained expertise and long-term capacity building.

Keywords: computer science education; teacher quality; teacher qualifications; STEM

This research was supported by generous funding from Google LLC and the Maryland Center for Computing Education. We are grateful for the assistance provided by the MLDS Center. All opinions are the authors' and do not represent the opinion of the MLDS Center or its partner agencies.

Introduction

Over the past decade, “Computer Science for All” initiatives across U.S. states—and around the world—have sought to bring computing training to all K-12 students. Course offerings and enrollments have followed suit. In the 2023-24 school year, 60% of public high schools offered at least one computer science (CS) course, nearly doubling from 35% in 2017-2018 (Code.org, 2024). This rapid expansion reflects more than just education policy momentum: it also responds to profound changes in the global economic and technological landscape. CS education, now increasingly integrated with AI education, serves both to prepare students for computing careers and to equip them with skills like computational thinking and AI literacy that support adaptive problem-solving and informed decision-making in diverse settings (Shein, 2024).

State policy has kept pace with this growing demand. Thirty-eight states have created a statewide plan for K–12 CS, with 12 now requiring CS for high school graduation by 2025 (Code.org, 2025). Maryland, which is the context for this study, is an early leader in this movement. By the 2012–2013 school year, approximately 60% of its high schools offered “high-quality” CS courses (e.g., AP CS, IB CS). This expansion accelerated with state legislative funding in 2018, leading to a point in the 2023–2024 school year where all public high schools in Maryland offered at least one CS course (with 96% offering a high-quality option in 2022–2023). Student enrollment has surged as well. The percentage of Maryland students who took at least one CS course rose from 7% in 2016 to 19% in 2022 (MLDS, 2026).

On one hand, growth in CS course offerings and enrollments align with policy intent and labor force needs. On the other hand, such *rapid* growth raises questions and potential concerns about implementation—namely, the quantity and quality of the CS teacher workforce. While teacher shortages affect many subjects, they are particularly acute in CS (NASEM, 2024).

Individuals with CS expertise have abundant non-teaching career opportunities (Yadav et al., 2016), contributing to a more severe shortage and a lack of stable teacher preparation pipelines as courses rapidly expand (Code.org, 2025). Furthermore, securing a high-quality candidate pool is an essential priority as much as addressing the sheer number of vacancies. In CS education, teacher quality is uniquely critical because rapid technological advances such as AI and cybersecurity continually reshape the content knowledge and pedagogical approaches required for effective instruction (Jetzinger et al., 2024).

In this paper, we extend the CS teacher workforce literature in three ways. First, while prior studies document CS expansion through course availability data (Bruno & Lewis, 2022), none directly compares enrollment growth to teacher workforce growth. We use linked enrollment and teacher assignment records to show that student demand substantially outpaced teacher supply in the context of Maryland, with schools absorbing excess demand partly through increased class sizes.

Second, although research identifies multiple entry routes into CS teaching (Bruno, 2025; CSTA, 2025; Ramagoni & Brylow, 2025), existing studies do not track how the composition of the CS teacher pipeline has evolved or analyze whether different pathways draw on systematically different labor pools. We show that in-service teachers transitioning from other subjects outnumbered newly hired teachers as a source of CS workforce growth. These groups differ substantially in that new entrants were predominantly male and Black with CS-specific endorsements and conditional licenses, whereas shifters were more gender-balanced, predominantly White, and transition from other subjects such as math or business backgrounds with traditional credentials.

Third, existing studies note that CS teaching assignments are often unstable (Bruno, 2025; Ni et al., 2023), but none systematically tracks assignment trajectories over time. We document high year-to-year churn, with substantial movement into and out of CS roles, and show that many teachers gradually shift into CS teaching rather than maintaining stable assignments. In particular, we track continuous reassignment patterns to identify CS teachers who switched out of the subject while remaining in teaching. While Atteberry et al. (2017) documents within-school subject switching as a common practice affecting teacher effectiveness, most turnover and mobility research focuses on teachers leaving schools or the profession entirely (Kistler et al., 2024; Nguyen & Redding, 2018). This subject-level instability within CS represents a gap in the existing literature. Together, these patterns suggest that for many teachers, CS teaching functions as a transitional role rather than a long-term subject specialization.

Our findings reveal that Maryland's CS expansion has relied heavily on internal subject shifters rather than newly recruited CS specialists, with most teachers holding non-CS primary certifications and many cycling through CS assignments on a short-term or low-concentration basis. These patterns raise important questions about instructional quality and student achievement. Our results offer policymakers and school district leaders empirical grounding for understanding the mechanisms driving CS program expansion, while highlighting the long-term institutional risks embedded in current staffing practices. Developing a sustainable pipeline of CS teachers must balance rapid staffing needs with deliberate investments in building a well-supported workforce, including CS-specific training for teachers from diverse backgrounds and opportunities for incremental concentration and specialization.

Motivating Literature

As CS education expands, student demand is increasingly outpacing states' capacity to sustain an adequate teacher workforce (Yadav et al, 2016). CS staffing pressures mirror broader national teacher supply challenges, particularly in STEM and Career and Technical Education (CTE). Shortages occur when open positions exceed the pool of qualified candidates, leading to unfilled vacancies or roles staffed by teachers who are uncertified or underprepared for the subject they teach (Craig et al., 2023; Nguyen et al., 2024). Schools that are rural and serve low-income, and predominantly minority communities face the greatest difficulty attracting and retaining STEM and CTE teachers, making shortages most persistent in these settings (Edwards et al., 2024; Sutchter et al., 2019). CS staffing is further complicated by subject-specific supply constraints. Schools report difficulty filling STEM positions three to four times more often than other subjects, and CTE positions at a rate of 57%, compared to 39% for academic subjects (Goldhaber et al., 2022; Kistler et al., 2024). These challenges are compounded by the administrative positioning of CS within school systems. In many states, CS courses fall under CTE program areas and CS teachers commonly hold CTE credentials rather than traditional academic licenses (Blazar et al., 2024; Bruno, 2025; Werner & Chen, 2025). Collectively, this evidence suggests that CS, straddling both STEM and CTE, faces structural recruitment and retention challenges that limit long-term workforce stability.

Beyond these structural conditions, CS teacher staffing needs are intensified by several distinct factors. The first factor is the rapid increase in demand for qualified CS teachers driven by policy mandates and curriculum expansion. When new subjects are introduced or existing subjects experience enrollment surges, teacher preparation programs and certification pathways cannot immediately scale to meet the need (Bruno & Lewis, 2022). This creates an inevitable supply-

demand gap, a pattern previously observed during the expansion of STEM education in the 1990s and 2000s and, more recently, with the implementation of ethnic studies curricula in California (Dugger, 2010; Penner & Ma, 2023).

The second factor is economic competition. Professionals with CS and technology expertise face high opportunity costs when choosing teaching over more lucrative industry roles (Nguyen, 2025). As a result, attrition rates are notably high, with up to 71% of new CS teachers leaving within four years, indicating a critical need for stronger retention strategies. Nationally, enrollment in preservice CS teacher education programs has declined by nearly half since 2010 (Beyond100K, 2024). These high opportunity costs are compounded by extreme market volatility in the technology sector, also applicable to CS college faculty staffing (VanDeGrift, 2023). Such volatility makes it difficult for individuals with CS training to commit to long-term career paths. Employment downturns in the CS industry (Crunchbase News, 2026), such as those seen in recent years, may temporarily increase decisions to teach CS, but these decisions may reverse when alternative opportunities expand. Recent boom-bust cycles (e.g, during the COVID pandemic and post-massive layoff), create unpredictable conditions that undermine long-term workforce planning (Saba, 2024).

