ANNENBERG
BROWN UNIVERSITY

EdWorkingPaper No. 24-945

Disparate Pathways: Understanding Racial Disparities in Teaching

David Blazar
University of Maryland
College Park

Max Anthenelli
University of Maryland
College Park

Wenjing Gao
University of Maryland
College Park

Ramon Goings
University of Maryland,
Baltimore County

Seth Gershenson
American University & IZA

Mounting evidence supporting the advantages of a diverse teacher workforce prompts policymakers to scrutinize existing recruitment pathways. Following four cohorts of Maryland public high-school students over 12 years reveals several insights. Early barriers require timely interventions, aiding students of color in achieving educational milestones that are prerequisites for teacher candidacy (high school graduation, college enrollment). While alternative pathways that bypass traditional undergraduate teacher preparation may help, current approaches still show persistent racial disparities. Data simulations underscore the need for race-conscious policies specifically targeting or differentially benefiting students of color, as race-neutral strategies have minimal impact. Ultimately, multiple race-conscious policy solutions addressing various educational milestones must demonstrate significant effects—approximately 30% increases—to reshape the teacher workforce to align with student body demographics.

VERSION: April 2024

Suggested citation: Blazar, David, Max Anthenelli, Wenjing Gao, Ramon Goings, and Seth Gershenson. (2024). Disparate Pathways: Understanding Racial Disparities in Teaching. (EdWorkingPaper: 24-945). Retrieved from Annenberg Institute at Brown University: https://doi.org/10.26300/4c4b-4q21

Disparate Pathways: Understanding Racial Disparities in Teaching

David Blazar, Max Anthenelli, Wenjing Gao, *University of Maryland College Park*
Ramon Goings, *University of Maryland, Baltimore County*
Seth Gershenson, *American University & IZA*

Abstract

Mounting evidence supporting the advantages of a diverse teacher workforce prompts policymakers to scrutinize existing recruitment pathways. Following four cohorts of Maryland public high-school students over 12 years reveals several insights. Early barriers require timely interventions, aiding students of color in achieving educational milestones that are prerequisites for teacher candidacy (high school graduation, college enrollment). While alternative pathways that bypass traditional undergraduate teacher preparation may help, current approaches still show persistent racial disparities. Data simulations underscore the need for race-conscious policies specifically targeting or differentially benefiting students of color, as race-neutral strategies have minimal impact. Ultimately, multiple race-conscious policy solutions addressing various educational milestones must demonstrate significant effects—approximately 30% increases—to reshape the teacher workforce to align with student body demographics.

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A210031 to the University of Maryland, College Park. The opinions expressed are those of the authors and do not represent views of the U.S. Department of Education. This research also was supported by the Maryland Longitudinal Data System (MLDS) Center. 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. Corresponding author: David Blazar, dblazar@umd.edu.

Introduction

Academics, policymakers, and practitioners agree that we need to address barriers to entry into teaching in order to *both* ameliorate widespread teacher shortages and increase diversity in the profession (Gist & Bristol, 2022; Sutcher et al., 2016). As rigorous, experimental investigations continue to document large effects of teacher-student race/ethnicity-matching on students' test-score performance, social-emotional learning, and educational attainment (Blazar, 2024; Dee, 2004; Gershenson et al., 2022), scholars argue that we need to redefine teacher quality to include teacher race (Gershenson et al., 2021; Hansen & Quintero, 2021) and ensure that race is considered when designing policies that aim to staff every classroom with an effective teacher. However, as the K-12 student population in the United States (U.S.) continues to grow more diverse, the teacher workforce remains overwhelmingly White (roughly 80% nationally) with little change over the past several decades (Taie & Lewis, 2022).

Descriptive research indicates that at least part of the mismatch between student and teacher demographics stem from "leaks" at multiple stages of the "teacher pipeline" (Lindsay et al., 2017)—or, what we prefer to call a "teacher pathway" that implies opportunities for re-entry. Lower rates of recruitment of teacher candidates of color may be due to lower rates of graduation from high school, college enrollment, and college graduation relative to White teacher candidates (Vegas et al., 2001). The licensure process can deter teacher candidates of color who may otherwise be successful in the classroom (Goldhaber & Hansen, 2010; Petchauer, 2014; Williams & Lewis, 2020). Further, court-ordered hiring guidelines intended to increase the share of Black teachers have been unsuccessful, in some contexts, suggesting that there are also biases in the hiring process (DuBois & Schanzenbach, 2017). Goings et al. (2021) found that school district human resource officers rely on intuitive hiring practices that lead to fewer teachers of color being considered for positions. Once individuals enter the profession, retention rates are lower for underrepresented teachers of color relative to White

teachers. These patterns appear to be driven primarily by the types of schools that teachers of color are hired into, suggesting a relationship between school working conditions and environments, teachers' familiarity with the local context, and retention rates of teachers of color (Carver-Thomas, 2018; Ingersoll et al., 2019).

The lack of racial and ethnic representation in the teacher workforce is therefore a multidimensional policy problem that requires multidimensional policy solutions. Scholars advocate and have developed, for example: (i) dual-enrollment programs that allow high school students to earn free, college-level credits and gain early exposure to career options (Blazar et al., 2024; Goings & Bianco, 2016); (ii) college scholarships for majoring in teaching that address acute economic challenges that many first-generation college students of color face (Harper & Griffin, 2010; Hrabowski & Sanders, 2015); and (iii) alternative routes to teacher certification that can fast-track the time it takes to earn a license and more readily support individuals of color to balance employment with course obligations, student teaching, and other opportunity costs of teacher preparation programs (Bergey et al., 2019; Dinkins & Thomas, 2016). However, to date, these strategies largely remain "promising practices" rather than tested solutions with known impacts (Carver-Thomas, 2018; Dilworth & Coleman, 2014; Edwards & Kraft, 2024; Gist et al., 2019).

This study, too, does not identify causal effects of specific policies and programs. Instead, our descriptive analyses aim to provide benchmarks and potential policy targets for expanding teacher recruitment pathways by answering the following policy questions: *When* does the teacher recruitment pathway influence the demographic makeup of the students progressing through it? *How* and *to what degree* will policies that target all students versus only students of color influence the effects of the identified barriers? "*When*" speaks to the multiple stages and steps on the pathway towards becoming a teacher: high school graduation, college enrollment, college graduation, earning a teaching degree, etc. "*How*" speaks to policy strategies that seek to fill teacher shortages generally—in a race-neutral

way—versus strategies that specifically support students of color to move along the pathway towards a career in teaching—in a race-conscious way. "*To what degree*" speaks to the magnitude of policy effects necessary to meaningfully change the demographic composition of the teacher workforce.

Following four Maryland public school cohorts for at least 12 years—from high school enrollment through college and into career—we come to four conclusions: First, because barriers appear early and accumulate over time, policy solutions must also start early in order to support students of color to meet educational attainment milestones that are prerequisites for becoming a teacher (e.g., graduating from high school, enrolling in college). It is insufficient to simply encourage college students to choose a teaching major. Second, expanding pathways into teaching that bypass traditional undergraduate teacher preparation programs may address some barriers to entry for individuals of color. In our sample, over 50% of newly hired Black teachers enter through an alternative route and with a conditional license that allows them to teach full time while finishing requirements for full/standard licensure (i.e., coursework, testing). That said, substantial disparities remain even with current approaches to alternative certification.

Third, data simulations indicate that policies that address these disparities and barriers must be race-conscious, meaning that they are targeted specifically to or differentially benefit students of color. Race-neutral policies that, instead, raise high-school graduation and college enrollment rates across the board will have very little if any effect on shifting teacher demographics. This point is intuitive and unsurprising but critical for policymaking. Finally, multiple interventions that address multiple educational attainment milestones along the pathway to becoming a teacher are necessary, and effects at each stage must be large—on the order of 30%—to attain a teacher workforce that is representative of the student body it serves. In our discussion and conclusion, we use existing credible evidence to address the feasibility of meeting these benchmarks.

Our findings from Maryland are relevant to the increasing number of states and geographic regions with no majority race/ethnicity in public schools, as well as stakeholders with an acute interest in expanding pathways to teaching for Black individuals. In Maryland, 37% of public-school students are Black, compared to 21% of teachers. We also examine pathways into teaching for Asian students—where the Maryland population is very close to the national average (6%)—and Hispanic students—where the population in Maryland is below the national average (11% versus roughly 25%) (National Center for Education Statistics, 2020).[1]

Motivating Literature and Conceptual Frameworks

Teacher "Pipelines" and "Pathways"

The "teacher pipeline" analogy has been central to multidisciplinary discussions on the teaching profession and teacher shortages for decades, stretching across the realms of educational research, policy, and economics. It presents a structured perspective on the trajectory of individuals transitioning from academic pursuits—both in K-12 settings and higher education—to careers in teaching.

In early work on this topic, Chen et al. (2000) investigated changes in the demographic and academic composition of college graduates as they progressed into the teaching profession: who entered the pipeline, who taught, and who intended to make teaching a long-term career. From a policy perspective, Ekstrom and Goertz (1985) drew upon the teacher pipeline model to assess potential state policies for increasing teacher supply and fostering equity. By mapping how state policies regulate the entry and exit of new educators at the numerous junctures of the pipeline, their study offered insights on potential areas of intervention (e.g., entrance into teacher education programs, teacher education curriculum, certification processes). Similarly, Haggstrom (1988)

[1] Throughout our paper, we refer to "Hispanic" rather than "Latinx" individuals because that is the naming convention used in our dataset.

advanced a comprehensive data-collection system—used to justify items for the national School and Staffing Survey—to inform the creation of effective workforce monitoring tools with a focus on the race/ethnicity of current and prospective teachers. Economists concerned with the supply and demand for teaching talent also adopt the pipeline analogy. For example, Murnane and Schwinden (1989) examined the equilibrium between supply and demand within this pipeline. By tracking college graduates' transitions from certification to classroom teaching in North Carolina, their research unveiled the delicate balance between certification choices and prevailing market demand.

Within this context, a critical and longstanding concern has been the so-called "leaky" pipeline for prospective teachers of color, which underscores systematic attrition at various stages of their academic and professional journeys. We identify two distinct strands of research in this area. One is primarily quantitative, building off of the policy and economics literature on teacher supply and demand to document the sharp mismatch in race/ethnicity between teachers and students, as well as to identify potential stages of the pipeline where the mismatch begins. Our own study fits primarily in this camp, and so we review relevant studies in the following section, where we also discuss the specific ways in which we extend this literature.

A second area of inquiry on the "leaky" teacher pipeline—often qualitative—seeks to understand the factors that prevent or deter individuals of color from pursuing a career in teaching. Historical analyses, for example, identify the landmark Brown v. Board of Education case in 1954 as a critical turning point, which resulted in a mass "displacement" of Black teachers in favor of keeping on White teachers in newly integrated schools (Fenwick, 2022; J. E. Haney, 1978; Irvine, 1988). Unfortunately, their representation has seen little improvement over subsequent decades (Milner, 2020). Compounding this challenge are recruitment barriers like an overemphasis on testing as a gatekeeper for entry into teaching (Baratz-Snowden, 1993; Murnane & Schwinden, 1989; Spellman, 1988) and contentious licensure exams that can have adverse impacts on Black candidates (W. Haney

et al., 1987; Madkins, 2011; Williams & Lewis, 2020). As described in the introduction, systemic racial disparities in income and wealth also hinder Black and other individuals of color from pursuing teacher education and certification, which require up-front investments of financial capital and time (Bergey et al., 2019; Dinkins & Thomas, 2016; Harper & Griffin, 2010).

Given all the contextual, historical, and systemic impediments that prevent prospective teacher candidates of color from joining the profession, we follow other scholars in adopting the term "pathway" instead of the traditionally used "pipeline" (Bianco et al., 2011; Farinde et al., 2015). This change moves away from the "leaky pipeline" analogy, which inadvertently—and sometimes intentionally—likens students to passive entities akin to liquid in a flawed pipe. The terms "pathway" and "pipeline" might be used interchangeably in some academic literature, but the imagery of a pipeline does not adequately represent the root causes of the "leaks" (Carter Andrews et al., 2019). The challenges or "leaks" that prospective teacher candidates of color face are not mere accidents. Many stem from systemic biases that deliberately and disproportionately keep certain groups out of teaching.

