

Staying Put: Positive Spillovers on Teacher Retention From a Middle School Science Initiative

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Abstract

Teacher shortages, especially in high-need subjects and schools, are a long-standing issue in many districts, and teacher turnover is a key driver. In this article, we examine the association between Urban Advantage (UA), a professional development-focused science initiative, and middle school science teacher retention in the nation's largest school district, New York City (NYC). We use detailed teacher-level administrative personnel data on 19 cohorts of teachers from NYC and UA program participation data and estimate likelihood of turnover using a discrete-time hazard model. UA teachers are roughly 3.8 percentage points less likely than similarly situated non-UA teachers to leave their school the following year. This study contributes to the limited evidence on how professional development-focused programs can promote teacher retention in hard-to-staff subjects and schools.

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Teacher shortages are a long-standing issue in many districts (Guarino et al., 2004; Ingersoll, 2003; Marinell & Coca, 2013; Nguyen & Redding, 2018). The Covid-19 pandemic may have exacerbated this challenge, with some research suggesting the pandemic lead to increases in teacher turnover: teachers leaving their school, including those who leave the profession entirely (Bastian & Fuller, 2023; Carver-Thomas et al., 2021; Noonoo, 2022). A recent estimate suggests 90% of the nationwide annual demand for teachers is created when teachers leave the profession, and two-thirds of teachers leave for reasons other than retirement (Carver-Thomas & Darling-Hammond, 2017). This may be particularly true for hard-to-staff subjects and schools. Science, technology, engineering, and math (STEM) teachers are more likely to turnover than their peers in other subjects, and the odds of leaving are 51% higher for middle school teachers than for elementary school teachers (Nguyen et al., 2020). Therefore, districts facing teacher shortages might consider policies that improve teacher retention (in addition to efforts to recruit new teachers).

The harmful effects of teacher turnover are well-documented: it increases the number of inexperienced teachers, reduces student achievement, disturbs school-community relationships, and increases school costs (Adnot et al., 2016; Atteberry et al., 2017; Hanushek et al., 2016; Ronfeldt et al., 2013; Sorensen & Ladd, 2020; Watlington et al., 2010). Evidence on whether professional development improves teacher retention is more limited (Garet et al., 2008; Coldwell, 2017). However, professional development and related teacher and school characteristics—greater career satisfaction, enhanced teacher collaboration, and improved student performance—are associated with reduced teacher turnover (Allen & Sims, 2017; Digaudio, 2017; Nguyen et al., 2020).

In this paper, we examine the association between a professional development-focused science initiative and middle school science teacher retention in the nation's largest school district, New York City (NYC). Our goal is to test the hypothesis that, all else equal, science teachers who participate in NYC's Urban Advantage (UA) program are less likely to leave their school or the district than their non-UA counterparts. UA is an initiative

designed to improve students' understanding of the process of scientific inquiry through high-quality teacher professional development and ancillary support, first implemented in the 2004 to 2005 school year. Over half of NYC middle schools have participated in the program. Between 2005 and 2021 UA served over 1,900 unique teachers, over 1,400 of whom were still teaching in NYC Department of Education schools in 2021 (over 800 of these teachers actively participated in UA in 2021). While the main goal of the UA program is to improve student science learning, this paper investigates another potential benefit of UA—improvements in teacher retention, given the importance of professional development on teachers' career decisions.

To understand the association between UA participation and the likelihood that science teachers leave their school or the district, we use variation in teachers' first year in the program and estimate a discrete-time hazard model that accounts for unobserved heterogeneity among teachers and schools that select into the program. We use detailed teacher-level administrative data on 19 cohorts of teachers from the NYC Department of Education (NYC DOE) and UA program participation data. Results suggest that UA teachers are roughly 3.8 percentage points less likely than non-UA teachers to leave their school in the following year. This study presents empirical evidence on the link between the UA program and improved teacher retention and contributes to the limited evidence on how professional development-focused programs can promote teacher retention in hard-to-staff subjects and schools.

The Urban Advantage Program

UA launched in September 2004 to bring together the resources of NYC's informal science education institutions (ISEIs) and NYC public schools to improve middle school science instruction. These institutions include the American Museum of Natural History (lead institution), Brooklyn Botanic Garden, New York Botanical Garden, New York Hall of Science, Queens Botanical Garden, Staten Island Zoological Society, the Wildlife Conservation Society's Bronx Zoo, and New York Aquarium. UA provides teachers and students in NYC Grades 6 to 8 the opportunity to engage in authentic science practice through professional development for teachers, classroom materials, administrator support, outreach to families, and access to cultural institutions. Professional development takes place at participating ISEIs and is conducted by science educators from the ISEIs and experienced UA teachers. Over the past 18 years, UA has grown and become

embedded in NYC's approach to science instruction, including a recent expansion into elementary schools (Hammerness et al., 2017; Slagus & Kelly, 2024).

UA is designed to meet the needs of both novice and experienced teachers. During their first year in UA, teachers attend up to 40 hours of professional learning that targets their capacity to effectively integrate science and engineering practices into their instruction. As part of their training, UA teachers work to incorporate the Next Generation Science Standards (NGSS)—standards that engage students in practices of science, conduct their own science learning, and work on long-term projects with other teachers that promote scientific inquiry. This framework is consistent with the teacher-as-learner model of professional development, which has proven effective for teachers in STEM education (Loucks-Horsley & Matsumoto, 1999). In their second year in UA teachers complete up to 22.5 hours of professional learning, and in their third year and beyond, teachers receive up to 12.5 hours of professional learning annually (teachers can continue in the program for up to 7 years total). The highest levels of professional learning culminate in offerings on reflective practice, in which teachers analyze student work or videos of their own teaching.

Participation in UA is voluntary; interested teachers and schools had to apply to participate in the program. Schools that had more than one science teacher interested in participating, among other criteria, had the highest chance of participating (a school may have only one teacher participate but it is more likely they have two or more teachers participate).

The program provides additional teacher- and school-level support beyond professional development. Teachers receive science materials and equipment to use in their classrooms. School administrators can participate in breakfast meetings to network with other administrators at schools in the program to learn ways to improve UA implementation at their school. UA teachers, administrators, students, and families receive vouchers for free admission to any of the ISEIs, and schools receive transportation funds to facilitate these trips. In the 2021 to 2022 school year, the total cost of UA was \$6.5 million. It served approximately 1,000 teachers: 900 middle school teachers and 100 elementary school teachers (a pilot to expand the program to elementary schools began in 2016), meaning UA costs approximately \$6,500 per teacher. Previous research has found that the UA program contributes to improvement in student achievement in science, particularly among students of UA teachers compared to students of non-UA teachers in the same school (Weinstein et al., 2014, 2023; Whitesell, 2016).