The third factor is a structural disconnect between rapid CS education growth and the fragmented, rigid system of teacher preparation and certification. Early “CS for All” initiatives prioritized recruiting teachers with formal CS training to ensure technical expertise. An early Computer Science Teacher Association (CSTA) reports describes certification barriers as “bugs in the system,” noting that many states required licenses in subjects like business or math rather than CS (Lang et al., 2013). This approach proved unsustainable as the supply of CS-certified graduates could not meet rising demand. In 2020, only 82 out of 150,000 newly certified teachers nationwide

received initial CS certification, far too few to staff the thousands of schools launching CS courses (DOE, 2022). Researchers emphasize that narrow and rigid pathways constrain hiring (Ottenbreit-Leftwich et al., 2022; Liao et al., 2025). Currently, three key certification pathways exist, including initial certification for those with CS or CS education degrees, add-on certification through endorsement programs, and authorization for teachers certified in other subjects who complete additional training or professional development (Ottenbreit-Leftwich et al., 2022; Code.org, 2025). In response, states have adopted a range of approaches, including the use of micro-credentials and training-based CS endorsements for in-service teachers, as well as increased exposure to CS coursework within preservice teacher preparation programs (Vegas et al., 2021).

Several studies document the substantial expansion of CS education with evidence on the growing demand. Code.org's 2025 report, a comprehensive national survey conducted in collaboration with state education agencies and various organizations, shows a near doubling of CS course availability in public high schools, from 35% to 60% between 2017 and 2025. State and district-level analyses reveal similar patterns. In California, CS course offerings grew from 31% to 57% of high schools between 2003 and 2018, with CS enrollments rising from 0.24% to 0.82% of all course enrollments (Bruno & Lewis, 2022). In Chicago, student participation in CS jumped from 22% to over 80% following the enactment of a graduation requirement (McGee et al., 2022). Liu et al. (2024) provided evidence of growing student participation in CS education in Maryland, finding that high quality CS course-taking (e.g. AP CS, CS Principles, Java Programming) rose from approximately 5% of the 2010 9th grade cohort to 20% of the 2017 cohort.

Evidence on the workforce capacity side is more limited and presents a mixed picture of whether CS teacher supply has kept pace with expanding CS course offerings. Code.org (2025) reports that the number of states offering CS-specific teacher certification grew from 27 to 44

between 2017 and 2024. Arkansas, an early leader with 100% of high schools offering CS, expanded its CS-certified teacher workforce from 20 to 400 through state investment (Fowler & Vegas, 2021). However, Ramagoni and Brylow (2025) find that in Wisconsin, a 34% increase in schools offering CS occurred alongside a 20% decline in certified CS teachers. These findings highlight a gap in the literature. While studies document either course expansion or teacher workforce characteristics separately, few directly link enrollment growth to teacher supply or how schools have adapted staffing practices to meet rising demand.

Beyond aggregate supply counts, research has examined the composition and qualifications of the CS teacher workforce. A consistent finding is that CS courses are frequently taught by teachers with non-CS subject backgrounds, suggesting substantial in-service transition into CS instruction. A 2025 CSTA national survey finds that 54% of CS teachers are female and 68% are White. Half of CS teachers teach mostly CS, while the other half teach CS less than 50% of the time. This aligns with the findings from another national survey (Ni et al., 2023), which finds that the majority of CS teachers carries multiple subject teaching assignments, with only 38% having 75% or more of their teaching responsibility in CS. Regarding credentials, the CSTA survey reveals that only 54% hold secondary CS certifications, while 25% hold CTE credentials. State-level administrative data provide more detailed portraits. In North Carolina, Bruno (2025) finds that 67% of CS courses are taught by teachers holding CTE Business and IT Education licenses and that CS teachers average three more years of experience than non-CS teachers, which implies existing teacher transition. More than 50% of CS courses are taught by teachers who also teach CS the previous year.

Despite these contributions, the literature remains limited in three ways. First, while studies document CS expansion through course availability and enrollment data (Bruno & Lewis, 2022;

Bruno, 2025; Code.org, 2025), none directly compares the rate of enrollment growth to the rate of teacher workforce growth. Certified teacher counts alone understate workforce capacity (Ramagoni & Brylow, 2025), as non-CS-certified teachers deliver a substantial portion of CS instruction. A more comprehensive picture requires linking course enrollment data with teacher assignment records and examining institutional responses such as class size adjustments, hiring, reassignment or course elimination that schools commonly used to address teacher shortages (Ingersoll, 2001; Sutchter et al., 2019).

Second, most studies rely primarily on cross-sectional snapshots, leaving longitudinal workforce dynamics unexplored. Although research identifies multiple entry points into CS teaching, no study systematically quantifies the relative contributions of newly hired teachers versus in-service teachers transitioning from other subjects to clearly picture how CS education is staffed. Third, while existing studies note that CS teaching assignments are often unstable (Bruno, 2025; Ni et al., 2023), no research systematically tracks year-to-year assignment trajectories. It remains unclear whether teachers gradually increase their CS concentration, maintain stable assignments, or cycle in and out of CS roles. Building on this limitation, we present an approach to identify “droppers” who teach CS in a given year but discontinue CS instruction in subsequent years while remaining in the teaching profession. By distinguishing droppers from teachers who exit teaching entirely, we isolate subject-specific discontinuation from general teacher turnover, enabling a more precise understanding of CS workforce dynamics and revealing a previously unmeasured dimension of workforce instability (Atteberry et al., 2017).

Our study addresses these gaps using three research questions in the context of Maryland: (1) How have enrollments in CS courses changed over the past decade in public high schools, and how has the CS teacher workforce grown? (2) How have schools staffed CS courses? (3) What are

the credentials, professional backgrounds, and assignment patterns of CS teachers, and how do these differ by entry pathway?

Research Design

Sample and Data

The context for our study is the state of Maryland, which initiated its commitment to expanding access to CS education through the “Securing the Future: Computer Science Education for All” legislation (HB 281) enacted in 2018 (Maryland General Assembly, 2018). This foundational policy mandated that all public high schools offer at least one High-Quality CS (HQ CS) course and simultaneously established the Maryland Center for Computing Education (MCCE). The MCCE aimed to expand CS to elementary and middle schools by 2022 and increase CS enrollment among underrepresented groups, including females, students with disabilities, and students from diverse racial and ethnic backgrounds (MCCE, 2023).

To sustain expansion and support instructional quality, Maryland staffs CS courses through multiple pathways. Traditional routes include CS education degree programs, while alternative certification includes the Conditional License (for employed teachers completing requirements, not tied to a preparation program) and the Resident Teacher License (for candidates completing a structured, state-approved alternative program) (Blazar et al., 2024; DOE, 2024). This dual-path model supports lateral entry and accelerates certification. Maryland also uses subject endorsements to designate approved teaching areas and has broadened CS eligibility to include teachers certified in adjacent fields, especially math and business (DOE, 2024).

Our analyses use statewide public-school data from Maryland, accessed through the Maryland Longitudinal Data System (MLDS) Center, which maintains records for all teachers and students in public schools beginning in the 2007–2008 school year. For this study, we focus on

high schools, the primary setting for CS instruction, and restrict the sample to the 2012-13 through 2023–2024 school years. We begin in 2012–13 as it is the first year when course roster data are available. These data allow us to precisely identify CS courses, CS course-takers, and the associated teachers. We also have access to comprehensive teacher workforce data that contains information on their credentials, demographics, teaching experiences, and job assignments, which are critical for our analyses.