Quantitative Research on Pathways into Teaching

We provide a quantitative analysis of the pathway into teaching, the barriers that students of color face, and potential solutions to address these barriers. Drawing on the "pathways" framework, we seek to advance existing quantitative scholarship on this topic. To do so, we review characteristics of extant quantitative analyses with the goal of identifying desirable features of data and analyses—which we, in turn, pick up in our work.

In one of the earliest studies of this kind, Henke (2001)) interrogated the transition between 4-year college graduates and early years as a teacher using the 1993 Baccalaureate and Beyond Longitudinal Study, noting that "White, non-Hispanic graduates continue to be more inclined than minority graduates to teach" (p. 97). Leaving aside the fact that the data they use cannot provide

insight into "inclinations", the analyses provide only a limited snapshot of the pathway: after individuals have entered college and selected a college major. Other early analyses similarly focus on these college-to-career transitions (Chen et al., 2000; Murnane & Schwinden, 1989).

With the expansion of statewide longitudinal data systems in the late 1990s and early 2000s, quantitative scholars have access to increasingly broader and richer data to study teacher recruitment pathways in more depth and detail, as well as draw generalizable conclusions to representative samples. For example, White et al. (2013) capitalized on Illinois' robust longitudinal data system to examine pathways into teaching beginning in high school, finding that racial/ethnic disparities begin much earlier than college and major selection. Researchers with access to other state administrative data followed suit with increasing frequency in Pennsylvania (Stohr et al., 2018), Massachusetts (Rucinski, 2023), Wisconsin (Chapman & Brown, 2020), Washington (Goldhaber & Mizrav, 2021), Indiana (Wan et al., 2021), and Michigan (Kilbride et al., 2023).

Putman et al. (2016) and Lindsay et al. (2017) moved beyond single states to the national scale, albeit with reduced data resolution. Dilworth and Coleman (2014) studied longitudinal data at the national scale, but focused on cohorts of college rather than high school students. One benefit of national analyses is that they include racially/ethnically heterogeneous samples and settings, both in terms of the student body and the current teacher workforce. Some state-based analyses conducted to date have populations of students of color that are similar to or greater than the national average (e.g., IL, TX, WA), but almost all have fairly small populations of teachers of color. Two exceptions are TX and WA, where there is a moderate share of Hispanic teachers (14% and 8%, respectively). Expanding teacher recruitment pathways to achieve a more racially diverse teacher workforce looks much different in racially/ethnically heterogeneous versus homogeneous settings.

Despite limitations of current state-based analyses with regard to student and teacher demographics, increased data resolution in state longitudinal data systems can have at least two

additional benefits. First, information on teacher certification allows scholars to distinguish between traditional and alternative teacher certification pathways (Rucinski, 2023; B. R. White et al., 2013). This multifaceted pathway conceptualization reduces the flattening of data into one "pipeline". People may step away from school only to later return, which requires that researchers capture alternative pathways into the profession and use data that allow for additional time for degree completion or hiring to occur. Second, data that includes geographic information—including whether individuals teach close to home—can provide insight on "grow-your-own" pathways that aim to recruit locally and ensure that demographics of school personnel more closely match the demographics of the district or region (Gist et al., 2019; Valenzuela, 2017). For example, (Lichtenberger et al., 2015) expanded on earlier work in Illinois to track the movement of students within the state as they progressed along the pathway. This spatial component is important for identifying geographic heterogeneity that can be masked when looking at state- or national-level averages.

Finally, Goldhaber and Mizrav (2021), Putman et al. (2016), and Rucinski (2023) conducted simulations that seek to identify where along the teacher pathway policy intervention may be most advantageous. Broadly, these simulations predict the effects on the final composition of the teacher workforce by artificially adjusting completion rates for certain groups of students to be equal to their counterparts. One example of this is increasing the college graduation rate of Black or Hispanic students to equal that of their White counterparts. This simulation assumes that a Black college graduate would continue onto teaching with the same likelihood independent of the simulated change in graduation rate.

Reviewing this body of the literature as a whole, we argue that there are several desirable features of quantitative analyses that examine the pathway into teaching for prospective teachers of color:

1. drawing on racially/ethnically diverse populations

2. starting the pathway as early as high school
3. linking individual student records over time, through college and into teaching
4. providing additional time for data collection after college graduation before measuring who becomes a teacher
5. disaggregating analyses by certification pathway (e.g., traditional versus alternative)
6. tracking whether a student teaches locally (e.g., in the same district they attended high school)
7. conducting simulations that consider possible effects of policy shocks

However, to our knowledge, no existing study has all of these features.

Another limitation of the current literature base is that many quantitative studies apply a "pipeline" rather than "pathway" perspective. Some studies specifically argue that students of color have lower aspirations than White individuals to become teachers, suggesting that the onus for expanding opportunity is on the individual rather than the system. Further, while recent studies that conduct policy simulations take up the important question of where and how we might expand current pathways, simulated policy designs almost always compare students of color to their White peers (e.g., artificially raising high school graduation rates of Black students to be the same as White students). This approach, too, implies a deficit perspective, rather than taking up the urging of Black scholars (and others) for "teacher educators, educational researchers, and educational policy makers to more deeply consider the *challenges* associated with racially and ethnically diversifying the teaching workforce" (Carter Andrews et al., 2019, p. 6; emphasis our own). Our study aims to fill these gaps.

Data, Sample, and Methods

Data

Data for our study come from the Maryland Longitudinal Data System (MLDS) Center, which includes person-level state population data for: (i) Maryland public primary and secondary schools (provided by the Maryland State Department of Education [MSDE]); (ii) all public and private higher

education institutions in the state (provided by the Maryland Higher Education Commission [MHEC]) and out-of-state college enrollment data for students who graduated from a Maryland public high school (from the National Student Clearinghouse [NSC]); and (iii) the teacher workforce in K-12 public schools (also supplied by MSDE). Data housed at MLDS link person records over time, beginning in the 2007-08 school year.

In our analyses, we focus on four cohorts of entering ninth graders—fall 2008 to fall 2011 (*n* = 270,681 students)—whom we can observe over at least a 12-year period, through key stages on the pathway towards becoming a teacher: (i) high school graduation; (ii) college enrollment, in either 2- or 4-year degree-seeking programs; (iii) completion of a bachelor's degree (which is a requirement for becoming a teacher, even if students start in a 2-year program)[2]; (iv) receipt of a bachelor's degree in teaching; and (v) observed as a teacher of record in Maryland K12 public schools, including their entering teaching license and whether or not the school where they work is in the same district where they attended high school. Many scholars and policymakers also are interested in retention rates once teachers enter schools. However, we exclude this step from our work given the length or the data panel: more than 12 years of data is needed to allow for opportunities for re-entry into the teaching pathway post college *and* to examine post-employment outcomes.

There are several important decision rules we make when constructing our dataset and key variables. First, we define the starting point of the pathway as the first time students enroll in a Maryland public school in 9th grade. This means that we exclude the first year of available data (2007-08) because we cannot observe if students repeated 9th grade relative to the prior year. Second, we define high school graduation as earning a Maryland high school diploma. Students are censored from the graduation data if they transferred from a Maryland public high school to an in-state private school

[2] In Maryland, all teacher certifications require that candidates have a bachelor's degree, with only one exception: the Professional and Technical Education (PTE) certificate that is relevant only for Career and Technical Education (CTE) teachers. However, the overall share of PTE-certified teachers is fairly small in any entering cohort (less than 100).

or out of state, neither of which is observed in our dataset. We treat these individuals as not having graduated, though overall patterns of results are the same if we instead treat these individuals as missing and exclude from this analysis. However, these individuals can re-emerge in the data if they enroll in a Maryland college or if they become a teacher in Maryland. In these instances, we impute high school graduation data, assuming that students who enroll in college had to have graduated from high school beforehand. Similarly, we are missing college enrollment data for students who transferred out of a Maryland public high school and enrolled in college out of state. Our NSC data track out-of-state college enrollments, but only for students who graduated from a Maryland public high school.

Fourth, we define a college degree in teaching based off of Classification of Instructional Program (CIP) codes that are used to categorize college majors in a consistent way across the state (and nationally). Fifth, we define our teacher variables somewhat narrowly as "observed as a teacher in a Maryland public school". We take this approach for practical and substantive reasons. We are not able to observe individuals who become teachers out of state or in a private school. That said, our definition has policy relevance because state policies often are designed to fill teacher shortages in the state and in public schools. Another benefit of this approach is that we have no missingness: a value of 1 indicates that an individual became a teacher in a Maryland public school, while a value of 0 indicates that an individual did not do so within the time period we observe (even if they became a teacher in a private school or out of state).

The teacher workforce data also include license type. To align with prior literature, we refer to certificates as one of two types: "traditional" versus "alternative", implying different routes to enter the profession (Walsh & Jacobs, 2007). A traditional or standard certificate that is valid for five years implies entry to teaching after completing an undergraduate degree in education and through an approved teacher preparation program. Traditional routes to certification may also run through master's degrees in teaching. However, given that we observe cohorts of students for 12 years, it is

unlikely that enough time passed for 9th graders to go on to earn both bachelor's and master's degrees before becoming a teacher. In contrast, alternative certificate or alternative route refer both to Maryland's resident teacher certificate and conditional certificate, which are given to individuals who start teaching full time before they fulfill all requirements for full certification (e.g., coursework, tests) and are valid for two years before individuals need to re-apply for a standard certificate. In Maryland, the key distinction is that the resident teacher certificate is associated with state-approved alternative-route teacher preparation *programs* (e.g., Teach for America), while conditional certificates are not necessarily associated with programs. There are similarities between these pathways (e.g., fast-tracking the licensure process) but also substantive differences. That said, resident teacher certificates are very rare in Maryland compared to conditional certificates (3% versus 21% of new entries). Therefore, in our main analyses, we pool resident teacher and conditional certificates under the same alternative certification umbrella, and then disaggregate results in the appendix.

Sample

In choosing cohorts for analysis, we aim to strike a balance between maximizing the number of students included in the sample[3] and maximizing the number of years we can follow students over time. Expanding pathways into teaching requires thinking about opportunities for re-entry and that may take more time. We take a data-driven approach to cohort selection by examining "time-to-event" histograms that capture the share of individuals who graduate from high school, enroll in college, etc. across years since 9th grade, by race/ethnicity (see Appendix Figure 1 and Appendix Table 1). These analyses indicate that the vast majority of students who graduate from high school do so three years after 9th grade, no matter their race/ethnicity (92%). Similarly, roughly 75% of college enrollees reach this milestone four years after 9th grade, though a larger share of Black (19%) and Hispanic individuals

[3] Data reporting guidelines from MLDS require that cell sizes are larger than 10 students.

(18%) take more than four years compared to Asian (10%) and White students (14%). Between-group differences are much larger starting with college degree receipt. Roughly 36% of White students who go on to become teachers do so eight years after 9th grade, generally implying that they took 4 years to complete high school and 4 years to complete college, majored in teaching as an undergraduate, and immediately entered the teacher workforce after college. Another 28% of White students who become teachers do so in nine years. In comparison, roughly 14% of Black students who go on to become teachers do so in eight years, 25% in nine years, 20% in 10 years, 18% in 11 years, and 21% in 12 years (or more, for those cohorts that we can observe for more than 12 years). In other words, if we examined pathways into teaching for fewer than 12 years, the quantitative data would censor a sizable share of Black students who otherwise go on to become teachers.

Compared to the national population of students between 2008 and 2011 (National Center for Education Statistics, 2020), Maryland has some distinct features (see Figure 1 and Appendix Table 2 for exact percentages): a larger population of Black students (37% in Maryland versus 16% nationally) and smaller shares of Hispanic students (11% versus 23%) and White students (44% versus 52%); the share of Asian students is similar (6% versus 5%). We view the large share of Black students as an asset for our analyses, particularly relative to prior state-based analyses with much smaller populations of Black individuals. In the experimental literature, there is robust evidence that Black teachers have large effects on varied student outcomes, not just for Black students (Dee, 2004; Gershenson et al., 2022) but also for all students (Blazar, 2024). Another beneficial feature of the Maryland context is variation in district size and urbanicity. Due to its county-based school district structure, three districts are among the 25 largest in the country (Montgomery, Prince George's, Baltimore County), and three more are among the 75 largest (Anne Arundel, Baltimore City, Howard). Of these six large districts, some are urban, others peri-urban, and others suburban. Maryland also has many small and more rural districts, which vary in their demographics (e.g., Dorchester is one of the

smallest districts and enrolls over 40% Black students, while Garrett and Allegany in the western-most part of the state enroll over 85% White students).