Literature Review: Teacher Turnover

The Scope of the Problem

There is a lack of detailed, timely, and nationally representative data on the K-12 education labor market in the United States (Bleiberg & Kraft, 2022; Nguyen et al., 2022). However, district- and state-specific research typically finds that there are significant differences in teacher turnover by grade level, subject, urbanicity, and school characteristics such as average student performance. Middle schools have particularly high turnover rates nationally (Nguyen et al., 2020) and in NYC: a quarter of teachers leave their schools within 1 year of entering the workforce, and more than one-half leave within the first 3 years (Marinell & Coca, 2013). It is especially difficult to recruit and retain science teachers (Guarino et al., 2004; Han & Hur, 2022; Ingersoll, 2003; Ingersoll & Perda, 2010; Marinell & Coca, 2013; Nguyen et al., 2020, 2022; Nguyen & Redding, 2018). Therefore, the UA program, which targets middle school science teachers, is serving a population with particularly high turnover rates.

The cost of teacher turnover is high. In 2004, the United Federation of Teachers estimated that the cost of a first-year NYC teacher leaving the district was \$13,200. More recent estimates from other districts or national data suggest the cost of replacing a teacher who leaves ranges from \$18,000 to \$21,000 (Barnes et al., 2007; Carroll, 2007; Carver-Thomas & Darling-Hammond, 2017; DeFeo et al., 2017). In addition to the direct financial burden that turnover imposes on schools and districts in terms of recruitment, teacher turnover imposes indirect costs through adverse effects on student performance and the exacerbation of turnover in future years (Sorensen & Ladd, 2020).

How Urban Advantage Might Affect Teacher Turnover

We use the conceptual framework advanced by Nguyen et al. (2020) to understand how the Urban Advantage program might affect teacher turnover. They categorize correlates of teacher turnover into three groups: external/policy factors, such as teacher evaluation policies, salaries, and union presence; school factors, such as administrative support, professional development, and student achievement; and personal factors, such as career satisfaction and content specialty. Their conceptual framework recognizes the interplay of these three categories in contributing to decisions to leave a school or district (or the profession entirely). As with many professions, turnover may be affected by job location (e.g., Reininger, 2012) and

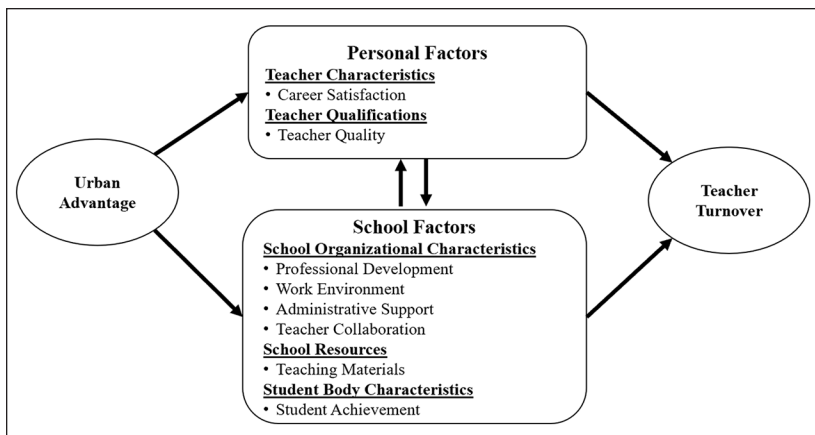


Figure 1. Conceptual Framework: Correlates of teacher turnover that might be affected by the Urban Advantage program.

Note. This is a modified version of the conceptual framework in Nguyen et al. (2020), presenting only those correlates through which Urban Advantage might be affect teacher turnover.

compensation (e.g., Feng & Sass, 2018). However, the UA program does not affect teacher's base salary or their school location, and so will not affect teacher turnover through these mechanisms. Figure 1 presents a modified version of Nguyen et al. (2020)'s conceptual framework with only those correlates that may be affected by UA and therefore explain how it could affect retention. We review how UA might affect each correlate and the literature in that area, particularly professional development, since this is the core of the program.

Professional Development. Relatively few quantitative studies have looked at the impacts of a specific professional development on teacher retention. Coldwell (2017), in a survey of over 500 teachers, and interviews with a subsample, found professional development impacts teachers' career trajectories and intermediate outcomes. Similarly, Erickson (2007) used nationally representative survey data and found more professional development and higher quality professional development were predictive of less turnover. DiGaudio (2017) examined the use of a specific professional development tool (the School Improvement Engine) in NYC schools, and found teacher retention was higher in schools using the tool than other NYC schools. In contrast, Garet et al. (2008), using an experimental design, found no impact

of a specific professional development on teacher retention. However, they noted teacher turnover itself may have hampered proper delivery of the treatment. Allen and Sims (2017), using data on teachers in England, examined whether STEM professional development courses were associated with improved science teacher retention, and found no impact. Though the evidence is mixed, a recent meta-analysis found teachers who indicate they have good in-service professional development have 16% lower odds of leaving (Nguyen et al., 2020).

Student Achievement. The odds of teacher turnover are 10% lower for schools with higher student achievement than schools with lower student achievement (Nguyen et al., 2020). If the UA program is successful at improving student achievement, it may impact teacher retention; indeed, a previous study found positive impacts of UA on students' scores on New York State's eighth grade science assessment (Weinstein et al., 2014). Student performance may also improve in ways not captured by standardized exams (e.g., improved attendance or engagement). These student-level impacts may be a mechanism through which UA affects teacher turnover.

Other Relevant Correlates of Teacher Retention. Some research finds higher quality teachers have higher retention (e.g., Vagi et al., 2019) and UA may improve teacher quality: program assessments have found UA teachers report more mastery of science content (About UA, n.d.). While some studies have questioned the sustainability of content knowledge gained through professional development, teachers who participate in programs that occur during the school year (like UA) lose their knowledge less rapidly (Liu & Phelps, 2020). Getting to engage with content experts at ISEIs may be another critical component of meaningful knowledge transfer (Baron et al., 2020). In addition, the current UA framework of inquiry-based, ongoing, and intensive professional development promotes long-term professional growth, which can improve teachers' career satisfaction. As reflected in the two-way relationship between personal and school factors in the conceptual framework for correlates of teacher turnover, this improved teacher quality and career satisfaction could affect school characteristics (e.g., lead to improvements in student achievement).

A better work environment is critical for lowering teacher turnover and is another potential way UA can promote teacher retention. There is significant evidence that teachers with strong administrative support are less likely to turnover (e.g., Kraft et al., 2016; see Nguyen et al., 2020 for a recent meta-analysis). The UA program provides resources for school leadership that may improve the work environment and administrative support, such as principal

breakfasts. Because principals and other school staff (e.g., parent coordinators) are involved in UA and contribute to the school's science program, science teachers in UA schools may have a more enriching and supportive environment.

Because UA is a school-level intervention that aims to create a cohort of science teachers across grades, there are increased avenues for teacher collaboration, another correlate of teacher turnover (Fuller et al., 2016; Kraft et al., 2016; Nguyen et al., 2020). Teachers also engage with a community of their peers outside the school and content experts at participating ISEIs through both professional development sessions and events. For example, UA hosts a citywide year-end event where students come together with families and educators to present their work at a science exposition. UA also provides teaching materials (e.g., materials for science labs); while the evidence on the association between school resources broadly and teacher turnover is mixed, literature suggests providing adequate teaching materials does matter to teachers (Nguyen & Spring, 2021, and cites therein).