We define CS courses following definitions established by the MCCE, which designates CS courses as those aligned with the 10-series Information Technology (IT) SCED code. Within this category, HQ CS courses are designated as advanced CS offerings. In addition, we define CS teachers as those whose annual course load consists of at least 50% CS-designated courses (1,120 unique teachers; 3,511 teacher-year observations). Advanced CS teachers represent a subset whose annual course load is at least 50% in HQ CS courses (706 unique teachers; 1,875 teacher-year observations).

To examine staffing patterns, we categorize CS teachers and track year-to-year movement into and out of CS teaching roles. Following previous work on teacher mobility research (Carver-Thomas & Darling-Hammond, 2017) and tracking teacher class assignment (Kalogrides et al, 2013), we define four mutually exclusive CS teacher transition groups: (1) new entrants, (2) shifters, (3) continuers, and (4) droppers. New entrants are teachers who began teaching CS in a given year without prior teaching experience in Maryland, as identified in the MLDS data. Shifters are teachers who previously taught non-CS subjects, either within STEM or non-STEM areas, and transitioned into CS instruction. Continuers are teachers who consistently taught CS, defined as those with a CS teaching assignment in both the current and previous year. Droppers are teachers

who exited CS instruction by moving to another subject area, meaning they taught CS in the prior year but teach another subject in the current year.

Method

This paper presents a descriptive analysis. First, we document trends in student enrollment in CS courses, CS course offerings as a share of all high school courses, and the size of the CS teacher workforce over the 12-year study period. Second, we examine how schools have accommodated rising CS enrollment. We track changes in average CS class size over time, comparing trends to STEM courses and the broader curriculum. On the supply side, we analyze year-to-year teacher transitions to quantify the relative contributions of new entrants, shifters, continuers, and droppers to CS staffing. We further investigate the subject-area origins of shifters and the destination subjects of droppers to understand whether teachers leaving CS to other subjects reduce their CS teaching load or exit entirely for other assignments.

Finally, we describe the demographic characteristics, licensure status, endorsement areas, and educational attainment of CS teachers. We conduct two sets of comparisons. First, we compare new CS teachers to new teachers in other subject areas to identify distinctive features of those entering CS instruction. Second, we compare across the four transition categories to examine whether teachers following different pathways bring systematically different professional backgrounds and credentials to their assignments.

Results

Growth in CS Enrollment and Teacher Workforce

Our analysis identifies a substantial increase in CS demand in Maryland high schools over the past several years. Figure 1, Panel A shows trends in CS course offerings (left y-axis) and course enrollments (right y-axis), which both increased substantially over the 12-year period that

our data cover. The share of high-school students taking at least one CS course grew from 6.4% in SY 2012-13 to 20.8% in SY 2023-24. CS courses doubled as a share of all offerings (1.4% to 2.7%). Similarly, in Panel B, we show that the number of CS teachers increased from 178 to 438 (1.0% to 2.4% of the high-school teacher workforce), and advanced CS teachers grew even faster from 38 to 288 (0.2% to 1.6%).

A key finding is the discrepancy between the rapid growth in students taking CS courses and the modest increase of CS teacher workforce. Between the measured periods, the proportion of students taking CS surged by 225%, while the growth in the teacher workforce was only 140%. This gap indicates that schools faced increasing difficulty in staffing CS courses adequately, as student demand significantly outpaced the growth of CS teachers. The resulting imbalance might create pressure for schools to adapt and innovate so they can keep up with the demand for CS courses. As we show below, schools responded to rising CS enrollments in three main ways: first, by enlarging class sizes; second, by hiring new CS teachers through diverse pathways; and third, by transitioning existing teachers into CS roles.

Increase in CS Class Size

Many studies on teacher shortages have found that schools often respond to such challenges by adjusting institutional mechanisms, particularly class size (Ingersoll, 2001; Sutchter et al., 2019). Our analysis of Maryland data reveals a similar pattern in CS courses, with substantial growth in average class sizes. As shown in Figure 2, average CS class sizes increased from 14.8 to 18.2 students (23%) over the decade, while advanced CS classes grew from 15.5 to 20.2 students (30%). These increases outpaced growth in both general high school courses (17.3 to 18.5, or 7%) and STEM courses more broadly (17.5 to 19.3, or 10%). While we cannot definitively determine whether rising CS class sizes were driven more by student demand or teacher shortages, the data

suggest schools responded pragmatically to enrollment pressures. Both factors likely played a role. Growing student interest increased enrollment, while limited teacher growth constrained staffing options, leaving schools to manage the imbalance by increasing class sizes. This uncertainty underscores the need for future research to disentangle the relative influence of demand and supply.

CS Teacher Staffing and Transitions

We further observe that schools recruited new entrants and reassigned in-service teachers from other disciplines to CS to address rising CS enrollments. Panel A of Figure 3 shows the number of all CS teachers who fall into each of the four staffing buckets (i.e., new entrants, shifters, continuers, droppers), while Panel B shows similar patterns for teachers working in HQ CS. New entrants (red bars) grew from 13 to 43, representing 8% of the CS teacher workforce on average across years. In contrast, shifters (teachers who changed subject areas; green bars) grew from 40 to 71, making up roughly 20% of CS teachers on average and a growing share over time. The advanced CS teacher group illustrates this pattern even more clearly given that 31% of this population are shifters, while only 8% are new entrants. These patterns indicate that while schools did bring in external hires, they relied more heavily on internal reassignments to meet demand. This reliance on shifters aligns with findings from previous studies in Wisconsin (Ramagoni & Brylow, 2025) and North Carolina (Bruno, 2025), which show that transitions of existing teachers from other subjects constitute a substantial portion of the high school CS workforce (Yadav et al., 2016)

While continuing CS teachers (yellow bars) naturally accumulated, a sizable and growing share of CS teachers dropped this subject (blue bars) and moved to other content areas. On average, 67% of CS teachers continued from the previous year, while 13% left CS for other subjects.

Advanced CS instruction leaned even more on reassignments, with 55% being continuers and 19% transitioned out. These subject drop rates are notably high compared to other contexts. Atteberry et al. (2017) reported that the subject switch rate is around 10% at the high school level based on longitudinal New York City data. Our CS subject drop rates of 13% to 19% exceed this benchmark and capture only teachers who moved to other content areas while remaining in the classroom. If we also counted those who left teaching altogether, total CS turnover would be higher still. For comparison, CTE teachers exit teaching entirely at a rate of 10% annually in Tennessee (Kistler et al., 2024). This pattern points to a notably unstable CS teacher workforce. As CS instruction faces distinctive pressures from rapid technological change (Menekse, 2015), frequent transitions in and out of CS roles can disrupt the accumulation of expertise, professional growth, and the implementation of coherent, high-quality curricula.

CS teacher assignment trajectories reveal highly fluid movement into CS roles. Teachers gradually increased their CS concentration, while exit was similarly gradual, with most droppers reducing their CS teaching load and later switching to other subjects. Using the Sankey diagram in Figure 4, we see that among shifters (Panel A), 87% came from other STEM subjects, while 13% came from non-STEM subjects. Of the STEM shifters, most had some prior CS teaching below our 50% threshold, suggesting gradual concentration increases rather than abrupt subject switches. However, this “smooth” entry into the field was offset by frequent transitions out of CS roles. Among teachers exiting CS (Panel B), most remained in STEM-related instruction: 68% continued teaching some CS but below the 50% threshold, and 18% moved to non-CS STEM subjects. Only 13% exited to non-STEM fields entirely. Even teachers who remained in STEM often shifted away from CS instruction, illustrating that teacher assignments are fluid rather than stable.