Methods

Most of our analyses involve visual presentations of descriptive statistics, which we orient readers to below in the Results sections. The policy simulations require more explanation, and we provide a full accounting of our mathematical expressions and derivations in the Technical Appendix. Broadly, our "policy shock" thought experiment asks: If a policy were to increase high school graduation (or college enrollment, or college graduation, etc.) of Asian, Black, or Hispanic students by X%, how much would teacher demographics shift? In designing the simulation, we are agnostic to the specific policy and its design. Instead, we think about these simulations as producing a minimal effect that is needed to shift teacher demographics meaningfully, which then can inform policy design and choice.

We make several key assumptions in these analyses. First, we assume that the magnitude of potential policy shocks ranges from 0% (status quo) to a maximum value that brings the share of individuals meeting that stage in the pathway to 100%. For example, if the high school graduation rate were 80%, the largest possible increase would be 25% (i.e., a 20-percentage point increase from 80% to 100%). Accordingly, based on baseline rates that we observe in the data, the maximum potential policy shock varies across pathway stages (e.g., high school graduation, college enrollment) and across race/ethnicity groups. By specifying a range of plausible policy shocks based on within-group patterns, we avoid setting benchmarks that compare students of color to their White peers. A 100% rate of high school graduation, college enrollment, etc. may not be realistic—or even desirable, for students whose career goals do not require a college degree—but instead represent an upper bound. As we shall see, meaningful changes to the demographic composition of the teaching force will require policy shocks that approach these upper bounds.

Second, we assume that simulated groups of newly induced high school graduates, college enrollees, etc. go on to subsequent pathway steps (e.g., graduating from college) and eventually enter teaching at the same rates we observe in the actual data. In other words, we assume that a policy shock at one step (e.g., high school graduation) does not affect the conditional probability of passing subsequent steps in the pathway (e.g., finishing college or becoming a teacher). This assumption is similar to those made in prior simulation studies (Goldhaber & Mizrav, 2021; Putman et al., 2016; Rucinski, 2023). Third, we assume that the pool of teachers can increase unbounded. This is a reasonable simplifying assumption because U.S. (and Maryland) teacher labor markets experience perennial and nontrivial teacher shortages (Sutcher et al., 2016).

We conduct these simulations under two scenarios. The first scenario increases the proportion of students who complete certain steps in the pathway equally for all races (i.e. race-neutral), and the other only increases the proportion for a specific race/ethnicity group (i.e. race-conscious). Unsurprisingly, race-conscious policy shocks are necessary to meaningfully diversify the teaching force.

Results

Our analyses highlight the large disconnect between the racial/ethnic composition of Maryland's 9th grade students and that of the few 9th graders who go on to become teachers. Figure 1 (and Appendix Table 2) shows that 37% of students in the 2008 through 2011 9th grade cohorts are Black. In contrast, only 21% of these students who go on to become teachers are Black. The corresponding proportions for Asian students are 6% and 4%, respectively; for Hispanic students, they are 11% and 7%, respectively. That the teacher proportions are smaller than the student proportions mean that Black, Asian, and Hispanic teachers are underrepresented. White teachers are overrepresented: the student body is 44% White, while 66% of the eventual teachers are White. Figure 1 also includes students categorized as "other" race/ethnicity (3%), which largely includes students

missing this information and a subset of students coded as multiple race/ethnicities in the state data. We include these students in Figure 1 so that bars collectively sum to 100%. However, we exclude the "other" group from subsequent analyses, as there is no meaningful interpretation for students who largely are missing race/ethnicity data.

Racial/Ethnic Composition Changes Along the Pathway into Teaching

Where along the pathway do changes in demographic representation occur? In Figure 2, we illustrate our conceptualization of the pathway into teaching—and the barriers that students from different race/ethnicity groups face—as a connected line plot that follows individuals from high school and into teaching. This approach allows us not only to show the proportion of students at various pathway steps in an intuitive visual way, but also allows for visualizing multiple pathways simultaneously. For example, given certification guidelines in Maryland and nationally, everyone must enroll and graduate from high school and college to continue along the pathway. We denote these steps as educational attainment. Depending on college major, a student can take either a traditional path into teaching (i.e., studying teaching as an undergraduate) or an alternative one (i.e., studying something else and then re-entering the teacher pathway post degree). We also add additional information on who goes on to teach in the same district in which they attended high school. Panel A shows the full pathway from high school to teaching, while Panel B zooms in on the final steps related specifically to teaching (which are difficult to observe in Panel A).

Figure 2 (and Appendix Table 3) shows that entering teaching is a rare outcome for students of all backgrounds: 1.8% of 9th grade students in Maryland public schools go on to become teachers in Maryland public schools. However, it is a particularly rare outcome for Black students (1% of Black 9th graders go on to become teachers), Hispanic students (1.2%), and Asian students (1.4%). In contrast, 2.8% of White 9th graders become teachers in Maryland. Again, this highlights the unrepresentativeness of Maryland's teaching force.

One way to examine differential access to pathway steps by race/ethnicity is to examine the slopes of the lines connecting one stage to another. For all groups, slopes are particularly steep between earning a 4-year college degree and earning a degree specifically in teaching. This may be one reason why policy interests often focus on encouraging college students to major in teaching. For Black and Hispanic students, slopes are steeper at several earlier stages in the pathway: between 9th grade and high school graduation, between high school graduation and college enrollment, and between college enrollment and 4-year college degree receipt. These patterns suggest that Black and Hispanic students face barriers earlier in the pathway than other students.

In Panel B, which focuses on steps related specifically to teaching, slopes are positive for Black, Hispanic, and White individuals between two latter stages: earning a bachelor's in teaching versus being hired as a teacher. This pattern indicates that individuals can still become teachers even if they do not earn a bachelor's degree in teaching, either through a traditional master's degree program or an alternative route. Overall, traditional certification routes are more common than alternative pathways: 1.4% of 9th graders go on to become teachers through a traditional route, compared to 0.4% of 9th graders who go through an alternative pathway. However, re-entry into the pathway through an alternative route is significantly more common for Black students. Over 50% of the Black 9th graders who go on to become teachers re-enter through an alternative route to certification, driven primarily by conditional certificates for individuals who earned a bachelor's degree outside of teaching and were hired by a local education agency while they worked to complete full certification (e.g., coursework, testing).

The final stage in the pathway examines whether individuals are hired locally by the school district in which they first enrolled in high school. Asian, Black, and Hispanic students who go on to teach are more likely to do so "close to home" (i.e., the slopes of these lines are fairly flat) than their White counterparts.

Where Figure 2 documents the share of individuals from each race/ethnicity group who move along the pathway towards teaching, Figure 3 shows demographic representation within each step (e.g., the share of individuals who enroll in college who are Black; see Appendix Table 2 for exact percentages). Further, Figure 4 shows step-to-step changes in demographic representation across steps. White students make up an increasing share of individuals along most steps in the pathway towards becoming a teacher. For example, while 44% of 9th grade students are White, 46% of high school graduates and college enrollees are White. For White students, we observe large step-to-step changes of roughly 10 percentage points or more at the college graduation and teaching degree steps.

Trends for Black individuals mirror those of White students in the opposite direction. Intuitively, this is because representation is roughly a zero-sum game for the largest groups: Black and White students make up over 80% of the Maryland public school population. Once again, trends in demographic representation for Black and White students differ dramatically between traditional and alternative pathways into teaching, which aligns with our findings from Figure 2. Black individuals, who comprise 37% of 9th graders, make up roughly 15% of college students who earn a bachelor's degree in teaching but close to 50% of individuals hired to teach through an alternative pathway. In contrast, Black individuals make up 21% of traditionally certified teachers. In Appendix Figure 2 (and Appendix Table 2), we further disaggregate demographic trends by resident teacher certificates (associated with state-approved alternative certification programs) versus conditional certificates (not associated with a program). We observe that Black teachers make up 49% of conditionally certified teachers and 36% of resident teachers.

Together, these descriptive analyses highlight many barriers that Black and other prospective teachers of color face on the pathway towards becoming a teacher (i.e., high school graduation, college enrollment, college graduation), and how these barriers accumulate across pathway steps. These analyses also suggest potential opportunities for attaining a more representative teaching force,

including in particular alternative-route certification where we see much stronger representation amongst Black individuals. At the same time, the transition into teaching through an alternative route does not make up for substantial underrepresentation at earlier stages in the pathway.

Simulated Policy Shocks to Expand Pathways into Teaching

Finally, in Figure 5, we plot the racial composition of the teaching force as a function of the size of hypothetical policy shocks to the number of students who progress through each stage of the teacher pathway. The horizontal axis measures the magnitude of the policy shock, from 0% to 30%. We choose 30% as the upper bound because it happens to be the magnitude of effect that brings teacher and student demographics in close alignment. Thirty percent also is the magnitude of the policy shock that brings the high school graduation rate for Black and Hispanic students to roughly 100%. In Appendix Table 4, we convert percent changes into percentage point changes for different groups and pathway steps.

The vertical axis measures the racial and ethnic composition of the teaching force. The Y intercept reports the status quo (i.e., no policy shocks, or X = 0). Moving from left to right on the X-axis shows how successively larger policy shocks to pathway transitions alter the demographic composition of the teaching force. For each race/ethnicity group, the horizontal dotted line identifies the share of students from that group. White individuals are excluded, as they are not the focus of policy intervention (i.e., there is no need to increase the share of White teachers).

The first panel focuses on a single-stage policy shock that only targets high school graduation, where we see minimal changes. This is true for other single-stage policy shocks that target college enrollment, college graduation, etc. (see Appendix Figure 3). Therefore, we instead focus on multi-stage policy shocks that simultaneously target and impact multiple steps on the pathway towards becoming a teacher. Given the centrality of certification pathway in our earlier findings, we consider a multi-stage policy shock aligned to a traditional route that includes earning a bachelor's degree in

teaching (i.e., "All Steps") versus a multi-stage policy shock that bypasses traditional undergraduate teacher education in favor of an alternative route. Notably, the figures are largely the same, indicating that there is minimal room to improve demographic representation for students of color by targeting undergraduate teacher education and traditional certification routes.

Figure 5 further reports simulated policy effects under two policy shock scenarios. "Race-conscious" policies only affect the transition of Black, Hispanic, or Asian teachers through pathway stages. Here, we could imagine policies that are either targeted to schools that disproportionately serve students of color or that disproportionately benefit students of color. Alternatively, "race-neutral" policies benefit all students, including White students, equally—for example, a statewide intervention that has homogenous effects. While this binary distinction is useful in illustrating a point, in practice a hybrid type of shock is most common: interventions that target specific schools or students facing particular barriers (e.g., chronic absence, low grades) will often benefit students of many racial and ethnic backgrounds, but provide a disproportionate benefit to students of color who have, on average, higher absence rates, lower GPAs, and so on, due to many systemic factors.

Unsurprisingly, fully race-neutral policy shocks have only modest effects on teacher demographics and fall woefully short of achieving anything close to a representative teaching force. For example, race-neutral policies that impact all pathway stages (and for all groups) by 30% only increase the share of Black teachers by roughly 2 percentage points (from 21% to roughly 23%). The reason is intuitive: by improving everyone's transitions along the teacher pathway, including that of White students, the massive amount of White student's pre-existing overrepresentation proves insurmountable when policy shocks add to their success on the teacher pathway. Only when *all* White students graduate high school, enroll in college, and complete college would race-neutral policies generate meaningful changes in the racial and ethnic composition of the teaching force—but at that point, the policies would be race-neutral in name only. We can see this result in Figure 5, where the

race-neutral trend is roughly flat. Small inflection points only occur at points of saturation (e.g., all White students graduated from high school or enrolled in college).

Race-conscious policy shocks provide some reason for optimism. Here, the dashed lines show that the growth in teacher diversity is approximately linear in shock size. There are two reasons for this. First, a (potentially non-intuitive) finding from our mathematical derivation is that the rate at which individuals go on to become teachers after the policy shock is similar in magnitude to that of the policy shock itself—largely because the likelihood of going on to become a teacher is so low (see Technical Appendix). For example, if high school graduation rates increase by 10% but only 1% of high school graduates go on to become teachers, the increase in teachers is only 0.1%. Second, by definition of our policy shock derivation, the policy intervention effects are additively separable across steps. This means that increasing the completion rates across five steps by 10% is equivalent to increasing the completion rate of one step by 50%.