Summary. The UA program provides many of the components of improving personal and school factors that could lead to increased teacher retention. The core of the UA program is professional development, which some literature has found is related to reduced teacher turnover. Other components of the UA program: support for administrators, opportunities for community building within and across schools, supplies, and an improved general work environment, may also reduce teacher turnover. Though we cannot separately capture the impact of the components of the UA program, the literature suggests UA may help keep teachers in NYC schools.

Data, Measures, and Sample

This study draws on three data sets from the NYC DOE, the UA program, and the New York State Department of Education. First, we use administrative individual-level longitudinal data on all teaching personnel employed by the NYC DOE, from academic years 2003 to 2022 (we refer to academic years by the calendar year of the Spring semester). The teacher data include their school, years of teaching experience, subject taught, and salary. Data on teachers' race/ethnicity, gender, and absences are not available for all years of the sample. While some research finds these are important predictors of teacher retention, earlier research in NYC found no substantial differences in teacher retention based on race/ethnicity or gender (Marinell & Coca, 2013). In addition, our results are robust to the exclusion of all teacher controls that are available (compare Column 1 of Tables 3 and 4 to our main results in

Column 5), increasing our confidence that estimates are not significantly biased by these omitted variables.

Second, these teacher-level data are combined with annual administrative records from the UA program to identify teachers who participated from 2005 to 2021. Third, we use publicly available school-level data from the New York State School Report Cards to measure school-level characteristics: total school enrollment; percentage of students who are Black, Hispanic, White, and Asian/other race (multiracial or Native American/Alaskan Indian); percentage of students who are English language learners, students with disabilities, and eligible for free or reduced-price lunch; school grade configuration (e.g., K–8, 6–8); percentage of students who met statewide proficiency standards on math and science exams; and pupil-teacher ratio.

Our variable of interest is participation in the UA program. Our primary definition is a dichotomous variable equal to 1 the year a teacher joins the UA program and each year thereafter, and equal to 0 otherwise (*UAPost*) because the skills and professional network teachers develop through UA likely impact their teaching practice even after they are no longer active in the program. Alternatively, we define participation as a dichotomous variable equal to 1 only in the years a teacher is an active participant in UA (*UACurrent*). We expect active participation in UA may have an even stronger association with retention.

The outcome, teacher turnover, is measured two ways: leaving the school and leaving the NYC DOE in the following academic year (i.e., outcomes for 2021 capture whether the teacher did not return to their school or district in the 2022 school year). For districts, teacher mobility between schools has different implications for staffing and cost than teacher mobility out of the district entirely. Urban districts are especially burdened with teacher mobility across schools within the district (Atteberry et al., 2017; Clotfelter et al., 2011; Lankford et al., 2002; Sorensen & Ladd, 2020; Perda, 2013).

Our sample includes all teachers who ever taught science in NYC public middle school grades 6 to 8, regardless of the grade configuration of the school. Our primary analysis sample includes middle school science teachers whom we can observe in their first year of teaching in NYC (cohorts 2003–2021). This eliminates roughly 1,900 teachers in cohorts 1964–2002 (30% of middle school science teachers we observe from 2003 to 2022), 337 of whom participated in UA (approximately 18% of UA teachers).

UA is a school-based program that requires the participation and buy-in of school administrators. Principals who are more proactive might encourage their teachers to sign up for the program, or, alternatively, teachers in less supportive environments might seek opportunities outside of their school. Therefore, teachers in non-UA schools may not be an appropriate

Table 1. Average Characteristics of Science Teachers in Ever-UA Schools, Cohorts 2003–2021.

Variable	All teachers (1)	Ever UA (2)	Never UA (3)
Number of teachers	3,311	1,009	2,302
Total number of teacher-year observations	23,126	8,801	14,325
(% of sample)		(38%)	(62%)
Annual salary (\$)	67,156	68,663	66,229
Teaching experience (%)			
1 year or less	15%	12%	17%
2–3 years	24%	22%	25%
4–5 years	18%	18%	18%
6–10 years	28%	31%	27%
10+ years	15%	18%	14%
Average years teaching at NYC DOE	5.0	5.5	4.8
Average years in UA	1.9	5.0	0.0
Colleagues in school in UA (%)	3.0%	4.6%	2.0%
Turnover in following year (%)			
Left school	18%	13%	21%
Left district	7%	3%	10%
Changed schools within district	10%	9%	11%
Turnover in 5 years (%)			
Left school	68%	64%	70%
Left district	48%	43%	51%
Changed schools within district	20%	21%	19%

counterfactual for teachers in UA schools. To account for school-level selection, we limit the main analysis sample to schools with teachers who participated in UA for at least 1 year.

Table 1 Column 1 presents descriptive statistics for the full sample of science teachers who ever taught in an ever-UA school, and Columns 2 and 3 disaggregate teachers who ever or never participated in UA. The sample includes 1,009 UA science teachers (approximately one-third of the total sample). Most teachers have 5 years or less of teaching experience. On average, UA participants have more teaching experience than non-UA participants (5.5 vs. 4.8 years), and higher average salaries. On average, UA teachers are in the program for 5 years and 4.6% of all other teachers in the school are also UA teachers. UA teachers are less likely to leave their school (13% vs. 21%) or the district (3% vs. 10%) the following year.

Methods

We estimate discrete-time hazard models that identify the change in the hazard probability of exit by comparing teacher turnover before and after middle school science teachers join the UA program, and account for unobserved heterogeneity using teacher random effects. Because logit coefficients are not directly interpretable, all results are expressed as average marginal effects.

We estimate the following discrete-time hazard logit model:

$$\text{logit}(h_{its}) = \mathbf{D}'_it \boldsymbol{\alpha} + \delta UA_{its} + \mathbf{X}'_{its} \boldsymbol{\beta} + u_i \quad (1)$$

where the hazard function $h_{its} = \Pr(\text{exit}_{its} = 1)$ is equal to the probability that teacher i leaves their school s in year $t + 1$ conditional on still being employed in year t . We also examine exit out of the district as a secondary outcome. $\mathbf{D}$ is a vector of period indicators that represent the baseline hazard; the longest we can track a teacher in the sample is 19 years (from school years 2003 to 2021), so there is an indicator for each period 1 through 19. The marginal effect of these period indicators will give us the hazard probability of exit in each time period. Adding an indicator variable for each period is the most flexible representation and does not impose any particular shape on the baseline hazard. The baseline hazard only predicts the time effect, without differentiating teachers by their respective characteristics (i.e., duration dependence). UA is the indicator $UAPost$ or $UACurrent$, and the marginal effect of UA is the association between UA participation and the hazard function.

The vector $\mathbf{X}$ includes the school-level characteristics described in the data section above, which could impact program participation and teacher turnover, available teacher characteristics (whether they are currently teaching science and their salary), as well as year effects to account for time-varying factors that may affect teacher labor market decisions common to all teachers (e.g., economic recession), cohort effects to adjust for differences in the 19 entering cohorts of teachers from 2003 to 2021, and local (community) school district effects. Community districts, based on geography, can affect school choice and residential decisions, and thus the characteristics of students and schools.