CS Teacher Background

Documenting who teaches CS and how teacher preparation differs by entry pathway provides foundational evidence on whether current staffing practices are developing a workforce equipped to deliver quality CS instruction. We analyzed new CS teachers' backgrounds by comparing them to other subject groups and the broader high school teacher workforce, as well as by their entry pathways, revealing several distinctive characteristics. Table 2, Panel A summarizes the background characteristics of new CS teachers compared to other groups' new teachers (STEM, non-STEM, and all subjects). Overall, new CS teachers differ substantially from the high school workforce as a whole. Specifically, only 37% were women (vs. 61% of all new teachers and 57% of STEM). A larger share (40%) was Black (vs. 23% of all teachers), consistent with research showing Black teachers are overrepresented in Maryland CTE fields (Blazar et al., 2024), where many CS courses are housed. CS teachers were also more likely to enter with a conditional license (67% vs. 32% of all new high school teachers). About one-quarter entered with a CS endorsement, and another quarter entered with a Professional and Technical Education (PTE) license, which allows substitution of industry experience for formal training and does not require a BA. As a result, 8% entered with a high school diploma or associate degree. Another quarter held endorsements in aligned fields, primarily CTE subjects (Business, Marketing, Technology Education) or math. These patterns suggest that Maryland relies not only on CS-certified candidates but also on teachers with adjacent subject licenses—both in STEM and CTE—allowing schools to fill positions quickly while maintaining a diverse workforce. However, the prevalence

of non-CS credentials underscores the need for subject-specific CS training to ensure instructional quality across these varied entry pathways (Wente & Mühling, 2025).

Understanding who flows into, remains in, or leaves CS roles allows us to examine teacher supply, workforce stability, and implications for instructional continuity. Based on Panel B in Table 2, Maryland relied on both new entrants and experienced teachers shifting into CS roles (shiffters, continuers), but these groups differ demographically and professionally. New entrants are predominantly male (62%) and Black (40%), whereas shiffters are more gender-balanced (53% male) and mostly White (66%), reflecting the existing workforce. Shiffters most commonly transitioned from math (19%) or business (18%), while continuers most often hold math (29%) or CS (17%) endorsements. Teachers leaving CS roles were disproportionately endorsed in business (21%) or math (16%). Taken together, these patterns reveal a diverse workforce entering CS through varied pathways, each bringing distinct professional backgrounds and credentials to the classroom. These varied pathways and credentials may carry implications for workforce stability, as prior research links licensure, course-load commitment, and CS teaching experience to teachers' professional identity in the CS subject (Ni et al., 2023).

Discussion and Implications

This study examines how Maryland high schools staffed CS courses amid rapid enrollment growth. We contribute to the literature in three ways. First, by linking enrollment and teacher assignment data, we document a substantial supply-demand gap. Student enrollment in CS grew by 225% while the teacher workforce grew by 140%, with schools absorbing excess demand partly through increased class sizes. Second, we quantify the relative contributions of different entry pathways and find that teachers shifting from other subjects consistently outnumbered newly hired

CS teachers, particularly in advanced CS instruction. Third, we characterize the backgrounds of CS teachers across pathways. Most hold non-CS primary certifications, and new entrants and shifters differ substantially in demographics, licensure, and endorsement areas. We also document high churn in CS assignments, with frequent movement into and out of CS roles suggesting that for many teachers, CS teaching is not a sustained subject specialization.

These patterns carry implications for policy and practice, though we acknowledge that descriptive findings cannot establish which staffing approaches produce the best instructional outcomes. The prevalence of shifters from STEM backgrounds suggests that formal transition pathways, such as tiered certification systems allowing gradual increases in CS responsibility, could help schools leverage existing human capital while building CS-specific expertise over time. This finding aligns with recent work that finds CS teachers are often well-qualified through holding full teaching credentials and accumulating years of classroom experience despite lacking CS-specific preparation (Bruno & Lewis, 2022). Indeed, the diversity of entry pathways may bring varied perspectives and industry experience into classrooms.

However, our findings suggest that the current staffing model may not support teachers in developing continuous CS expertise. First, many CS teachers face fragmented workloads within a given year. Shifters who transitioned into CS roles still devoted only 62% of their load to CS on average, while droppers who exited CS continued teaching the subject at 26% of their load. These split assignments dilute teachers' focus on CS-specific content and pedagogy, a pattern consistent with broader STEM research on fragmented workloads (Luft et al., 2020; Thompson Lee et al., 2025). Second, beyond within-year fragmentation, teachers might experience instability across years as they move into and out of CS roles. Teachers entering through either pathway could potentially develop CS expertise over time, but the high rate of churn could interrupt this trajectory.

Each time teachers exit and re-enter CS instruction, they may experience a re-novicing effect, losing accumulated expertise and restarting the learning curve (Atteberry et al., 2017). Third, this instability undermines the development of professional identity. Research suggests that sustained subject-area commitment is associated with stronger teaching identity and instructional investment (Ni et al., 2023). Frequent transitions in and out of CS roles may prevent teachers from forming a stable identification with CS as their professional domain.

Together, these dynamics raise questions about the sustainability of the current CS teacher pipeline. When teachers face fragmented workloads, remain perpetually out-of-field, and lack opportunities to develop strong professional identities, the system struggles to build and retain the deep expertise that effective CS instruction demands. Policymakers might therefore consider strategies that promote more concentrated and sustained CS assignments, allowing teachers to accumulate the subject-specific experience associated with instructional improvement (Kini & Podolsky, 2016).

Despite our contributions, several limitations remain that need to be overcome in future studies. For example, administrative data cannot capture teachers' intentions or preferences, so we cannot determine whether transitions reflect individual choices, administrative reassignments, or lack of support. Future research should examine whether entry pathway and credentialing predict retention and, ultimately, student outcomes, which are questions our descriptive analyses cannot address. Qualitative work that explores teachers' experiences navigating CS assignments would complement these administrative data by illuminating the mechanisms underlying the workforce dynamics we observe.