Figure 5 demonstrates that race-conscious policies can meaningfully alter teacher demographics, but only when multiple policy solutions simultaneously address various educational milestones *and* when each demonstrates significant effects. For example, for Black individuals, parity between teachers and students is achieved with approximately 30% increases. Parity is not the only benchmark to consider. The literature suggests that more than 40% of Black teachers, for example, may be important to ensure that Black, White, Hispanic, and Asian students all have access to teachers of color. In this case, policy shocks would need to have even larger effects. That said, parity is discussed as one policy benchmark by several scholars (Dilworth & Coleman, 2014; Putman et al., 2016). For Hispanic students, parity is achieved with smaller effects of roughly 12%, while necessary effects for Asian students are even smaller (roughly 5%) because student and teacher demographics for these groups already are in fairly close alignment (see Figure 1). For the teacher workforce *as a whole* to reflect the diversity of the student body—and for Asian, Black, Hispanic, and White students

all to have access to a diverse group of teachers—the larger effects of roughly 30% are a critical benchmark.

Are These Policy Contours and Benchmarks Achievable?

The simulations presented in the previous section suggest that increasing Asian, Black, and Hispanic students' graduation, enrollment, completion, and teacher-entry rates each by upwards of 30% would yield a representative teaching force in Maryland. Is doing so realistic? There is no singular intervention that would accomplish these goals immediately. However, there is a growing body of credible evidence on a variety of interventions and practices—both big and small—that together have the potential to make substantial progress towards these goals. Importantly, many interventions and inputs delivered in elementary, middle, and high school have both immediate and longer-term effects, such that a singular intervention may increase the educational attainment of students of color at multiple points along the pathway to becoming a teacher. This makes the assumption of observing shocks (improvements) at each level quite reasonable.

Teachers provide a useful starting point for this discussion, as teachers are generally considered the most important school-provided input and are known to improve student outcomes in both the immediate and long term. For example, Jackson (2018) shows that in North Carolina, a one SD increase in 9th grade teachers' "non-cognitive" value added increases students' graduation rate by about 2%. Because graduating high school is a prerequisite to attending college, it is perhaps unsurprising to see that these teachers also increase behaviors associated with enrolling in postsecondary education, such as taking a college entrance exam (2%) and stating an intent to attend college (3%). But, such effects are not limited to high school teachers: Chetty et al. (2014) show that a one SD increase in elementary and middle school teacher effectiveness raises the probability of enrolling in college by about 2% and completing college by about 3%. Papageorge et al. (2020) show that a malleable teacher behavior—holding high expectations of students—significantly increases

educational attainment: a modest 15 pp increase in college expectations increases the likelihood that a student will earn a four-year college degree by about 5%. This is all to say that providing more equal access to effective teachers across the K-12 experience would get us well on our way to the 30% benchmark (Clotfelter et al., 2023).

Similarly, while the current study is motivated by a general belief that students of all backgrounds would benefit from a more diverse and representative teaching force, students of color would benefit disproportionately. Black students in particular benefit from exposure to Black teachers. As early as elementary school, having a Black teacher significantly increases Black students' long-run educational attainment: Gershenson et al. (2022) show that having at least one Black teacher between kindergarten and third grade increases high school graduation and college enrollment rates by 13% and 19%, respectively, which again get us about halfway to our goal of 30% increases. There is admittedly a "chicken and egg" problem here. Increasing access to same-race teachers for Black students requires that we have more Black teachers to start. That said, there also are classroom assignment and teacher retention policies that could increase the odds that students of color experience same-race or same-ethnicity teachers at least once in elementary or middle school.

Other school inputs, practices, and behaviors could be targeted that benefit all students, but disproportionately benefit Black and Hispanic students (and indeed, many already are being considered, if not implemented, in districts across the nation). For example, reducing the frequency of chronic absence would increase school engagement and ultimately increase educational attainment, particularly among students of color, who have higher absence rates. Liu et al. (2021) suggest that eliminating 20 student absences would increase both high school graduation and college enrollment rates by about 40%. Class size reductions are another example. Random assignment to a small classroom in elementary school increased Black students' college enrollment rate by about 20%, an effect that is more than twice as large as that for White students (Dynarski et al., 2013).

Another evidence-based, race-neutral strategy for boosting college completion rates of students of color is to invest in community colleges, which is a more common entry point into higher education for students of color. For example, an intensive case management intervention in Texas increased female students' rate of degree attainment by about 30% (Evans et al., 2020). When it comes to influencing postsecondary students' choice of major and college graduates' choice of occupation—specifically selection into teaching—less is known. Indeed, this is a motivating factor for the current study. College students' choice of major does respond to information about earnings, albeit inelastically, though this type of intervention is unlikely to be helpful in the context of teaching since education often is considered a relatively low paying major (Wiswall & Zafar, 2015).

Preliminary evidence from urban teacher residency programs and grow-your-own programs is promising. For example, related research on the impact of Maryland's Teacher Academy of Maryland (TAM) program, which is a Career and Technical Education (CTE) and dual-enrollment program that provides early exposure to teaching and the opportunity to earn college-level credits towards an undergraduate degree in teaching, increased Black girls' entry into teaching by 78% and White girls' by only 38% (Blazar et al., 2024). Aligned to the current analyses, almost all of the effect for Black girls is driven by alternative routes into teaching that bypass traditional undergraduate teacher education. Similarly, urban teacher residency graduates tend to be about twice as racially diverse as other novice entrants and in some cities (e.g., Boston) these programs contribute 25% or even 50% of the incoming novice teacher cohort (Guha et al., 2016; Papay et al., 2012).

In sum, we have a robust body of credible evidence regarding interventions that could be deployed at every level of schooling, particularly in elementary and middle school, that improve achievement and attainment in both the short and long run. These interventions are already thought to be beneficial due to long-run socioeconomic benefits of improved educational achievement and attainment, but would create additional positive spillover effects of creating a more diverse and

representative teaching force. These additional benefits are typically omitted from cost-benefit calculations of educational interventions.

At the same time, a limiting factor for policymaking may be the need for race-conscious approaches. Many of the interventions described above differentially benefit Black and other students of color, which is why we highlight them. However, most are not *designed* through a race-conscious lens, with the possible exception of some urban teacher residency programs that adopt culturally responsive approaches (Goings et al., 2018; Herman, 2023). In the absence of race-conscious approaches, policy effects will need to be much larger than 30% to achieve greater alignment between teacher and student demographics.

Discussion

In many ways, our descriptive analyses and policy simulations in Maryland lead to similar conclusions about the labor market for prospective teachers of color documented elsewhere: (i) students of color face many barriers when navigating pathways into teaching (Lindsay et al., 2017; Putman et al., 2016); (ii) alternative routes to certification may be one avenue for decreasing barriers to entry, as teacher candidates of color experience stronger representation in these alternative pathways compared to traditional pathways (An & Koedel, 2021; Guha et al., 2016; Papay et al., 2012); and (iii) there is a "draw of home" amongst teachers generally that is particularly pronounced amongst teachers of color (Boyd et al., 2005; Redding, 2022). Analyses from Maryland lend generalizability to other state-based analyses, as the Mid-Atlantic region has distinct demographic characteristics and is an understudied region on teacher labor markets, which often focus on other settings with older state longitudinal data systems such as Massachusetts, North Carolina, Tennessee, Texas, and Washington.

Extending beyond the prior literature, we document and emphasize several key facts that are essential to account for when designing policies that advance a "teacher diversity" agenda. First, potential teachers of color face barriers at every node on the pathway, meaning that there is no magic

pressure point or silver bullet. The research literature acknowledges this point, often advocating for strategies that target several different recruitment pools: high school students, college students, career changers (Carver-Thomas, 2018; Dilworth & Coleman, 2014). Like our quantitative analysis, qualitative lines of inquiry also advocate for strategies that start as early as possible in students' school-to-career pathway, recognizing that barriers to entry for Black and Hispanic students begin in high school (if not before). State policy generally reflects this reality too. The vast majority of U.S. states (plus the District of Columbia) have programs or legislation related to teacher recruitment targeted towards high school students, in addition to college students and career changers (Garcia, 2020). At the same time, the policy arena is not known for its patience, often emphasizing short-term solutions for longer-term, systemic problems (Lewis & Hogan, 2019). Because of the need to start early, we emphasize that meaningful changes in the composition of the teacher workforce will take a long time to observe, even with large-scale investment year after year.

Second, achieving a representative teacher workforce is possible with sustained investment, but requires race-conscious approaches that are not the norm in education policy and are increasingly politicized. Despite broad interest in teacher diversity amongst state policymakers (Garcia, 2020)—where it is fairly intuitive that race-conscious approaches are needed—we have a very difficult time allocating high-quality resources in an equitable way and in support of minoritized populations (Clotfelter et al., 2023; National Academies of Sciences & Medicine, 2023). Particularly for common goods like public education, we often focus on equality. As the saying goes, "a rising tide lifts all boats". We recognize how civil rights law constraints federal, state, and local agencies from targeting resources based solely on race (Civil Rights Act, 1964). That said, a key finding—if not *the* central finding—of this paper is that race-neutral approaches will have little to no impact on shifting teacher demographics.

Third, drawing on credible evidence from other studies, we believe that there are ways to engage in race-conscious policymaking at the magnitude that is needed. Above, we highlight common-sense approaches for supporting more students of color to reach educational attainment milestones that are prerequisites for teaching, including reduced class size, assignment to high-quality, same-race teachers, and expanding pathways into community college (as a transition point towards a bachelor's degree). These solutions—and the evidence supporting them—is not new, further highlighting the fact that while we can do them, we have not done so yet—or at least not in a race-conscious way and at the scale required.

Finally, we note that some of the current strategies that may be most likely to advocate race-conscious approaches also are some of the most controversial and hotly contested in the education policy arena. Public charter schools hire many more teachers of color than traditional public schools (Gershenson, 2019)—potentially because of their strong presence in urban districts—yet are fiercely debated for their pedagogical approaches, funding, and potential cream-skimming (Hassel, 2011). Further, while oversubscribed charter schools can boost test scores substantially in the short term (Cohodes, 2018), the evidence is fairly mixed on the effects of charter schools on educational attainment outcomes of students of color. Some lottery studies show positive effects on 4-year college enrollment for schools that primarily enroll Black or Hispanic students (Angrist et al., 2016), while other studies show negative effects on high school graduation for Black students (Cullen et al., 2006). Because of this, we do not highlight charter schools as a strategy that may address racial disparities in teaching.

As noted throughout this paper, teachers of color also are meaningfully represented in many alternative-route teacher certification pathways and programs. Yet, like charter schools, there is concern and controversy around relying on alternative routes to certification as a primary avenue for expanding teacher recruitment pathways and diversifying the profession. In particular, there is

reasonable concern that decreasing barriers to entry may come at the cost of less rigorous and comprehensive training (T. White et al., 2020). In Maryland, the vast majority of teachers who enter through an alternative pathway have a conditional teacher license, rather than a resident teacher license attached to high-profile programs like Teach for America. Similarly, in Massachusetts (Bacher-Hicks et al., 2023) and Washington state (Backes & Goldhaber, 2023), there is substantially more diversity in recruitment pathways where barriers to entry are particularly low (e.g., emergency credentials). It is possible that "under-certified" teachers are less effective in their first couple of years on the job, creating a possible short-term tradeoff between diversity and student achievement gains (Laczko-Kerr & Berliner, 2002). However, the evidence on this topic is not conclusive. What we do know is that years of teaching is a much stronger correlate of teacher effectiveness than certification (Chingos & Peterson, 2011) such that any initial decreases in test-score effectiveness could be made up over time. Further, test scores are only one dimension of teacher effectiveness, and an emerging quantitative and causal literature indicates that Black teachers bring a range of mindsets, practices, and skills to their work (e.g., growth mindset beliefs) that benefit Black and non-Black students' attendance, in addition to test scores (Blazar, 2024).

Conclusion

Ultimately, we view alternative routes into teaching as a likely important contributor to shifting teacher demographics. But, we also view resources that begin much earlier (in high school and even before) as critical for addressing the systemic barriers that we have created for students of color—and Black and Hispanic students in particular—to become teachers.