If unobserved heterogeneity exists and we ignore it, our hazard estimate will be biased. To illustrate this point, imagine there are two groups of science teachers: one that has a strong preference to teach and has a low risk of leaving their job and another that took the job out of necessity and has a high risk of exit. Further, assume these two groups' risk of leaving teaching is different, but each is constant over time. In time period 1, the high-risk group is

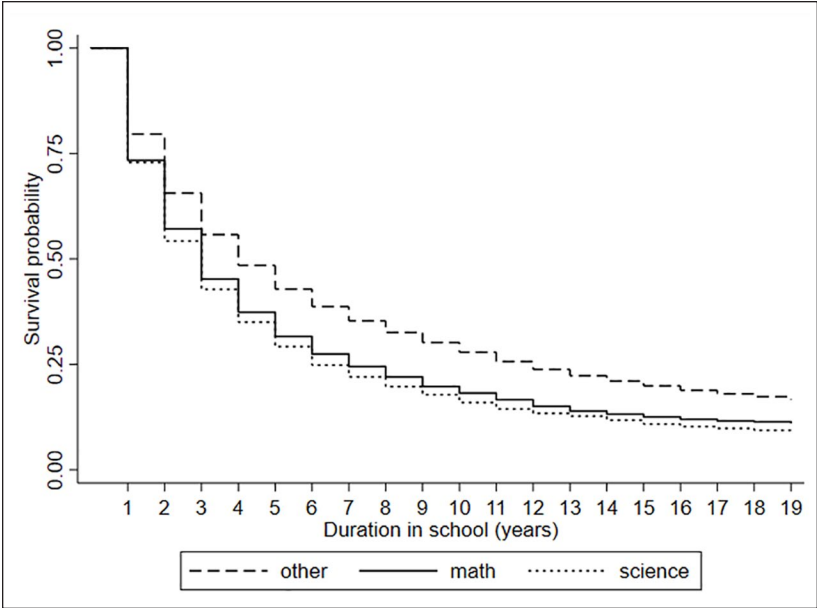


Figure 2. Kaplan–Meier survival estimates of teaching in the same school the following academic year.

Notes. This figure illustrates the proportion of teachers who remain teaching in the same school the following academic year. The sample includes all teachers observed in their first year of teaching in New York City public schools (entering cohorts 2003–2021); results are similar (retention is the lowest among science teachers) when the sample is limited to teachers who ever work in middle schools (schools serving Grades 6–8).

more likely to exit, consequently, the remaining group of teachers now has fewer high-risk teachers. If we ignore these differences in teachers we may see declining hazards over time merely as a consequence of aggregation across different groups although the groups themselves have *constant* (but different) hazards over time. To ensure there are no unobservable individual confounders associated with a teacher’s probability of exit, we accommodate for unobserved heterogeneity among teachers by adding a teacher-specific error term, u_i (random effect). We also estimate a model that accounts for school-level unobserved heterogeneity by replacing u_i with a school-specific error term. All standard errors are clustered at the school level.

Results

Figure 2 and Table 2 provide descriptive evidence that turnover is higher for science teachers in NYC than for teachers in other subjects. The survival

Table 2. Kaplan–Meier Survival Estimates of Teaching in the Same School the Following Academic Year.

Period	Science teachers	Math teachers	All other teachers
1	0.7287	0.7337	0.7960
2	0.5423	0.5711	0.6562
3	0.4277	0.4523	0.5576
4	0.3500	0.3735	0.4845
5	0.2921	0.3160	0.4284
6	0.2478	0.2743	0.3867
7	0.2201	0.2448	0.3530
8	0.1971	0.2200	0.3255
9	0.1778	0.1974	0.3018
10	0.1593	0.1817	0.2787
11	0.1438	0.1661	0.2565
12	0.1335	0.1501	0.2380
13	0.1269	0.1389	0.2229
14	0.1174	0.1317	0.2103
15	0.1081	0.1252	0.1988
16	0.1023	0.1196	0.1883
17	0.0980	0.1155	0.1800
18	0.0937	0.1137	0.1732
19	0.0884	0.1111	0.1662

Notes. This table reflects the proportion of teachers who remain teaching in the same school the following academic year (graphed in Figure 1). The sample includes all teachers observed in their first year of teaching in New York City public schools (entering cohorts 2003–2021); results are similar (retention is the lowest among science teachers) when the sample is limited to teachers who ever work in middle schools (schools serving Grades 6–8).

probabilities show the unadjusted fraction of teachers who remain teaching at their school in each period, for cohorts 2003 to 2021. When teachers enter the district (in time period 0) the survival is 1 (or 100%). In the following year (time period 1), the share drops to a 0.80 for teachers of subjects other than math or science and approximately 0.73 for math and science teachers. The largest decline in survival rates for all subjects is in the first year of teaching; over time, turnover in each period diminishes. We present only three groups in Figure 2 and Table 2 for readability, but we also separately examined English, social studies, and special education, which all have higher retention than science. Overall, in 2004 (the year before UA began) 17% of all teachers, and 20% of middle school science teachers, left their school the following year. This is similar to turnover rates over the entire 2003 to 2021 period:

on average, 18% of teachers left their school the following year and 20% of middle school science teachers left their school the following year.

Our primary finding is that compared to non-UA science teachers, UA science teachers are less likely to leave their school and less likely to leave the NYC DOE. This finding is consistent across different model specifications and samples. Table 3 presents hazard model estimates of the association of UA with the probability that a science teacher leaves the school and Table 4 presents hazard model estimates of the association of UA with the probability that a science teacher leaves the district, conditional on not having left until that point. Column 1 only accounts for year effects, cohort, and community school district effects. Columns 2 and 3 successively add observable teacher and school characteristics. Column 4 additionally accounts for school-level unobserved heterogeneity (school random effect). Column 5 accounts for individual unobserved heterogeneity (teacher random effect, as reflected in equation (1)). Column 6 also includes the teacher random effect reflected in equation (1), but replaces our preferred indicator of UA participation (participating in the current or any prior year, *UAPost*) with an indicator for active UA participation in the given year (*UACurrent*). We show all of these specifications for completeness but focus our discussion of the results on our preferred specification that accounts for individual heterogeneity (Columns 5 and 6).

First, we find UA science teachers are 3.8percentage points (pp) less likely to leave their school in the following academic year (Table 3 Column 5). This change represents a 20% decline in baseline turnover rates. To put this in perspective, studies that have investigated the impact of monetary incentives in hard-to-staff schools and subjects have estimated up to a 30% reduction in turnover (Clotfelter et al., 2008; Cowan & Goldhaber, 2018). The association is even greater for UA teachers currently participating in UA (Table 3 Column 6)—they are 4.8percentage points less likely to leave their school in the following academic year.

Second, the estimation statistics suggest unobserved heterogeneity among teachers is relatively unimportant in predicting whether a teacher will leave their school, after adjusting for observable teacher and school characteristics among UA-participating schools. Rho (ρ), at the bottom of Columns 5 and 6, denotes the share of the total variance in the probability of exit that can be attributed to variance in unobserved teacher heterogeneity. For models with leaving the school as the outcome, rho is not statistically different from zero (as indicated by *p* values above 0.10). In other words, the baseline hazard and observable predictors model the hazard probability of exit relatively well.