References

- Atteberry, A., Loeb, S., & Wyckoff, J. (2017). Teacher Churning: Reassignment Rates and Implications for Student Achievement: Reassignment Rates and Implications for Student Achievement. *Educational Evaluation and Policy Analysis*, 39(1), 3-30. <https://doi.org/10.3102/0162373716659929>
- Beyond100K. (2024). "Our Approach." <https://beyond100k.org/our-approach/>
- Blazar, D., Song, D., Goings, R., Plasman, J., & Gottfried, M. (2024). *Pathways into the CTE teaching profession: A descriptive analysis of degrees, licenses, and race in Maryland*. (EdWorkingPaper: 24-975). Retrieved from Annenberg Institute at Brown University
<https://doi.org/10.26300/ffyy-z977>
- Bruno, P. (2025). Who teaches high-school computer science, and does it matter? *Computer Science Education*, 1–30. <https://doi.org/10.1080/08993408.2025.2464489>
- Bruno, P., & Lewis, C. M. (2022). Computer science trends and trade-offs in California high schools. *Educational Administration Quarterly*, 58(3), 386–418. <https://doi.org/10.1177/0013161X211054801>
- Carver-Thomas, D. & Darling-Hammond, L. (2017). *Teacher turnover: Why it matters and what we can do about it*. Palo Alto, CA: Learning Policy Institute.
- Craig, C. J., Hill-Jackson, V., & Kwok, A. (2023). Teacher shortages: What are we short of? *Journal of Teacher Education*, 74(3), 209–213. <https://doi.org/10.1177/00224871231166244>
- CrunchBase News (2026). The Crunchbase Tech Layoffs Tracker. Retrieved from <https://news.crunchbase.com/startups/techlayoffs/#:~:text=By%20the%20numbers,tech%20companies%20in%20the%20U.S>
- Code.org, CSTA, ECEP Alliance (2025). 2025 State of Computer Science Education. Retrieved from <https://advocacy.code.org/stateofcs>
- CSTA (2025). The 2025 Computer Science Teacher Landscape Report. Retrieved from <https://landscape.csteachers.org/>
- Dugger, W. E. (2010, December). *Evolution of STEM in the United States*. Paper presented at the 6th Biennial International Conference on Technology Education Research, Queensland, Australia.
- Edwards, D. S., Kraft, M. A., Christian, A., & Candelaria, C. A. (2024). Teacher shortages: A framework for understanding and predicting vacancies. *Educational Evaluation and Policy Analysis*, 01623737241235224. <https://doi.org/10.3102/01623737241235224>
- Fowler, B., & Vegas, E. (2021). How England Implemented Its Computer Science Education Program. *Center for Universal Education at The Brookings Institution*.
- Goldhaber, D., Krieg, J., Theobald, R., & Goggins, M. (2022). Front end to back end: Teacher preparation, workforce entry, and attrition. *Journal of Teacher Education*, 73(3), 253-270.
- Ingersoll, R. M. (2001). Teacher turnover and teacher shortages: An organizational analysis. *American educational research journal*, 38(3), 499-534.
- Jetzinger, F., Baumer, S., & Michaeli, T. (2024, March). Artificial intelligence in compulsory K-12 computer science classrooms: A scalable professional development offer for computer

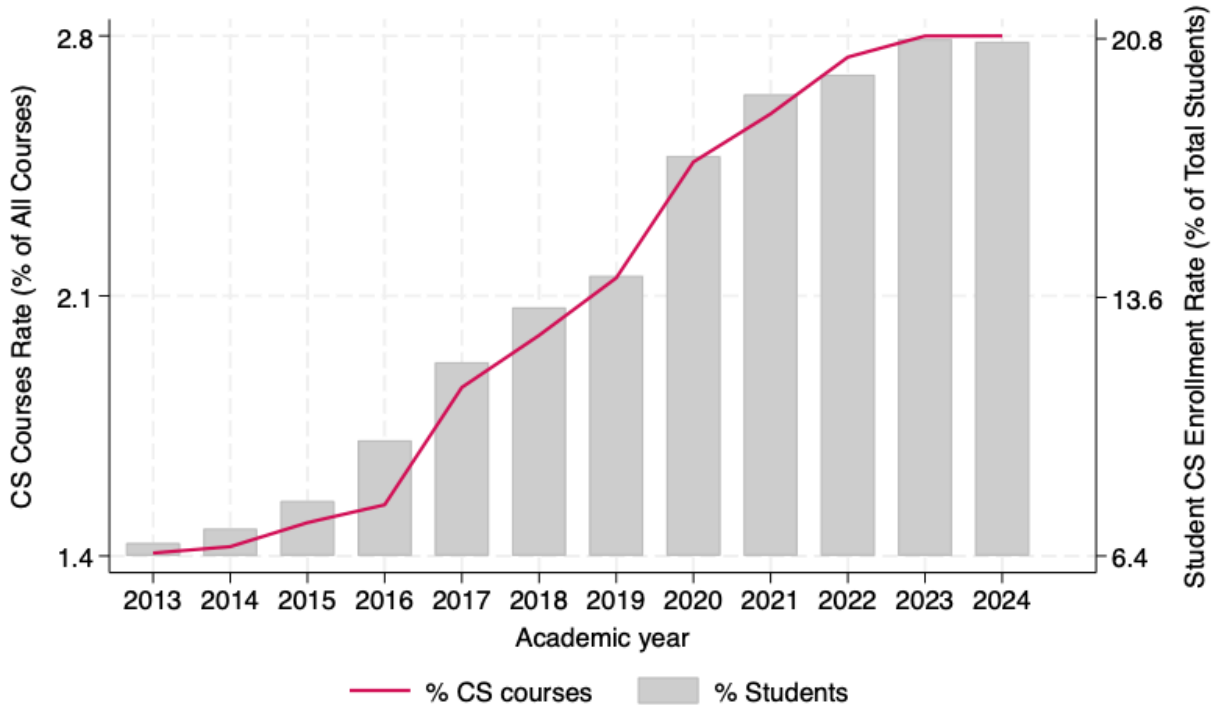
- science teachers. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1* (pp. 590-596).
- Kalogrides, D., Loeb, S., & Bételle, T. (2013). Systematic sorting: Teacher characteristics and class assignments. *Sociology of Education*, 86(2), 103-123. <https://doi.org/10.1177/0038040712456555>
- Kini, T., & Podolsky, A. (2016). Does Teaching Experience Increase Teacher Effectiveness? A Review of the Research. *Learning Policy Institute*.
- Kistler, H., Dougherty, S. M., & Woods, S. C. (2024). Teacher exit and educational opportunity: Lessons from career and technical education. *Educational Researcher*, 53(3), 156–166. <https://doi.org/10.3102/0013189X231223132>
- Lang, K., Galanos, R., Goode, J., Seehorn, D., Trees, F., Phillips, P., & Stephenson, C. (2013). Bugs in the system: Computer science teacher certification in the US. *The Computer Science Teachers Association and The Association for Computing Machinery*.
- Liao, Y. C., Karlin, M., Margulieux, L., & Calandra, B. (2025). Building Bridges, Breaking Barriers: Exploring the Dynamics and Key Factors Shaping Computer Science Education Pathways in Teacher Preparation. *Journal of Technology and Teacher Education*, 33(1), 5-35.
- Liu, J., Conrad, C., & Blazar, D. (2024). Computer science for all? The impact of high school computer science courses on college majors and earnings. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4709691>
- Luft, J. A., Hanuscin, D., Hobbs, L., & Törner, G. (2020). Out-of-field teaching in science: An overlooked problem. *Journal of Science Teacher Education*, 31(7), 719-724. <https://doi.org/10.1080/1046560X.2020.1814052>
- Maryland General Assembly. (2018). “Securing the Future: Computer Science Education for All,” <https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/hb0281?ys=2018RS&search=True>. Last accessed on January 22, 2026.
- Maryland State Department of Education. (2024). *Pathways to initial licensure*. <https://marylandpublicschools.org/about/pages/dee/certification/routes-to-initial-certification.aspx>. Last accessed on January 22, 2026.
- Maryland Longitudinal Data System (MLDS). (2026), “Maryland Computer Science Dashboard,” <https://mldscenter.maryland.gov/ComputerscienceDashboard.html>. Last accessed on January 22, 2026.
- McGee, S., Dettori, L., & Rasmussen, A. (2022). *Impact of the CPS computer science graduation policy on student access and outcomes*. The Learning Partnership. <https://doi.org/10.51420/report.2022.4>
- Menekse, M. (2015). Computer science teacher professional development in the United States: A review of studies published between 2004 and 2014. *Computer Science Education*, 25(4), 325–350. <https://doi.org/10.1080/08993408.2015.1111645>
- National Academies of Sciences, Engineering, and Medicine (NAEM; 2024). *Equity in K-12 STEM education: Framing decisions for the future*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26859>
- Nguyen, T. D. (2025). The supply and quality of STEM teachers. *Humanities and Social Sciences Communications*, 12(1), 359. <https://doi.org/10.1057/s41599-025-04648-8>
- Nguyen, T. D., Lam, C. B., & Bruno, P. (2024). What do we know about the extent of teacher shortages nationwide? A systematic examination of reports of U.S. teacher shortages. *AERA Open*, 10, 23328584241276512. <https://doi.org/10.1177/23328584241276512>