References

An, Y., & Koedel, C. (2021). How do teachers from alternative pathways contribute to the teaching workforce in urban areas? Evidence from kansas city. *AERA Open*, *7*, 233285842110269. https://doi.org/10.1177/23328584211026952

Angrist, J. D., Cohodes, S. R., Dynarski, S. M., Pathak, P. A., & Walters, C. R. (2016). Stand and deliver: Effects of Boston's charter high schools on college preparation, entry, and choice. *Journal of Labor Economics*, *34*(2), 275–318. https://doi.org/10.1086/683665

Bacher-Hicks, A., Chi, O. L., Tichnor-Wagner, A., & Baloch, S. (2023). Who becomes a teacher when entry requirements are reduced? An analysis of emergency licenses in Massachusetts. EdWorkingPaper no. 23-857. *Annenberg Institute for School Reform at Brown University*. https://eric.ed.gov/?id=ED639241

Backes, B., & Goldhaber, D. (2023). The relationship between pandemic-era teacher licensure waivers and teacher demographics, retention, and effectiveness in new jersey. Working paper no. 286-0623. *National Center for Analysis of Longitudinal Data in Education Research (CALDER)*. https://eric.ed.gov/?id=ED629658

Baratz-Snowden, J. (1993). Assessment of teachers: A view from the national board for professional teaching standards. *Theory Into Practice*, *32*(2), 82–85. https://doi.org/10.1080/00405849309543579

Bergey, B. W., Ranellucci, J., & Kaplan, A. (2019). The conceptualization of costs and barriers of a teaching career among Latino preservice teachers. *Contemporary Educational Psychology*, *59*, 101794.

Bianco, M., Leech, N. L., & Mitchell, K. (2011). Pathways to teaching: African American male teens explore teaching as a career. *Journal of Negro Education*, *80*(3), 368–383.

Blazar, D. (2024). Why Black teachers matter. *Educational Researcher*.

Blazar, D., Gao, W., Gershenson, S., Goings, R., & Lagos, F. (2024). *Do Grow-Your-Own programs work? Evidence from the Teacher Academy of Maryland.*

Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2005). The draw of home: How teachers' preferences for proximity disadvantage urban schools. *Journal of Policy Analysis and Management*, *24*(1), 113–132. https://doi.org/10.1002/pam.20072

Carter Andrews, D. J., Castro, E., Cho, C. L., Petchauer, E., Richmond, G., & Floden, R. (2019). Changing the narrative on diversifying the teaching workforce: A look at historical and contemporary factors that inform recruitment and retention of teachers of color. *Journal of Teacher Education*, *70*(1), 6–12. https://doi.org/10.1177/0022487118812418

Carver-Thomas, D. (2018). Diversifying the Teaching Profession: How to Recruit and Retain Teachers of Color. *Learning Policy Institute*. https://eric.ed.gov/?id=ED606434

Chapman, A., & Brown, A. (2020). A teacher who looks like me: Examining racial diversity in wisconsin's teacher workforce and the student-to-teacher pipeline. *Wisconsin Policy Forum*. https://eric.ed.gov/?id=ED612773

Chen, X., Knepper, P. R., Geis, S., & Henke, R. R. (2000). *Progress through the teacher pipeline 1992-93 college graduates and elementary secondary school teaching as of 1997*. National Center for Education Statistics.

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2014). Measuring the impacts of teachers II: Teacher value-added and student outcomes in adulthood. *American Economic Review*, *104*(9), 2633–2679.

Clotfelter, C. T., Ladd, H. F., & Clifton, C. R. (2023). Racial differences in student access to high-quality teachers. *Education Finance and Policy*, *18*(4), 738–752.

Cohodes, S. (2018). Policy issue: Charter schools and the achievement gap. *The Future of Children*, 1–16.

Cullen, J. B., Jacob, B. A., & Levitt, S. (2006). The effect of school choice on participants: Evidence from randomized lotteries. *Econometrica*, *74*(5), 1191–1230. https://doi.org/10.1111/j.1468-0262.2006.00702.x

Dee, T. S. (2004). Teachers, race, and student achievement in a randomized experiment. *The Review of Economics and Statistics*, *86*(1), 195–210. https://doi.org/10.1162/003465304323023750

Dilworth, M. E., & Coleman, M. J. (2014). *Time for a change: Diversity in teaching revisited*. National Education Association.

Dinkins, E., & Thomas, K. (2016). Black teachers matter: Qualitative study of factors influencing african american candidates success in a teacher preparation program. *AILACTE Journal*, *13*(1), 23–40.

DuBois, C. C., & Schanzenbach, D. W. (2017). *The effect of court-ordered hiring guidelines on teacher composition and student achievement*. National Bureau of Economic Research. https://www.nber.org/papers/w24111

Dynarski, S., Hyman, J., & Schanzenbach, D. W. (2013). Experimental evidence on the effect of childhood investments on postsecondary attainment and degree completion. *Journal of Policy Analysis and Management*, *32*(4), 692–717. https://doi.org/10.1002/pam.21715

Edwards, D. S., & Kraft, M. A. (2024). *Grow your own: An umbrella term for very different localized teacher pipeline programs*. https://edworkingpapers.com/sites/default/files/ai24-895.pdf

Ekstrom, R. B., & Goertz, M. E. (1985). *The teacher supply pipeline: The view from four states*. Educational Testing Service. https://eric.ed.gov/?id=ED266118

Evans, W. N., Kearney, M. S., Perry, B., & Sullivan, J. X. (2020). Increasing community college completion rates among low-income students: Evidence from a randomized controlled trial evaluation of a case-management intervention. *Journal of Policy Analysis and Management*, *39*(4), 930–965. https://doi.org/10.1002/pam.22256

Farinde, A. A., LeBlanc, J. K., & Otten, A. S. (2015). Pathways to teaching: An examination of Black females' pursuits of careers as k-12 teachers. *Educational Research Quarterly*, *38*(3), 32–51.

Fenwick, L. T. (2022). *Jim crow's pink slip: The untold story of black principal and teacher leadership*. Harvard Education Press.

Garcia, A. (2020). Grow your own teachers: A 50-state scan of policies and programs. *New America*. https://eric.ed.gov/?id=ED609132

Gershenson, S. (2019). Student-teacher race match in charter and traditional public schools. *Thomas B. Fordham Institute*. https://eric.ed.gov/?id=ED596107

Gershenson, S., Hansen, M. J., & Lindsay, C. A. (2021). *Teacher diversity and student success: Why racial representation matters in the classroom*. Harvard Education Press Cambridge, MA.

Gershenson, S., Hart, C. M., Hyman, J., Lindsay, C. A., & Papageorge, N. W. (2022). The long-run impacts of same-race teachers. *American Economic Journal: Economic Policy*, *14*(4), 300–342.

Gist, C. D., Bianco, M., & Lynn, M. (2019). Examining grow your own programs across the teacher development continuum: Mining research on teachers of color and nontraditional educator pipelines. *Journal of Teacher Education*, *70*(1), 13–25. https://doi.org/10.1177/0022487118787504

Gist, C. D., & Bristol, T. J. (2022). *Handbook of research on teachers of color and indigenous teachers*. American Educational Research Association.

Goings, R. B., & Bianco, M. (2016). It's hard to be who you don't see: An exploration of black male high school students' perspectives on becoming teachers. *The Urban Review*, *48*, 628–646.

Goings, R. B., Brandehoff, R., & Bianco, M. (2018). To diversify the teacher workforce, start early. *Educational Leadership*, *75*(8), 50–55.

Goings, R. B., Walker, L. J., & Wade, K. L. (2021). The influence of intuition on human resource officers' perspectives on hiring teachers of color. *Journal of School Leadership*, *31*(3), 189–208. https://doi.org/10.1177/1052684619896534

Goldhaber, D., & Hansen, M. (2010). Using performance on the job to inform teacher tenure decisions. *American Economic Review*, *100*(2), 250–255. https://doi.org/10.1257/aer.100.2.250

Goldhaber, D., & Mizrav, E. (2021). The" prospective" teacher pipeline: Simulation evidence on levers to influence teacher diversity. research brief. calder policy brief no. 28-1121. *National Center for Analysis of Longitudinal Data in Education Research (CALDER)*. https://eric.ed.gov/?id=ED616144

Guha, R., Hyler, M. E., & Darling-Hammond, L. (2016). The teacher residency: An innovative model for preparing teachers. *Learning Policy Institute*. https://eric.ed.gov/?id=ED606443

Haggstrom, G. W. (1988). *Assessing teacher supply and demand*. RAND Corporation. https://eric.ed.gov/?id=ED299224

Haney, J. E. (1978). The effects of the Brown decision on Black educators. *The Journal of Negro Education*, *47*(1), 88–95.

Haney, W., Madaus, G., & Kreitzer, A. (1987). Charms talismanic: Testing teachers for the improvement of american education. *Review of Research in Education*, *14*(1), 169–238. https://doi.org/10.3102/0091732X014001169

Hansen, M., & Quintero, D. (2021). *Boosting teacher diversity requires bold, extensive action*. Brookings Intitution. https://policycommons.net/artifacts/4144083/boosting-teacher-diversity-requires-bold-extensive-action/4952718/

Harper, S. R., & Griffin, K. A. (2010). Opportunity beyond affirmative action: How low-income and working-class Black male achievers access highly selective, high-cost colleges and universities. *Harvard Journal of African American Public Policy*, *17*, 43.

Hassel, B. C. (2011). *The charter school challenge: Avoiding the pitfalls, fulfilling the promise*. Brookings Institution Press.

Henke, R. R. (2001). *Attrition of new teachers among recent college graduates: Comparing occupational stability among 1992-93 graduates who taught and those who worked in other occupations*. National Center for Education Statistics.

Herman, K. (2023). What we know now: Urban teacher residency models, teacher shortages, and equity. *Issues in Teacher Education*, *32*(1), 56–73.

Hrabowski, F. A., & Sanders, M. G. (2015). *Increasing racial diversity in the teacher workforce: One university's approach*. https://vtechworks.lib.vt.edu/handle/10919/84031

Ingersoll, R., May, H., & Collins, G. (2019). Recruitment, employment, retention and the minority teacher shortage. *Education Policy Analysis Archives*, *27*(37). https://eric.ed.gov/?id=EJ1213628

Irvine, J. J. (1988). An analysis of the problem of disappearing black educators. *The Elementary School Journal*, *88*(5), 503–513. https://doi.org/10.1086/461553

Jackson, C. K. (2018). What do test scores miss? The importance of teacher effects on non–test score outcomes. *Journal of Political Economy*, *126*(5), 2072–2107. https://doi.org/10.1086/699018

Kilbride, T., Strunk, K. O., Rogers, S., & Wasif, U. (2023). Tracking progress through Michigan's teacher pipeline. *Education Policy Innovation Collaborative at Michigan State University*. https://epicedpolicy.org/wp-content/uploads/2023/06/TeacherWorkforceReport_June2023.pdf

Laczko-Kerr, I., & Berliner, D. C. (2002). The effectiveness of "Teach for America" and other under-certified teachers. *Education Policy Analysis Archives*, *10*, 37–37.

Lewis, S., & Hogan, A. (2019). Reform first and ask questions later? The implications of (fast) schooling policy and 'silver bullet' solutions. *Critical Studies in Education*, *60*(1), 1–18. https://doi.org/10.1080/17508487.2016.1219961

Lichtenberger, E. J., White, B. R., & DeAngelis, K. J. (2015). The geography of the new teacher pipeline. policy research: Ierc 2015-1. In *Illinois Education Research Council*. Illinois Education Research Council. https://eric.ed.gov/?id=ED558201

Lindsay, C. A., Blom, E., & Tilsley, A. (2017). *Diversifying the classroom: Examining the teacher pipeline*. Urban Institute. https://www.urban.org/features/diversifying-classroom-examining-teacher-pipeline

Liu, J., Lee, M., & Gershenson, S. (2021). The short-and long-run impacts of secondary school absences. *Journal of Public Economics*, *199*, 104441.

Madkins, T. C. (2011). The Black teacher shortage: A literature review of historical and contemporary trends. *Journal of Negro Education*, *80*(3), 417–427.

Milner, H. R. (2020). Black teacher: White school. *Theory Into Practice*, *59*(4), 400–408. https://doi.org/10.1080/00405841.2020.1773180

Murnane, R. J., & Schwinden, M. (1989). Race, gender, and opportunity: Supply and demand for new teachers in North Carolina, 1975–1985. *Educational Evaluation and Policy Analysis*, *11*(2), 93–108. https://doi.org/10.3102/01623737011002093

National Academies of Sciences & Medicine. (2023). *Closing the opportunity gap for young children*. https://nap.nationalacademies.org/catalog/26743/closing-the-opportunity-gap-for-young-children

National Center for Education Statistics. (2020). Racial/ethnic enrollment in public schools. *(Annual Reports: The Condition of Education)*.