Third, the baseline hazard shows that the probability of turnover for science teachers declines over time (negative duration dependence). This is

Table 3. Probability that a Science Teacher Leaves the School the Following Year.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
UAPost	-0.031*** (0.008)	-0.036*** (0.008)	-0.038*** (0.008)	-0.040*** (0.008)	-0.038*** (0.009)	
UACurrent						-0.048*** (0.009)
Baseline hazard						
D_{02}	0.002 (0.017)	0.004 (0.018)	0.006 (0.017)	0.007 (0.015)	0.006 (0.015)	0.007 (0.015)
D_{03}	-0.064** (0.027)	-0.060** (0.027)	-0.057** (0.027)	-0.055** (0.022)	-0.057** (0.023)	-0.055** (0.024)
D_{04}	-0.110*** (0.033)	-0.105*** (0.035)	-0.101*** (0.034)	-0.099*** (0.028)	-0.101*** (0.029)	-0.099*** (0.032)
D_{05}	-0.149*** (0.040)	-0.143*** (0.041)	-0.137*** (0.041)	-0.134*** (0.033)	-0.137*** (0.033)	-0.135*** (0.033)
D_{06}	-0.153*** (0.044)	-0.146*** (0.046)	-0.139*** (0.045)	-0.137*** (0.037)	-0.139*** (0.037)	-0.138*** (0.037)
D_{07}	-0.204*** (0.048)	-0.196*** (0.050)	-0.189*** (0.049)	-0.188*** (0.039)	-0.189*** (0.039)	-0.188*** (0.048)
D_{08}	-0.213*** (0.050)	-0.204*** (0.053)	-0.198*** (0.052)	-0.197*** (0.041)	-0.198*** (0.044)	-0.196*** (0.055)
D_{09}	-0.224*** (0.052)	-0.215*** (0.054)	-0.210*** (0.053)	-0.210*** (0.042)	-0.210*** (0.048)	-0.209*** (0.065)
D_{10}	-0.235*** (0.054)	-0.227*** (0.057)	-0.221*** (0.056)	-0.221*** (0.043)	-0.221*** (0.052)	-0.219*** (0.048)
D_{11}	-0.224*** (0.058)	-0.215*** (0.061)	-0.210*** (0.060)	-0.209*** (0.048)	-0.210*** (0.052)	-0.208*** (0.068)
D_{12}	-0.253*** (0.053)	-0.247*** (0.055)	-0.241*** (0.054)	-0.242*** (0.043)	-0.241*** (0.060)	-0.240*** (0.043)
D_{13}	-0.257*** (0.055)	-0.252*** (0.057)	-0.247*** (0.055)	-0.247*** (0.043)	-0.247*** (0.064)	-0.246*** (0.043)
D_{14}	-0.258*** (0.056)	-0.252*** (0.058)	-0.247*** (0.057)	-0.248*** (0.044)	-0.247*** (0.065)	-0.246*** (0.044)
D_{15}	-0.261*** (0.055)	-0.255*** (0.058)	-0.250*** (0.056)	-0.251*** (0.044)	-0.250*** (0.067)	-0.249*** (0.044)
D_{16}	-0.282*** (0.047)	-0.275*** (0.049)	-0.271*** (0.048)	-0.272*** (0.037)	-0.271*** (0.078)	-0.269*** (0.037)
D_{17}	-0.271*** (0.052)	-0.265*** (0.054)	-0.260*** (0.053)	-0.261*** (0.043)	-0.260*** (0.072)	-0.258*** (0.042)
D_{18}	-0.258*** (0.064)	-0.252*** (0.066)	-0.248*** (0.064)	-0.249*** (0.050)	-0.248*** (0.069)	-0.247*** (0.050)

(continued)

Table 3. (continued)

Variable	(1)	(2)	(3)	(4)	(5)	(6)
<i>N</i>	12,936	12,936	12,936	12,936	12,936	12,936
ρ	n/a	n/a	n/a	0.0162	0.0001	0.0015
<i>p</i> -value	n/a	n/a	n/a	0.001	0.486	0.481
Teacher characteristics		x	X	x	X	x
School characteristics			X	x	X	x
School random effects				x		
Teacher random effects					X	x

Notes. All estimates are average marginal effects. The sample includes New York City public middle schools that ever participated in the Urban Advantage (UA) program and teachers who ever taught science in Grades 6 to 8 and were observed in their first year of teaching (entering cohorts 2003–2021). All models include year, cohort, and district effects. Teacher characteristics include salary and an indicator if they are a science teacher in the current year. ρ denotes the total variance in the outcome contributed by school level variance (Column 4) and teacher level variance (Columns 5 and 6). The *p*-value is for the null hypothesis that ρ is equal to zero. The highlighted estimate is the main result. Standard errors clustered by school in parentheses. ***p* < .05. ****p* < .01.

Table 4. Hazard Model Estimates: Probability that a Science Teacher Leaves the School District the Following Year.

	(1)	(2)	(3)	(4)	(5)	(6)
UAPost	−0.016*** (0.004)	−0.021*** (0.004)	−0.025*** (0.004)	−0.025*** (0.004)	−0.036*** (0.006)	
UACurrent						−0.039*** (0.006)
Baseline hazard						
D_{02}	0.013 (0.014)	0.014 (0.014)	0.016 (0.014)	0.016 (0.013)	0.016 (0.012)	0.028** (0.013)
D_{03}	−0.079*** (0.016)	−0.076*** (0.016)	−0.072*** (0.016)	−0.071*** (0.014)	−0.060*** (0.015)	−0.044*** (0.015)
D_{04}	−0.142*** (0.017)	−0.139*** (0.017)	−0.134*** (0.017)	−0.133*** (0.015)	−0.122*** (0.017)	−0.100*** (0.017)
D_{05}	−0.214*** (0.018)	−0.208*** (0.019)	−0.202*** (0.019)	−0.200*** (0.016)	−0.192*** (0.017)	−0.164*** (0.019)
D_{06}	−0.242*** (0.019)	−0.233*** (0.020)	−0.228*** (0.020)	−0.226*** (0.017)	−0.225*** (0.018)	−0.192*** (0.020)
D_{07}	−0.299*** (0.021)	−0.287*** (0.023)	−0.282*** (0.023)	−0.281*** (0.018)	−0.290*** (0.018)	−0.252*** (0.021)

(continued)

Table 4. (continued)