- Nguyen, T. D., & Redding, C. (2018). Changes in the demographics, qualifications, and turnover of American STEM teachers, 1988–2012. *AERA Open*, 4(3), 2332858418802790. <https://doi.org/10.1177/2332858418802790>
- Ni, L., Tian, Y., McKlin, T., & Baskin, J. (2023). Who is teaching computer science? Understanding professional identity of American computer science teachers through a national survey. *Computer Science Education*, 34(2), 285–309. <https://doi.org/10.1080/08993408.2023.2195758>
- Ottenbreit-Leftwich, A. T., Childs, J., Fletcher, C., Kim, J., Edwards, K. M., & Hendrickson, K. (2022). Defining computer science teacher qualification pathways. *Policy Futures in Education*, 14782103221123364. <https://doi.org/10.1177/14782103221123364>
- Penner, K., & Dan Ma. (2023). Access to Ethnic Studies in California Public Schools. (EdWorkingPaper: 23-886). Retrieved from Annenberg Institute at Brown University: <https://doi.org/10.26300/5ffx-4727>
- Ramagoni, S. G., & Brylow, D. (2025). Addressing the computer science teacher shortage: A case study of Wisconsin public high schools. *Proceedings of the 56th ACM Technical Symposium on Computer Science Education V. 1*, 945–951. <https://doi.org/10.1145/3641554.3701952>
- Saba, Z. (2024). Layoffs and corporate performance: evidence based on the US tech industry. *Journal of Economics and Finance*, 48(3), 644-667.
- Shein, E. (2024). The impact of AI on computer science education. *Communications of the ACM*, 67(9), 13–15. <https://doi.org/10.1145/3673428>
- Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2019). Understanding teacher shortages: An analysis of teacher supply and demand in the United States. *Education Policy Analysis Archives*, 27, 35. <https://doi.org/10.14507/epaa.27.3696>
- Thompson-Lee, S., See, B. H., & Klassen, R. M. (2025). A systematic review of STEM teacher recruitment and retention interventions. *International Journal of STEM Education*, 12(1), 33.
- U.S. Department of Education, Office of Postsecondary Education. (2022). *Preparing and Credentialing the Nation's Teachers: The Secretary's Report on the Teachers Workforce*. <https://title2.ed.gov/>
- VanDeGrift, T. (2023, March). Alumni as Teachers and Mentors for CS 1 Students: Solving the Staffing Shortage and Students' Reflections about Career and College Advice. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1* (pp. 1124-1130).
- Vegas, E., Hansen, M., & Fowler, B. (2021). *Building skills for life: How to expand and improve computer science education around the world*. The Brookings Institution.
- 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?* Chicago, IL: Illinois Workforce and Education Research Collaborative (IWERC). <https://dpi.uillinois.edu/applied-research/iwerc/current-projects/cs-ed-research/>
- Wente, P., & Mühlhling, A. (2025). Subject and educational beliefs of CS teachers: How career pathways can affect computer science education. *Computer Science Education*, 1–41. <https://doi.org/10.1080/08993408.2025.2580656>
- Yadav, A., Gretter, S., Hambrusch, S., & Sands, P. (2016). Expanding computer science education in schools: Understanding teacher experiences and challenges. *Computer Science Education*, 26(4), 235–254. <https://doi.org/10.1080/08993408.2016.1257418>

Figures and Tables

Figure 1. Share of CS Courses, Students, and CS teachers in Maryland High Schools