Papageorge, N. W., Gershenson, S., & Kang, K. M. (2020). Teacher expectations matter. *Review of Economics and Statistics*, *102*(2), 234–251.

Papay, J. P., West, M. R., Fullerton, J. B., & Kane, T. J. (2012). Does an urban teacher residency increase student achievement? Early evidence from boston. *Educational Evaluation and Policy Analysis*, *34*(4), 413–434. https://doi.org/10.3102/0162373712454328

Petchauer, E. (2014). "Slaying ghosts in the room": Identity contingencies, teacher licensure testing events, and African American preservice teachers. *Teachers College Record: The Voice of Scholarship in Education*, *116*(7), 1–40. https://doi.org/10.1177/016146811411600701

Putman, H., Hansen, M., Walsh, K., & Quintero, D. (2016). High hopes and harsh realities: The real challenges to building a diverse workforce. In *Brookings Institution*. Brookings Institution.

Redding, C. (2022). Are homegrown teachers who graduate from urban districts more racially diverse, more effective, and less likely to exit teaching? *American Educational Research Journal*, *59*(5), 939–974. https://doi.org/10.3102/00028312221078018

Rucinski, M. (2023). Three leaks in the massachusetts teacher pipeline. An essay for the learning curve. In *Urban Institute*. Urban Institute. https://eric.ed.gov/?id=ED629053

Spellman, S. O. (1988). Recruitment of minority teachers: Issues, problems, facts, possible solutions. *Journal of Teacher Education*, *39*(4), 58–63. https://doi.org/10.1177/002248718803900411

Stohr, A., Fontana, J., & Lapp, D. (2018). Patching the leaky pipeline: Recruiting and retaining teachers of color in Pennsylvania. In *Research for Action*. Research for Action. https://eric.ed.gov/?id=ED589381

Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2016). A coming crisis in teaching? Teacher supply, demand, and shortages in the u.s. In *Learning Policy Institute*. Learning Policy Institute. https://eric.ed.gov/?id=ED606666

Taie, S., & Lewis, L. (2022). Characteristics of 2020-21 Public and Private K-12 School Teachers in the United States: Results from the National Teacher and Principal Survey. First Look. NCES

2022-113. In *National Center for Education Statistics*. National Center for Education Statistics. https://eric.ed.gov/?id=ED624491

Valenzuela, A. (2017). Grow your own educator programs: A review of the literature with an emphasis on equity-based approaches. literature review. *Equity Assistance Center Region II, Intercultural Development Research Association*. https://eric.ed.gov/?id=ED582731

Vegas, E., Murnane, R. J., & Willett, J. B. (2001). From high school to teaching: Many steps, who makes it? *Teachers College Record: The Voice of Scholarship in Education*, *103*(3), 427–449. https://doi.org/10.1111/0161-4681.00121

Walsh, K., & Jacobs, S. (2007). Alternative certification isn't alternative. In *Thomas B. Fordham Institute*. Thomas B. https://eric.ed.gov/?id=ED498382

Wan, Y., Pardo, M., & Xia, J. (2021). Understanding the teacher pipeline for Indiana's k-12 public schools. REL 2021-065. In *Regional Educational Laboratory Midwest*. Regional Educational Laboratory Midwest. https://eric.ed.gov/?id=ED610909

White, B. R., DeAngelis, K. J., & Lichtenberger, E. J. (2013). The student has become the teacher: Tracking the racial diversity and academic composition of the teacher supply pipeline. policy research: ierc 2013-3. In *Illinois Education Research Council*. Illinois Education Research Council. https://eric.ed.gov/?id=ED555440

White, T., Woodward, B., Graham, D., Milner, H. R., & Howard, T. C. (2020). Education policy and black teachers: Perspectives on race, policy, and teacher diversity. *Journal of Teacher Education*, *71*(4), 449–463. https://doi.org/10.1177/0022487119879895

Williams, J. A., & Lewis, C. W. (2020). Enriching their potential: Supporting black male teacher candidates in the age of edtpa. *Peabody Journal of Education*, *95*(5), 472–483. https://doi.org/10.1080/0161956X.2020.1828685

Wiswall, M., & Zafar, B. (2015). Determinants of college major choice: Identification using an information experiment. *The Review of Economic Studies*, *82*(2), 791–824.

Figures

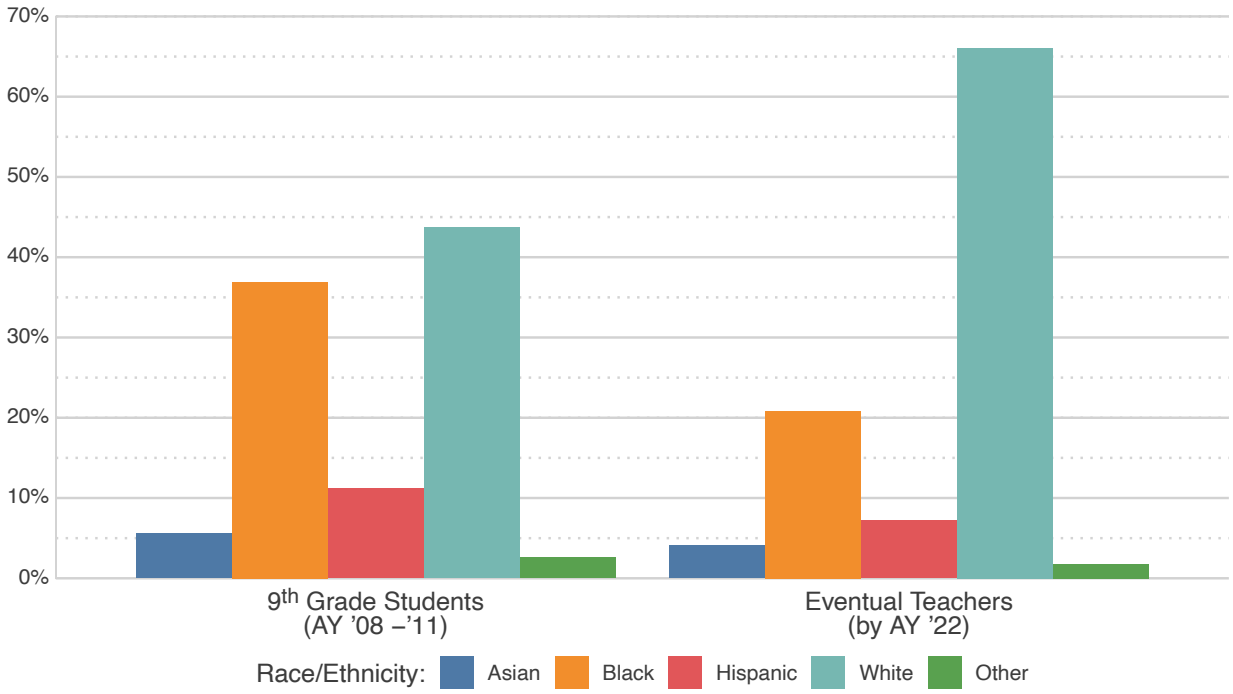


Figure 1. Demographic Characteristics of Students and Those Who Become Teachers Within 12 Years

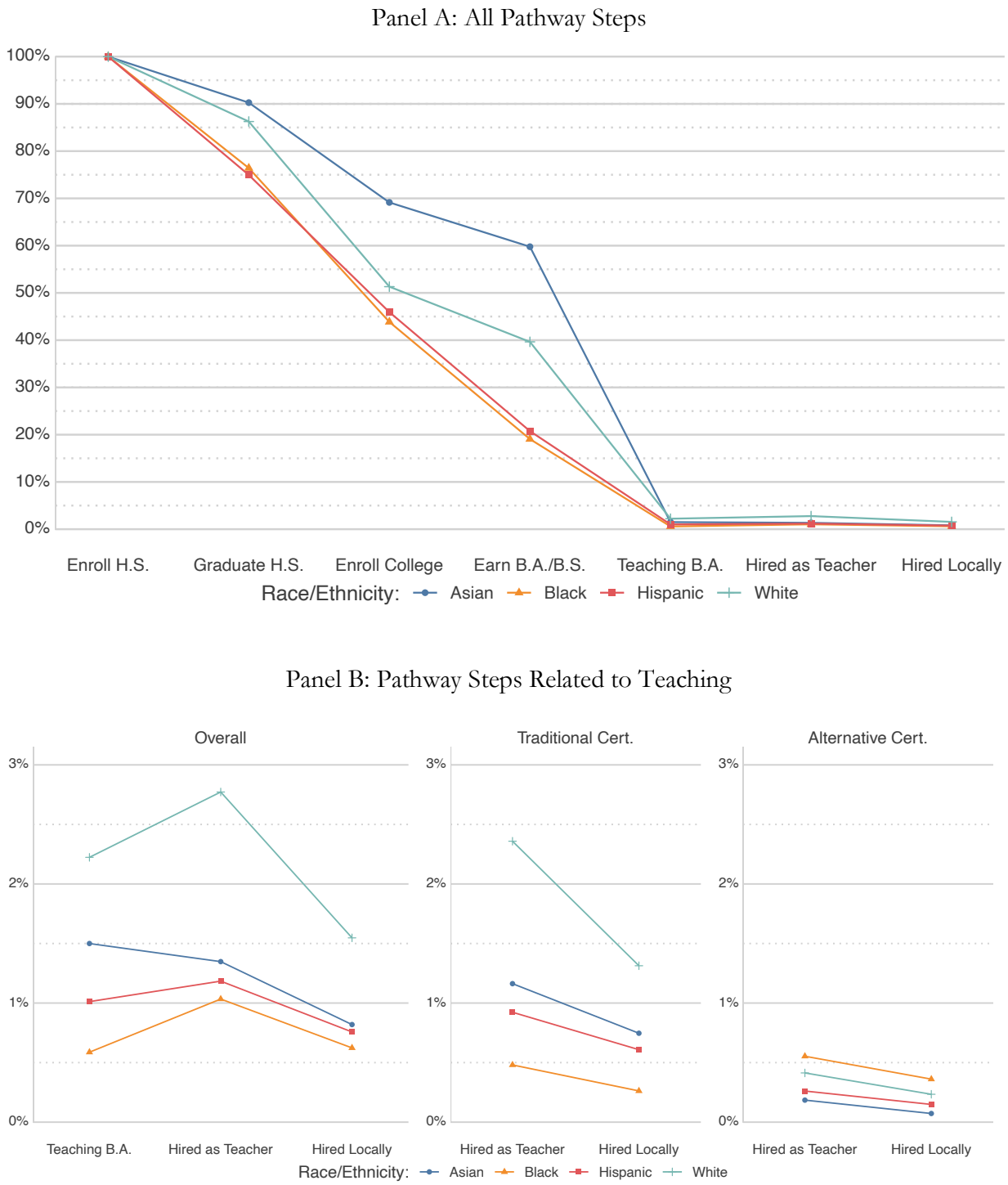


Figure 2. Share of Ninth Grade Students at Each Subsequent Stage on the Pathway into Teaching within 12 Years, by Race/Ethnicity