	(1)	(2)	(3)	(4)	(5)	(6)
D_{08}	-0.315*** (0.023)	-0.302*** (0.025)	-0.297*** (0.025)	-0.296*** (0.019)	-0.313*** (0.018)	-0.269*** (0.022)
D_{09}	-0.328*** (0.024)	-0.315*** (0.026)	-0.310*** (0.026)	-0.309*** (0.019)	-0.334*** (0.019)	-0.284*** (0.023)
D_{10}	-0.346*** (0.026)	-0.333*** (0.028)	-0.327*** (0.028)	-0.327*** (0.020)	-0.362*** (0.019)	-0.307*** (0.024)
D_{11}	-0.346*** (0.026)	-0.333*** (0.028)	-0.328*** (0.028)	-0.328*** (0.020)	-0.367*** (0.020)	-0.310*** (0.025)
D_{12}	-0.361*** (0.027)	-0.349*** (0.029)	-0.343*** (0.029)	-0.343*** (0.021)	-0.392*** (0.021)	-0.330*** (0.026)
D_{13}	-0.367*** (0.027)	-0.355*** (0.030)	-0.350*** (0.030)	-0.350*** (0.021)	-0.405*** (0.021)	-0.340*** (0.027)
D_{14}	-0.371*** (0.027)	-0.359*** (0.030)	-0.354*** (0.030)	-0.354*** (0.021)	-0.414*** (0.022)	-0.347*** (0.027)
D_{15}	-0.374*** (0.027)	-0.362*** (0.030)	-0.357*** (0.030)	-0.357*** (0.021)	-0.420*** (0.022)	-0.351*** (0.027)
D_{16}	-0.377*** (0.027)	-0.365*** (0.030)	-0.359*** (0.030)	-0.360*** (0.021)	-0.426*** (0.023)	-0.356*** (0.027)
D_{17}	-0.376*** (0.027)	-0.364*** (0.030)	-0.359*** (0.030)	-0.359*** (0.021)	-0.425*** (0.023)	-0.355*** (0.028)
D_{18}	-0.378*** (0.027)	-0.366*** (0.030)	-0.360*** (0.030)	-0.361*** (0.021)	-0.429*** (0.023)	-0.358*** (0.028)
N	23,037	23,037	23,037	23,037	23,037	23,037
ρ	n/a	n/a	n/a	0.0215	0.3108	0.2122
p -value	n/a	n/a	n/a	<0.001	<0.001	<0.001
Teacher characteristics		x	x	x	X	x
School characteristics			x	x	X	x
School random effects				x		
Teacher random effects					X	x

Notes. All estimates are average marginal effects. The sample includes New York City public middle schools that ever participated in the Urban Advantage (UA) program and teachers who ever taught science in Grades 6 to 8 and were observed in their first year of teaching (entering cohorts 2003–2021). All models include year, cohort, and district effects. Teacher characteristics include salary, and an indicator if they are a science teacher in the current year. ρ denotes the total variance in the outcome contributed by school level variance (Column 4) and teacher level variance (Columns 5 and 6). The p -value is for the null hypothesis that ρ is equal to zero. The highlighted estimate is the main result. Standard errors clustered by school in parentheses. ** $p < .05$. *** $p < .01$.

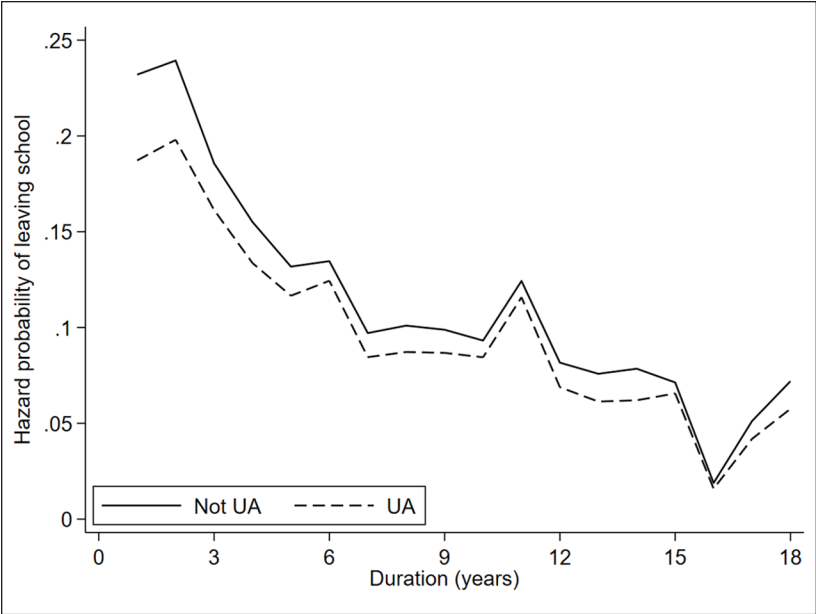


Figure 3. Estimated hazard for the probability that a science teacher leaves the school in the following year.
Note. The sample includes New York City public middle schools that ever participated in the Urban Advantage (UA) program and teachers who ever taught science in Grades 6 to 8 and were observed in their first year of teaching (entering cohorts 2003–2021). Results are average predicted probabilities from estimating Model 1 in the paper for each time period $t = 1$ through $t = 18$. UA=Urban Advantage.

further illustrated in Figure 3, which is a graphical representation of estimates in Column 5 of Table 3, calculated for each time period 1 to 18 (none of the teachers we observe in their 19th year of teaching leave their school or the district so we cannot estimate hazards for $t = 19$). In all time periods, UA teachers (dashed line) are less likely than non-UA teachers (solid line) to leave their school. The gap is wider at the start of a teacher’s career, consistent with existing literature that suggests that teacher turnover is the highest for novice teachers, though benefits remain through year 18.

Table 4 presents analogous results for the probability of leaving the NYC public school district. UA science teachers are 3.6 percentage points less likely to leave the NYC school district than non-UA science teachers (Column 5). Again, the associations are greater for active UA teachers, who are 3.9 percentage points less likely to leave the district (Column 6). However, unlike the

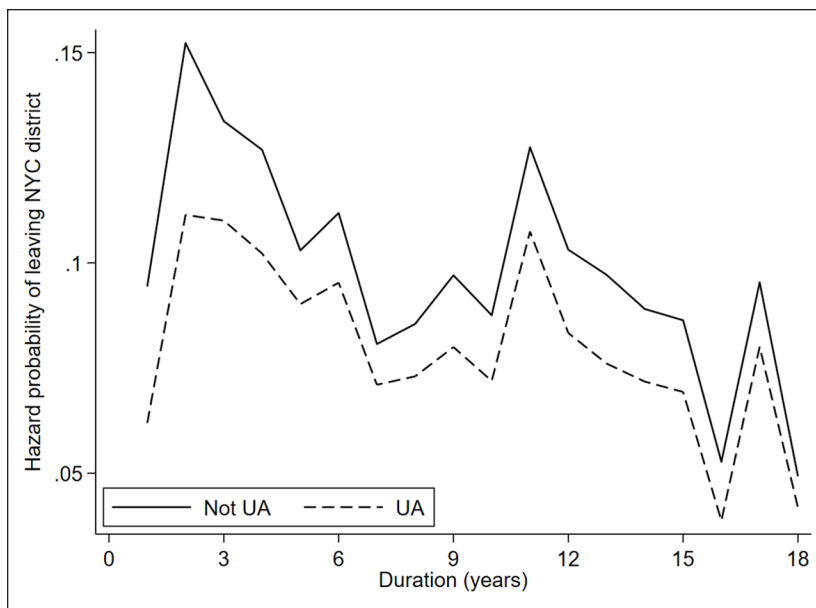


Figure 4. Estimated hazard for the probability that a science teacher leaves the district in the following year.