Panel A: Share of CS Courses and Students



Panel B: Share and Number of CS Teachers

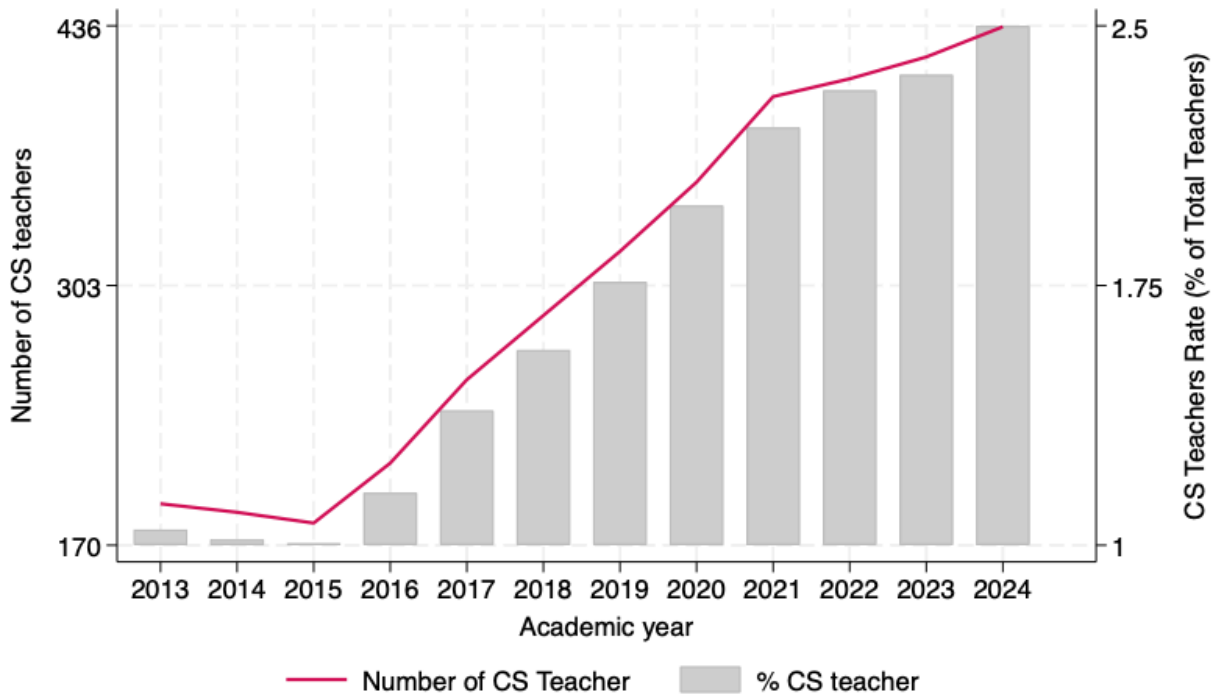


Figure 2. Average Class Size per Teacher Over Time

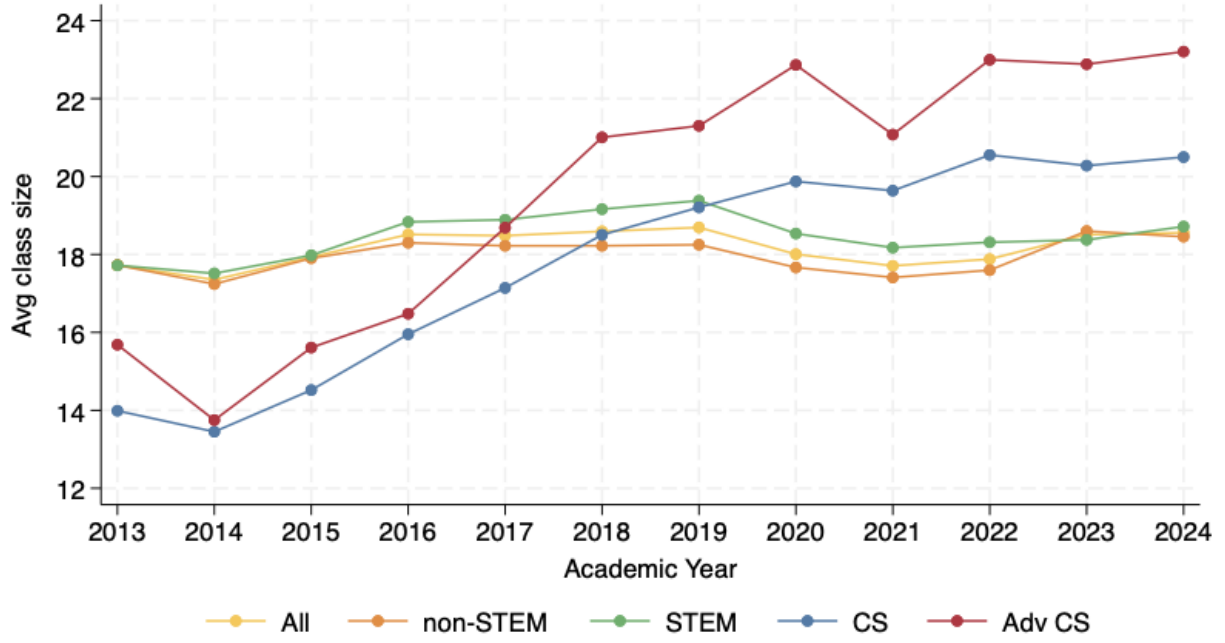


Figure 3. Time Trends in CS Staffing Patterns

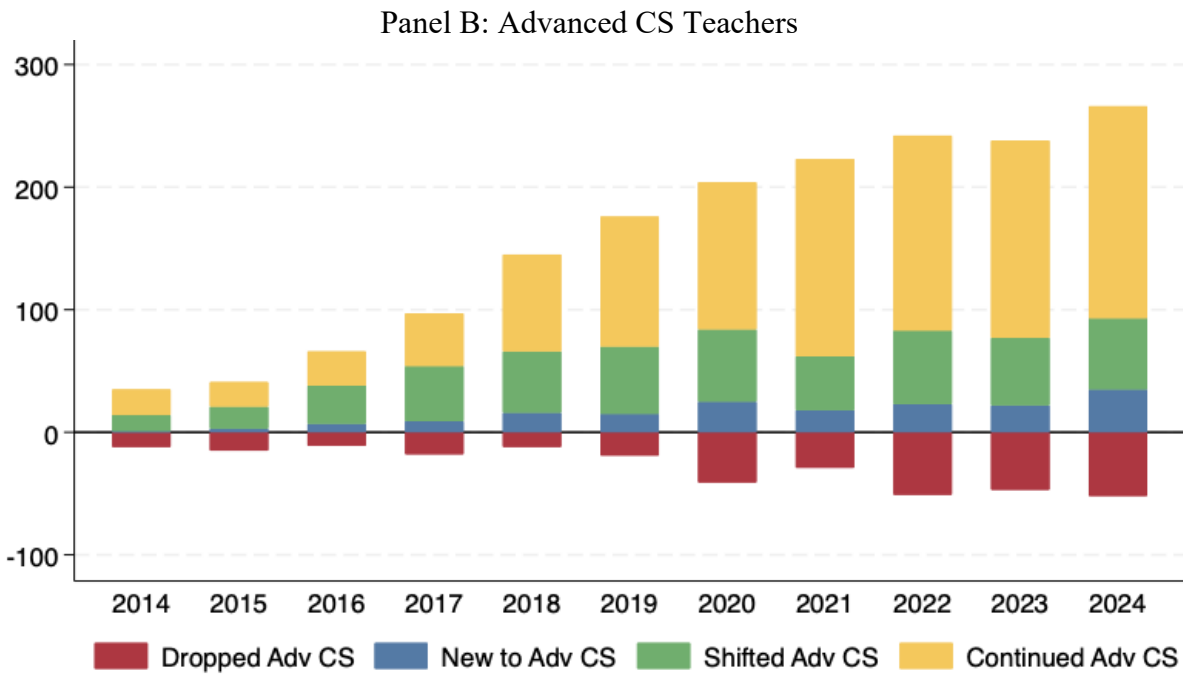
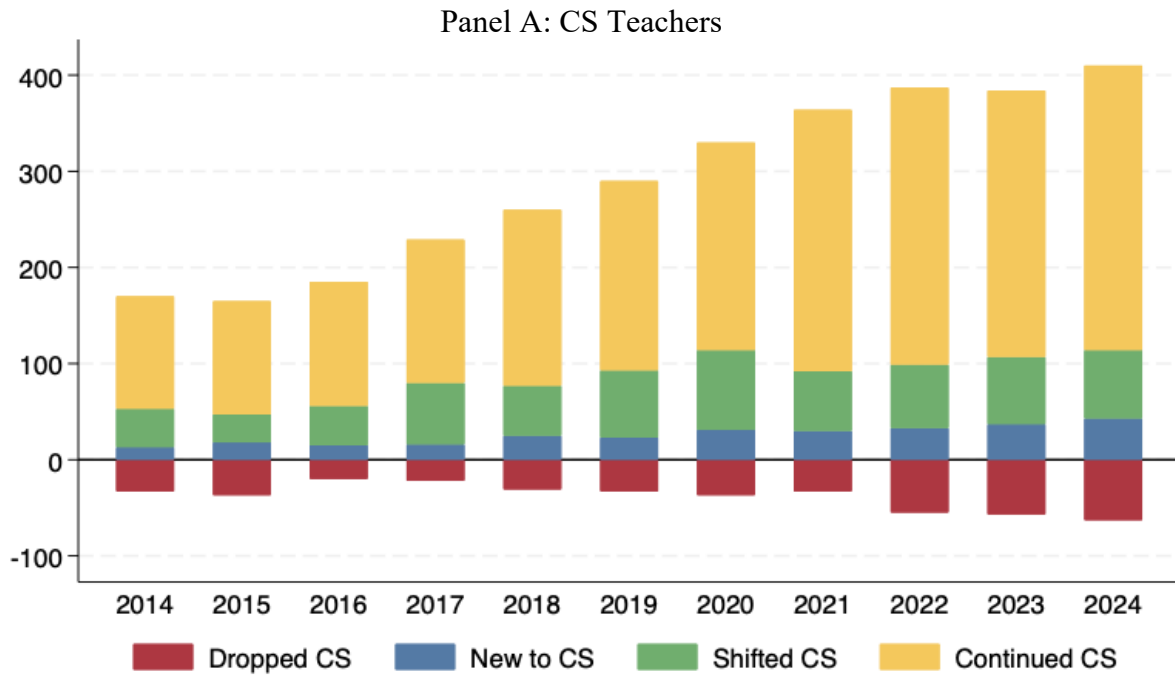
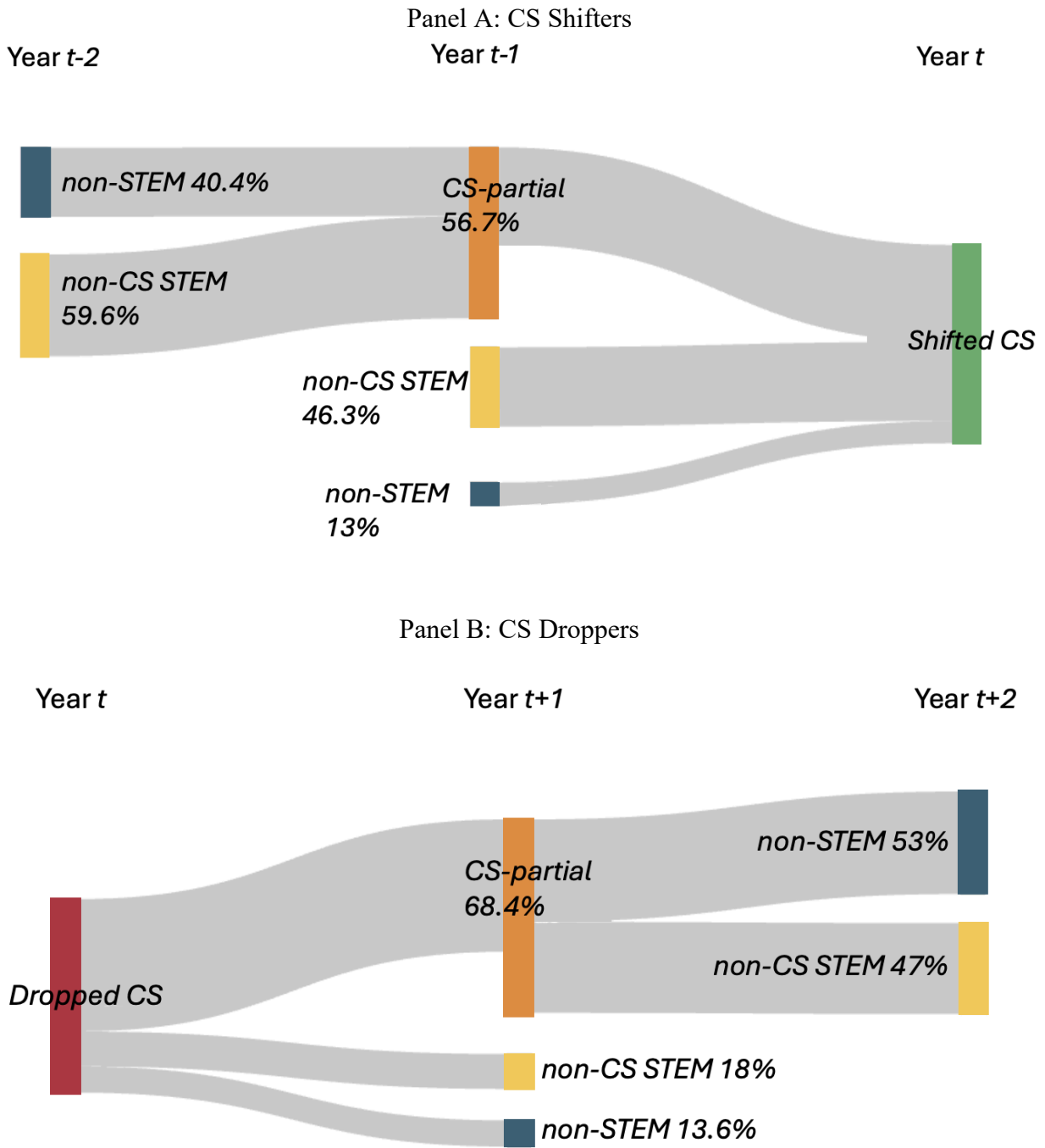