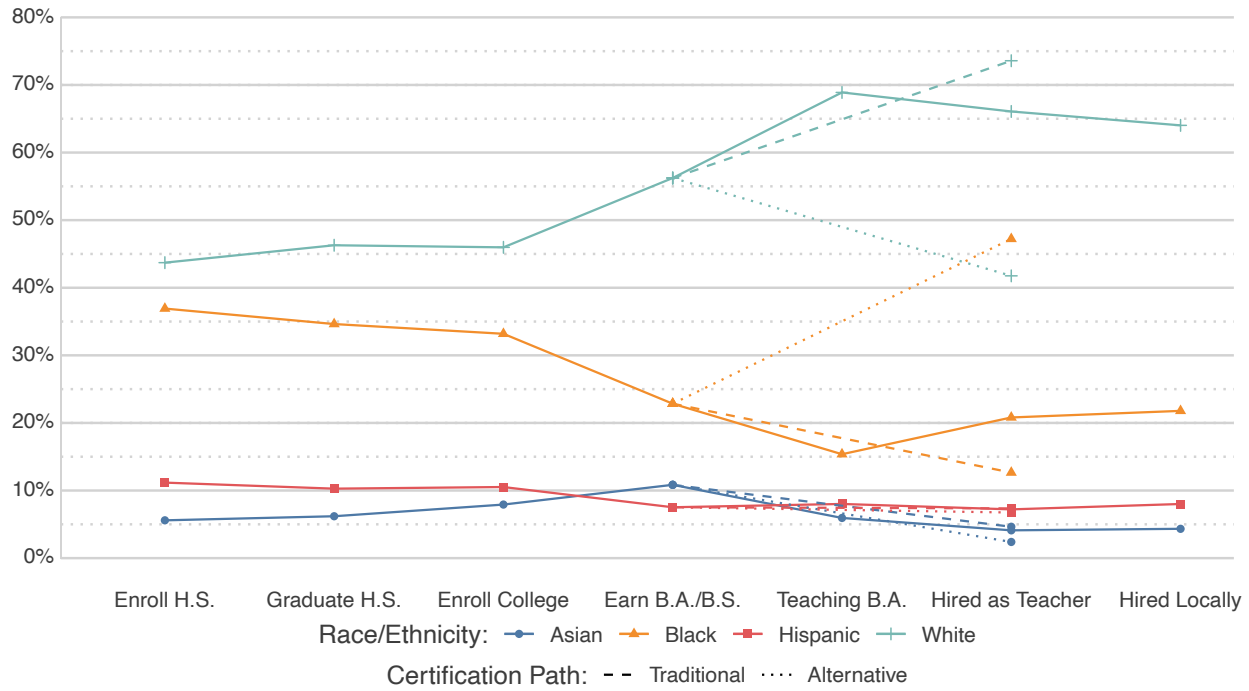
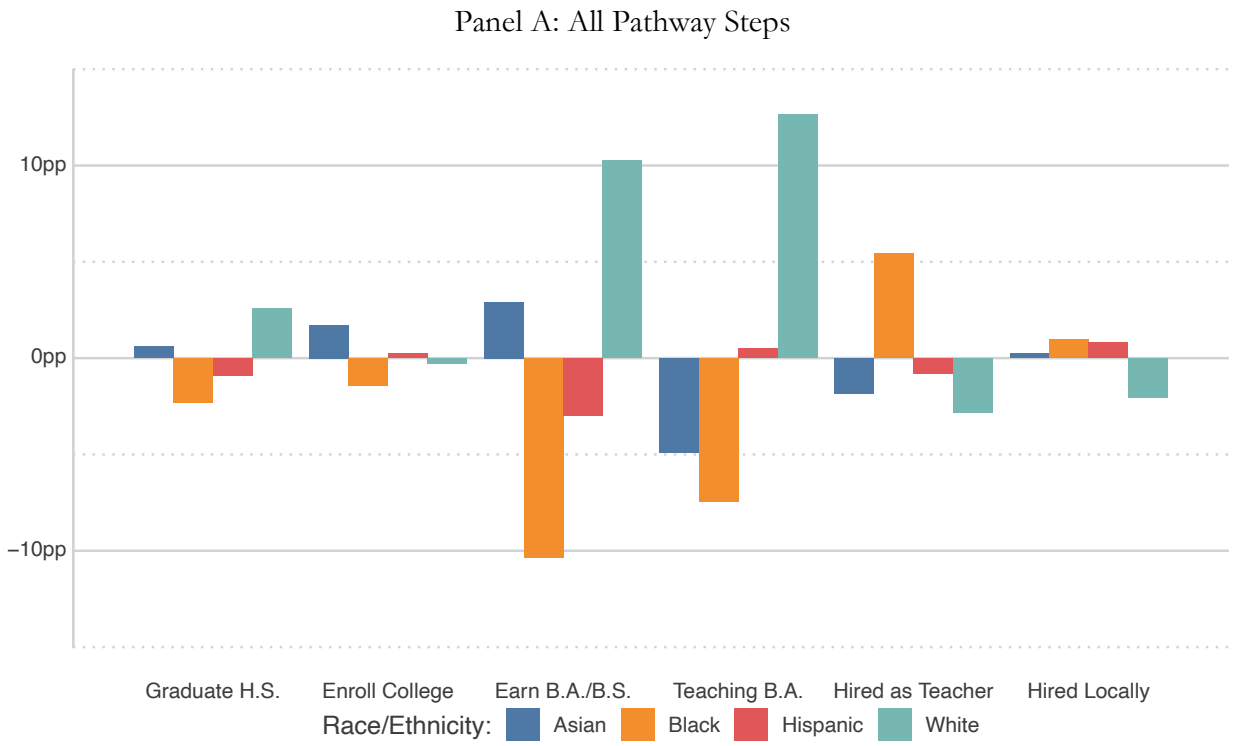


Figure 3. Demographic Makeup of Students by Race/Ethnicity at Each Pathway Step



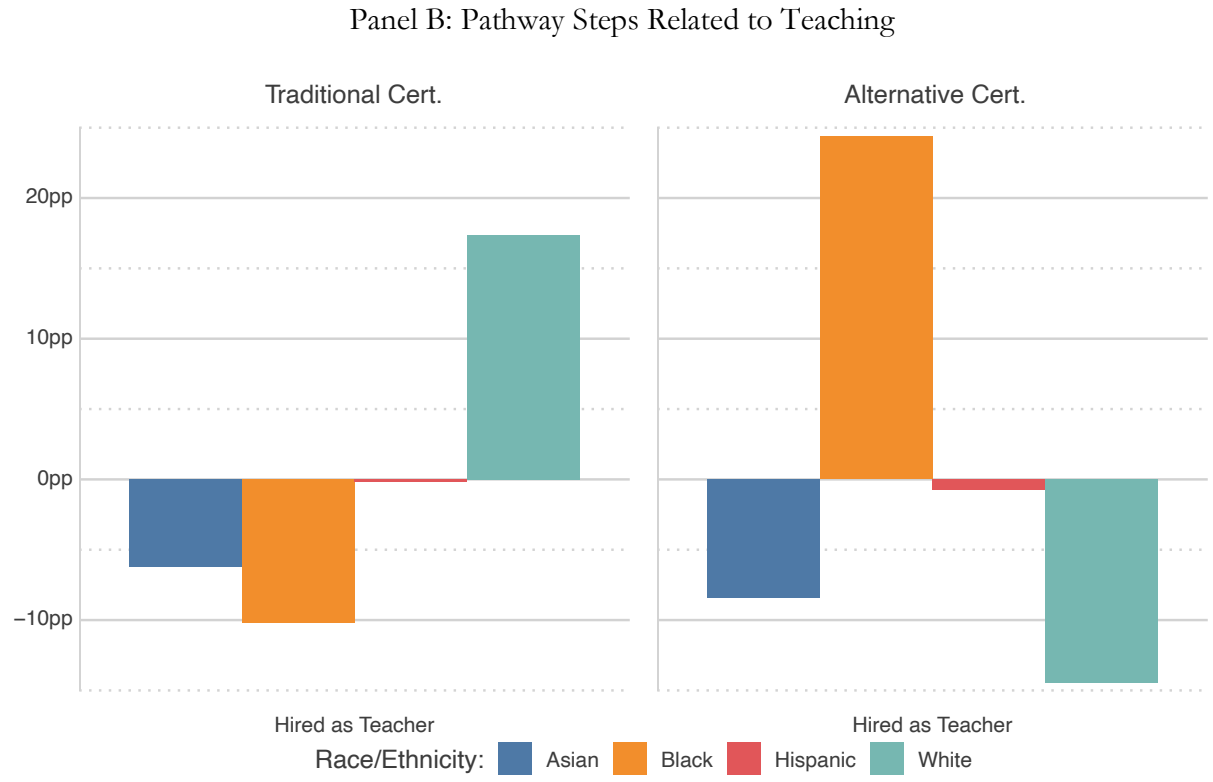


Figure 4. Step-to-Step Changes in Demographic Makeup

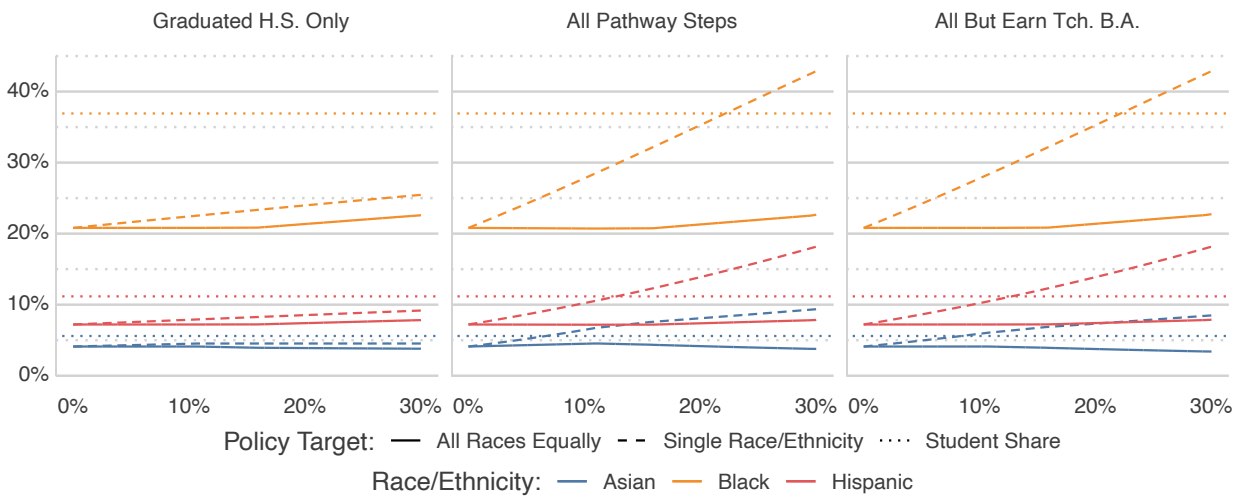
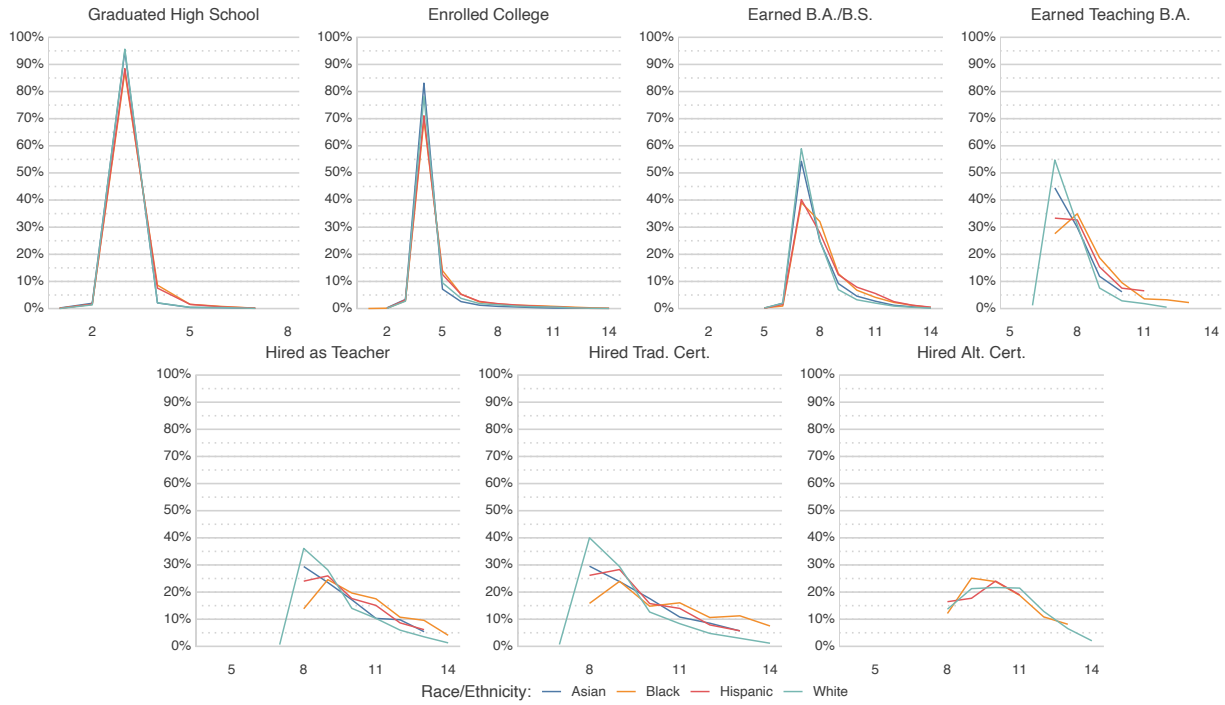