Note. The sample includes New York City public middle schools that ever participated in the Urban Advantage (UA) program and teachers who ever taught science in Grades 6 to 8 and were observed in their first year of teaching (entering cohorts 2003–2021). Results are average predicted probabilities from estimating Model 1 in the paper for each time period $t=1$ through $t=18$. UA=Urban Advantage.

results for leaving the school, some of the variance in the probability of exiting the district can be attributed to variance in unobserved school or teacher heterogeneity (as reflected in the estimation statistics at the bottom of Columns 4, 5, and 6 in Table 4). That is, there are unobserved school or teacher characteristics that predict their likelihood of leaving the district. If these characteristics are correlated with participation in UA, our estimates of the association of UA participation and the probability of leaving the district may be biased. We do not interpret our estimates as causal, and particularly for estimated associations with exiting the district, we are more cautious in interpreting these estimates. However, as with results for leaving the school, results for leaving the district suggest benefits of UA to teachers with varying levels of experience. In Figure 4, we see that in all time periods, UA teachers (dashed line) are less likely than non-UA teachers (solid line) to leave the district.

Taken together, the results suggest that the UA program, designed to improve students' science achievement, is also associated with improved retention among science teachers in NYC middle schools; the magnitude of these associations are practically significant.

Discussion and Conclusion

The UA program is a unique formal–informal partnership made possible through an ongoing collaboration between participating ISEIs and the NYC DOE. Despite the growing number of informal collaborations between schools and external institutions, research on the impact of such partnerships is sparse, particularly on teacher retention. This study examines changes in the risk of teacher turnover after UA participation using rich longitudinal data on science teachers in NYC middle schools. The results suggest that UA significantly reduces the risk of leaving a school by 4 percentage points and reduces the risk of leaving the district by 3 percentage points.

A key limitation of this study is that participation into the UA program is not random so the estimated relationships between UA participation and teacher turnover are not causal. Additionally, the study did not have data to empirically examine the specific mechanisms by which UA could influence teacher turnover. However, based on existing literature, several components of the UA program could be potential mechanisms, such as professional development and mentorship, enhanced collaboration among teachers and administrators in schools, and more engaged/higher-performing students.

Teacher turnover has both financial and academic consequences for schools and districts. Though our results are not causal, and we do not conduct a formal benefit-cost analysis, it is possible that high-quality professional development, such as that provided by the UA program, is a cost-effective intervention for teacher retention. This may be especially true if improved teacher retention is one of multiple benefits of the UA program—that is, the primary objective is to improve student science outcomes, and improved teacher retention is a spillover benefit.

Though the UA program is specific to NYC, school districts in urban areas have a unique opportunity to take advantage of the concentration of science-rich cultural institutions in their cities. More than 70% of science-rich cultural institutions in the United States have programs that are specifically designed for schools and teachers, but few of them have been formally institutionalized (Bevan et al., 2010). All states and districts allocate time and financial resources specifically to professional development (Loeb et al., 2009). While UA is an innovative intervention, it is possible for other school districts to implement similar programs.

Results from this article give insight into measures policymakers and school administrators can take to improve working conditions and workplace satisfaction and promote teacher retention, such as content-focused professional development and classroom instruction support, especially in schools and subjects that struggle most with teacher turnover. Our results also highlight that school-community educational partnerships, which are typically able to mobilize many different resources, can have an important role in supporting not only students but also teachers.

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References

- About UA. (n.d.). Urban Advantage NYC. Retrieved June 27, 2023, from <https://www.urbanadvantagenyc.org/about-ua/>
- Allen, R., & Sims, S. (2017). *Improving science teacher retention: Do National STEM Learning Network professional development courses keep science teachers in the classroom?* Wellcome Trust. <https://cms.wellcome.org/sites/default/files/science-teacher-retention.pdf>

- Atteberry, A., Loeb, S., & Wyckoff, J. (2017). Teacher churning: Reassignment rates and implications for student achievement. *Educational Evaluation and Policy Analysis*, 39(1), 3–30. <https://doi.org/10.3102/0162373716659929>
- Annot, M., Dee, T., Katz, V., & Wyckoff, J. (2016). Teacher turnover, teacher quality, and student achievement in DCPS (No. w21922). National Bureau of Economic Research. https://www.nber.org/system/files/working_papers/w21922/w21922.pdf
- Baron, C., Sklarwitz, S., Bang, H., & Shatara, H. (2020). What teachers retain from historic site-based professional development. *Journal of Teacher Education*, 71(4), 392–408. <https://doi.org/10.1177/0022487119841889>
- Barnes, G., Crowe, E., & Schaefer, B. (2007). The cost of teacher turnover in five school districts: A pilot study. *National Commission on Teaching and America's Future*. <https://files.eric.ed.gov/fulltext/ED497176.pdf>
- Bastian, K. C., & Fuller, S. C. (2023). Educator attrition and mobility during the Covid-19 pandemic. *Educational Researcher*, 52(8), 516–520.
- Bevan, B., Dillon, J., Hein, G. E., Macdonald, M., Michalchik, V., Miller, D., Root, D., Rudder, L., Xanthoudaki, M., & Yoon, S. (2010). Making science matter: Collaborations between informal science education organizations and schools. *Center for Advancement of Informal Science Education (CAISE)*. <https://www.informalscience.org/sites/default/files/MakingScienceMatter.pdf>
- Bleiberg, J., & Kraft, M. A. (2022). What happened to the K-12 education labor market during COVID? The acute need for better data systems. (EdWorkingPaper: 22-544). Annenberg Institute at Brown University. <https://doi.org/10.26300/2xw0-v642>
- Carroll, T. (2007). The high cost of teacher turnover. Prepared for the National Commission on Teaching and America's Future. <https://files.eric.ed.gov/fulltext/ED498001.pdf>
- Carver-Thomas, D., Leung, M., & Burns, D. (2021). *California teachers and COVID-19: How the pandemic is impacting the teacher workforce*. Learning Policy Institute.
- Carver-Thomas, D., & Darling-Hammond, L. (2017). Teacher turnover: Why it matters and what we can do about it. *Learning Policy Institute*. https://learningpolicyinstitute.org/sites/default/files/product-files/Teacher_Turnover_REPORT.pdf
- Clotfelter, C. T., Glennie, E. J., Ladd, H. F., & Vigdor, J. L. (2008). Teacher bonuses and teacher retention in low-performing schools evidence from the North Carolina \$1,800 teacher bonus program. *Public Finance Review*, 36(1), 63–87. <https://doi.org/10.1177/1091142106291662>
- Clotfelter, C. T., Ladd, H. F., & Vigdor, J. L. (2011). Teacher mobility, school segregation, and pay-based policies to level the playing field. *Education Finance and Policy*, 6(3), 399–438. https://doi.org/10.1162/EDFP_a_00040
- Coldwell, M. (2017). Exploring the influence of professional development on teacher careers: A path model approach. *Teaching and Teacher Education*, 61, 189–198. <https://doi.org/10.1016/j.tate.2016.10.015>