Table 1. Composition of CS Teachers and Advanced CS Teachers

	CS Teachers				Advanced CS Teachers			
	New entrants	Shifters	Continuers	Droppers	New entrants	Shifters	Continuers	Droppers
2014	6%	20%	58%	16%	2%	28%	45%	26%
2015	9%	14%	58%	18%	5%	32%	36%	27%
2016	7%	20%	63%	10%	9%	40%	36%	14%
2017	6%	25%	59%	9%	8%	39%	37%	16%
2018	9%	18%	63%	11%	10%	32%	50%	8%
2019	7%	22%	61%	10%	8%	28%	54%	10%
2020	8%	23%	59%	10%	10%	24%	49%	17%
2021	8%	16%	69%	8%	7%	17%	64%	12%
2022	7%	15%	65%	12%	8%	20%	54%	17%
2023	8%	16%	63%	13%	8%	19%	56%	16%
2024	9%	15%	63%	13%	11%	18%	54%	16%
Total	284	648	2242	421	174	488	1071	307

Figure 4. Trajectories Into and Out of Teaching CS



Note: CS-partial teachers is defined as having less than 50% of their workload in CS and teach more than one CS course in a year.

Table 2. Characteristics of Maryland High School Teacher by Subject and Pathway

Characteristics	Panel A: New Teachers					Panel B: CS Teachers by Pathway			
	All	non-STEM	STEM	CS	Adv CS	CS New Entrants	CS Shifters	CS Continuers	CS Droppers
Demographics									
Years of Experience	3.23	3.27	3.18	4.61	4.77	4.61	12.06	13.83	13.36
Age	34.53	34.53	34.53	39.66	40.25	39.66	45.04	46.72	45.88
Female	0.61	0.64	0.58	0.38	0.37	0.38	0.46	0.41	0.47
Male	0.38	0.36	0.42	0.62	0.62	0.62	0.53	0.57	0.53
Other Gender	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
Asian	0.05	0.03	0.08	0.08	0.10	0.08	0.03	0.04	0.05
Black	0.24	0.25	0.23	0.41	0.36	0.41	0.26	0.24	0.28
Hispanic	0.07	0.09	0.05	0.05	0.06	0.05	0.02	0.01	0.02
White	0.61	0.60	0.62	0.43	0.44	0.43	0.66	0.67	0.63
Other Race	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.02
License/Certification									
Traditional	0.60	0.63	0.56	0.32	0.32	0.32	0.70	0.66	0.71
Conditional	0.33	0.32	0.35	0.67	0.67	0.67	0.26	0.31	0.26
Resident Teacher	0.07	0.05	0.09	0.01	0.01	0.01	0.04	0.03	0.03
Degree									
HS/AA	0.03	0.03	0.02	0.08	0.03	0.08	0.01	0.05	0.02
BA	0.57	0.56	0.58	0.51	0.50	0.51	0.50	0.42	0.47
MA+	0.40	0.41	0.40	0.42	0.46	0.42	0.49	0.53	0.50
Entry Subject Area									
Computer Science	0.01	0.00	0.02	0.24	0.29	0.24	0.08	0.17	0.08
Prof./Tech. Education	0.05	0.05	0.04	0.24	0.10	0.24	0.05	0.12	0.06
Missing	0.10	0.11	0.09	0.15	0.20	0.15	0.01	0.00	0.01
Business Ed./Marketing	0.02	0.02	0.03	0.09	0.12	0.09	0.18	0.12	0.21
Technology Education	0.02	0.00	0.04	0.08	0.11	0.08	0.12	0.09	0.10
Math	0.12	0.00	0.29	0.06	0.09	0.06	0.19	0.29	0.16
Elementary Education	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.04
Working Conditions									
Avg. class size	18.63	18.49	18.82	20.05	23.09	20.05	19.78	18.37	18.76
CS course ratio	0.02	0.00	0.04	0.78	0.79	0.80	0.62	0.83	0.26
STEM course ratio	0.32	0.00	0.81	0.88	0.90	0.89	0.80	0.91	0.56
Teachers	13,568	8,021	5,547	301	175	301	648	2242	421