Figure 5. Simulated Effects of Policy Shocks on Shifting Teacher Demographics

Appendix



Appendix Figure 1. Time-to-Event Distributions for Completing Each Pathway Step, in Years Since Ninth Grade

Appendix Figure 2. Simulated Effects of Single-Stage Policy Shocks on Shifting Teacher Demographics, by Pathway Step

Appendix Table 1. Distribution of Time-to-Event for Each Pathway Step, by Race/Ethnicity

Years to Complete	All	Asian	Black	Hispanic	White	Other
Graduated High School						
3	91.9%	94.9%	87.3%	88.5%	95.6%	92.9%
4	5.0%	2.1%	8.6%	7.6%	2.1%	4.2%
Enrolled College						
4	74.8%	83.1%	69.4%	71.1%	78.2%	73.5%
5	11.2%	7.2%	14.0%	12.6%	9.5%	11.3%
6	4.4%	2.6%	5.3%	5.3%	3.8%	4.5%
Earned B.A./B.S.						
7	52.4%	54.3%	39.1%	40.2%	58.9%	56.9%
8	26.9%	24.9%	32.1%	27.9%	25.1%	26.1%
9	9.0%	9.2%	12.9%	12.5%	7.0%	7.6%
10	4.5%	4.6%	6.8%	7.9%	3.2%	3.2%
Earned Teaching B.A.						
7	48.0%	44.5%	27.6%	33.3%	54.8%	39.7%
8	31.7%	30.0%	34.9%	32.7%	31.0%	35.3%
9	10.2%	11.9%	18.7%	15.4%	7.6%	10.3%
10	4.5%	6.2%	9.5%	7.5%	2.9%	7.4%
Hired as Teacher (Overall)						
8	30.1%	29.4%	13.8%	24.0%	36.1%	25.8%
9	27.0%	23.5%	24.6%	26.0%	28.2%	23.6%
10	15.6%	17.2%	19.7%	17.6%	14.0%	16.9%
11	12.2%	10.3%	17.5%	15.1%	10.3%	11.2%
12	7.4%	9.8%	10.8%	8.7%	6.0%	11.2%
13	5.1%	5.4%	9.6%	6.2%	3.5%	5.6%
Hired as Teacher (Trad. Cert.)						
8	35.3%	29.6%	15.8%	26.2%	40.0%	29.9%
9	28.3%	23.9%	24.0%	28.3%	29.4%	25.4%
10	13.4%	17.6%	14.8%	15.8%	12.7%	14.9%
11	9.9%	10.8%	16.0%	14.0%	8.4%	10.5%
12	6.0%	8.5%	10.6%	7.9%	4.8%	9.0%
13	4.4%	5.7%	11.3%	5.7%	3.0%	4.5%
Hired as Teacher (Alt. Cert.)						
8	13.5%	28.6%	12.1%	16.5%	13.7%	13.6%
9	22.8%	21.4%	25.1%	17.7%	21.3%	18.2%
10	22.7%	14.3%	23.9%	24.1%	21.7%	22.7%
11	19.6%	7.1%	18.8%	19.0%	21.5%	13.6%
12	12.0%	17.9%	10.9%	11.4%	12.9%	18.2%
13	7.3%	3.6%	8.1%	7.6%	6.5%	9.1%

Appendix Table 2. Demographic Makeup of Students by Race/Ethnicity at Each Pathway Step

Pathway Step	Asian	Black	Hispanic	White	Other
Enrolled in High School	5.6%	36.9%	11.2%	43.7%	2.6%
Graduated High School	6.2%	34.6%	10.3%	46.3%	2.6%
Enrolled in 2- or 4-Year College	7.9%	33.2%	10.5%	46.0%	2.4%
Earned B.A./B.S.	10.8%	22.8%	7.5%	56.2%	2.6%
Earned Teaching B.A./B.S.	5.9%	15.4%	8.0%	68.9%	1.8%
Hired as Teacher (Overall)	4.1%	20.8%	7.2%	66.1%	1.8%
Hired as Teacher (Trad. Cert.)	4.6%	12.7%	7.4%	73.6%	1.8%
Hired as Teacher (Alt. Cert.)	2.4%	47.2%	6.7%	41.8%	1.9%
Resident Alt. Cert.	--	35.5%	10.1%	47.1%	--
Conditional Alt. Cert.	1.9%	48.8%	6.3%	41.0%	1.9%
Hired Locally	4.3%	21.8%	8.0%	64.0%	1.9%
Observations	15,135	99,931	30,235	118,319	7,061

Notes: "--" indicates that cell sizes are too small to report.

Appendix Table 3. Share of Ninth Grade Students at Each Subsequent Stage on the Pathway into Teaching within 12 Years, by Race/Ethnicity

Pathway Step	All	Asian	Black	Hispanic	White	Other
Enrolled in High School	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Graduated High School	80.52%	90.08%	74.86%	73.20%	85.77%	80.75%
Enrolled in 2- or 4-Year College	48.79%	69.14%	43.86%	45.94%	51.32%	44.81%
Earned B.A./B.S.	30.82%	59.78%	19.07%	20.76%	39.64%	30.19%
Earned Teaching B.A./B.S.	1.41%	1.50%	0.59%	1.01%	2.22%	0.96%
Hired as Teacher (Overall)	1.83%	1.35%	1.03%	1.18%	2.77%	1.26%
Hired as Teacher (Trad. Cert.)	1.40%	1.16%	0.48%	0.92%	2.36%	0.95%
Hired as Teacher (Alt. Cert.)	0.43%	0.19%	0.55%	0.26%	0.41%	0.31%
Resident Alt. Cert.	0.05%	0.05%	0.05%	0.05%	0.05%	0.03%
Conditional Alt. Cert.	0.38%	0.13%	0.50%	0.21%	0.36%	0.28%
Hired Locally	1.06%	0.82%	0.62%	0.76%	1.55%	0.75%
Observations	270,681	15,135	99,931	30,235	118,319	7,061

Note: Some students are missing high school graduation data and, subsequently, college data if they moved out of a Maryland public school high after 9th grade. This includes 26,332 students overall (9.7%), 1,148 Asian students (7.6%), 10,943 Black students (11.0%), 3,445 Hispanic students 11.4%), 9,963 White students (8.4%), and 833 students of another/missing race/ethnicity (11.8%). We treat these individuals as 0s when computing attainment rates.

Appendix Table 4. Magnitude of Simulated Policy Shocks in Percentage Points

Effects in %	Asian	Black	Hispanic
Graduated High School			
5%	4.5	3.7	3.7
10%	9.0	7.5	7.3
15%	13.5	11.2	11.0
20%	18.0	15.0	14.6
25%	22.5	18.7	18.3
30%	27.0	22.5	22.0
Enrolled College			
5%	3.5	2.2	2.3
10%	6.9	4.4	4.6
15%	10.4	6.6	6.9
20%	13.8	8.8	9.2
25%	17.3	11.0	11.5
30%	20.7	13.2	13.8
Earned B.A/B.S.			
5%	3.0	1.0	1.0
10%	6.0	1.9	2.1
15%	9.0	2.9	3.1
20%	12.0	3.8	4.2
25%	14.9	4.8	5.2
30%	17.9	5.7	6.2
Earned Teaching B.A.			
5%	0.1	0.0	0.1
10%	0.2	0.1	0.1
15%	0.2	0.1	0.2
20%	0.3	0.1	0.2
25%	0.4	0.1	0.3
30%	0.5	0.2	0.3
Hired as Teacher			
5%	0.1	0.1	0.1
10%	0.1	0.1	0.1
15%	0.2	0.2	0.2
20%	0.3	0.2	0.2
25%	0.3	0.3	0.3
30%	0.4	0.3	0.4

Technical Appendix: Mathematical Model for the Policy Shock Simulation

The policy shock analyses ask: If a policy were to increase high school graduation (or college enrollment, or college graduation, etc.) of Asian, Black, or Hispanic students by X%, how much would teacher demographics shift?

At its most basic, we start this exploration with the following equation, focusing on a policy shock targeting high school graduation only. The number of students who finish high school after the policy shock (n'_{hs}) is equal to the number of students who finish high school before policy shock (n_{hs}) multiplied by the quantity 1 plus the magnitude of the policy shock (S_{hs}):

$$n'_{hs} = n_{hs}(1 + S_{hs}) \qquad (1)$$

S_{hs} goes from 0 (i.e., no policy shock) to S'_{hs} maximum value, which is the value of the policy shock that brings the share of individuals meeting that stage in the pathway to 100%. For example, if the high school graduation rate were 80% and we wanted to increase it to 100% (a 20-percentage point increase) we could simulate an increase from 0% to 25%.

Next, we assume that, after a policy change, the rate of high school graduates continuing on to additional stages in the pathway—and eventually becoming teachers—remains the same as before. For example, if 80% of high school students graduated and 60% of them enrolled in college, there is a 75% college enrollment rate for high school graduates. We propose that this 75% college enrollment rate also applies to additional students graduating high school due to the policy change. More generally:

$$n'_{ce} = n'_{hs}P(ce|hs) \qquad (2)$$

In other words, the number of individuals who enroll in college after the policy shock targeting high school graduation (i.e. n'_{ce}) is simply equation (1) multiplied by the probability of enrolling in college before the policy shock, conditional on graduating from high school.

To estimate the number of individuals who eventually become teachers as a result of the policy shock targeting high school graduation, we extend this pattern across all stages in the pathway including college graduation (n'_{cg}), a degree in education (n'_{me}), and becoming a teacher (n'_{T}):

$$n'_{cg} = n'_{ce}P(cg|ce) \qquad (3)$$
$$n'_{me} = n'_{cg}P(me|cg) \qquad (4)$$
$$n'_{T} = n'_{me}P(T|me) \qquad (5)$$

Substituting terms and multiplying out, equation (5) can be rewritten as:

$$n'_T = n_{hs}P(T|me)P(me|cg)P(cg|ce)P(ce|hs)(1 + S_{hs}) \qquad (6)$$

These conditional probabilities simplify to the probability of teaching given that a student graduated from high school:

$$n'_T = n_{hs}P(T|hs)(1 + S_{hs}) \qquad (7)$$

Because $P(T|hs)$ can be rewritten as n_T/n_{hs}, n_{hs} drops out and the equation (7) can be rewritten as:

$$n'_T = n_T(1 + S_{hs}) \qquad (8)$$

A (potentially non-intuitive) finding from the mathematical notation is that the increase in the rate that individuals go on to become teachers after the policy shock targeting high school graduation is the same as the magnitude of the policy shock itself.

From here, we can recognize that the same form of this equation would hold not just for a policy shock affecting increases in high school graduation, but for a policy shock targeting any of the subsequent steps. We denote the symbol *i* as a placeholder representing any single step in the pathway. Additionally, this equation will hold for different race/ethnicity groups, *r*, where we could apply different magnitudes of shocks to different groups:

$$n'_{T,r} = n_{T,r}(1 + S_{i,r}) \qquad (9)$$

Finally, to figure out how the demographics of the pool of teachers would change following a given policy shock, we take this expression for one race/ethnicity group and divide it by the sum of that expression over all groups, but where each race/ethnicity group has its own maximum value of the policy shock:

$$P(r|T) = \frac{n_{T,r}(1 + S_{i,r})}{\sum_r n_{T,r}(1 + S_{i,r})} \quad , \quad S_{i,r} \in [0, \frac{n_{i-1,r}}{n_{i,r}} - 1] \qquad (10)$$

The notation for the range of $S_{i,r}$ is simply a rewriting of equation (1) above that solves for $S_{i,r}$. This also means that the probability of becoming a teacher for one group of students depends on when another group of students reaches saturation (i.e., 100%) in previous steps in the pathway. Equation (10) is what we use to generate the single-stage policy shock figures (mostly shown in the appendix).

The approach to single-step policy shocks also applies to the equation for policy shocks that simultaneously affects multiple stages in the pathway. The same procedure that allowed us to cancel conditional probabilities seen in equation (6) remains the same. However, the product of each policy shock remains from step *i,* the first step we apply a shock to, all the way to *k,* the final step in the pathway.

$$P(r|T') = \frac{n_{T,r}\prod_i^k(1 + S_{i,r})}{\sum_r n_{T,r}\prod_i^k(1 + S_{i,r})}, S_{i,r} \in [0, \frac{n_{i-1,r}}{n_{i,r}} - 1] \qquad (11)$$

Equation (11) is what we use to generate the multi-stage policy shocks shown in the main text.