- Cowan, J., & Goldhaber, D. (2018). Do bonuses affect teacher staffing and student achievement in high poverty schools? Evidence from an incentive for national board certified teachers in Washington State. *Economics of Education Review*, 65, 138–152. <https://doi.org/10.1016/j.econedurev.2018.06.010>
- DeFeo, D. J., Tran, T., Hirshberg, D., Cope, D., & Cravez, P. (2017). *The cost of teacher turnover in Alaska*. Center for Alaska Education Policy Research (CAEPR). <https://scholarworks.alaska.edu/handle/11122/7815>
- DiGaudio, L. M. (2017). *Implications of the school improvement engine for teacher retention and school organizational health* [Doctoral dissertation, Walden University]. ProQuest Dissertations Publishing. <https://www.proquest.com/pqdt-global/docview/1864787149/DB9FF943F6154FE9PQ>
- Erickson, S. J. (2007). *An examination of the relationship between professional development and teacher turnover*. [Doctoral dissertation, University of Oregon]. ProQuest Dissertations Publishing.
- Feng, L., & Sass, T. R. (2018). The impact of incentives to recruit and retain teachers in “hard-to-staff” subjects. *Journal of Policy Analysis and Management*, 37(1), 112–135. <https://doi.org/10.1002/pam.22037>
- Fuller, B., Waite, A., & Irribarra, D. (2016). Explaining teacher turnover: School cohesion and intrinsic motivation in Los Angeles. *American Journal of Education*, 122(4), 537–567. <https://doi.org/10.1086/687272>
- Garet, M. S., Cronen, S., Eaton, M., Kurki, A., Ludwig, M., Jones, W., Uekawa, K., Falk, A., Bloom, H. S., Doolittle, F., Zhu, P., Sztajnberg, L., & Silverberg, M. (2008). *The impact of two professional development interventions on early reading instruction and achievement (NCEE 2008-4030)*. National Center for Education Evaluation and Regional Assistance. <https://ies.ed.gov/ncee/pdf/20084030.pdf>
- Guarino, C. M., Santibañez, L., Daley, G. A., & Brewer, D. (2004). A review of the research literature on teacher recruitment and retention (TR-164-EDU). RAND. https://www.rand.org/pubs/technical_reports/TR164.html
- Hammerness, K., MacPherson, A., Macdonald, M., Roditi, H., & Curtis-Bey, L. (2017). What does it take to sustain a productive partnership in education? *Phi Delta Kappan*, 99(1), 15–20. <https://doi.org/10.1177/0031721717728272>
- Han, D., & Hur, H. (2022). Managing turnover of STEM teacher workforce. *Education and Urban Society*, 54(2), 205–222. <https://doi.org/10.1177/00131245211053562>
- Hanushek, E. A., Rivkin, S. G., & Schiman, J. C. (2016). Dynamic effects of teacher turnover on the quality of instruction. *Economics of Education Review*, 55, 132–148. <https://doi.org/10.1016/j.econedurev.2016.08.004>
- Ingersoll, R. M. (2003). Turnover and shortages among science and mathematics teachers in the United States. In J. Rhoton & P. Bowers (Eds.), *Science teacher retention: Mentoring and renewal* (pp. 1–12). NSTA Press.
- Ingersoll, R. M., & Perda, D. (2010). Is the supply of mathematics and science teachers sufficient? *American Educational Research Journal*, 47(3), 563–594. <https://doi.org/10.3102/0002831210370711>

- Kraft, M. A., Marinell, W. H., & Yee, D. (2016). School organizational contexts, teacher turnover, and student achievement: Evidence from panel data. *American Educational Research Journal*, 53(5), 1411–1449. <https://doi.org/10.3102/0002831216667478>
- Lankford, H., Loeb, S., & Wyckoff, J. (2002). Teacher sorting and plight of urban schools: A descriptive analysis. *Educational Evaluation and Policy Analysis*, 24(1), 37–62. <https://doi.org/10.3102/01623737024001037>
- Liu, S., & Phelps, G. (2020). Does teacher learning last? Understanding how much teachers retain their knowledge after professional development. *Journal of Teacher Education*, 71(5), 537–550. <https://doi.org/10.1177/0022487119886290>
- Loeb, S., Miller, L. C., & Strunk, K. O. (2009). The state role in teacher professional development and education throughout teachers' careers. *Education Finance and Policy*, 4(2), 212–228. <https://doi.org/10.1162/edfp.2009.4.2.212>
- Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics*, 99(5), 258–271. <https://doi.org/10.1111/j.1949-8594.1999.tb17484.x>
- Marinell, W. H., & Coca, V. M. (2013). *Who stays and who leaves? Findings from a three-part study of teacher turnover in NYC middle schools*. Research Alliance for New York City Schools. <http://media.ranycs.org/2013/003>
- Nguyen, T. D., Lam, C. B., & Bruno, P. (2022). *Is there a national teacher shortage? A systematic examination of reports of teacher shortages in the United States* (EdWorkingPaper: 22-631). Annenberg Institute at Brown University: <https://doi.org/10.26300/76eq-hj32>
- Nguyen, T. D., Pham, L. D., Crouch, M., & Springer, M. G. (2020). The correlates of teacher turnover: An updated and expanded Meta-analysis of the literature. *Educational Research Review*, 31, 100355. <https://doi.org/10.1016/j.edurev.2020.100355>
- Nguyen, T. D., & Redding, C. (2018). Changes in the demographics, qualifications, and turnover of American STEM teachers, 1988–2012. *AERA Open*, 4(3), 1–13. <https://doi.org/10.1177/2332858418802790>
- Nguyen, T. D., & Springer, M. G. (2021). A conceptual framework of teacher turnover: A systematic review of the empirical international literature and insights from the employee turnover literature. *Educational Review*, 75(5), 993–1028. <https://doi.org/10.1080/00131911.2021.1940103>
- Noonoo, S. (2022, May 2). The mental health crisis causing teachers to quit. *EdSurge*. <https://www.edsurge.com/news/2022-05-02-the-mental-health-crisis-causing-teachers-to-quit>
- Perda, D. (2013). *Transitions into and out of teaching: A longitudinal analysis of early career teacher turnover* [Doctoral dissertation, University of Pennsylvania]. ProQuest Dissertations Publishing.
- Reininger, M. (2012). Hometown disadvantage? It depends on where you're from: Teachers' location preferences and the implications for staffing schools. *Educational Evaluation and Policy Analysis*, 34(2), 127–145. <https://doi.org/10.3102/0162373711420864>

- Ronfeldt, M., Loeb, S., & Wyckoff, J. (2013). How teacher turnover harms student achievement. *American Educational Research Journal*, 50(1), 4–36. <https://doi.org/10.3102/0002831212463813>
- Sorensen, L. C., & Ladd, H. F. (2020). The hidden costs of teacher turnover. *AERA Open*, 6(1), 1–24. <https://doi.org/10.1177/2332858420905812>
- Slagus, L. M., & Kelly, A. M. (2024). Professional development partnership between urban middle school science teachers and informal science institutions. *Research in Science & Technological Education*, 42(2), 294–314. <https://doi.org/10.1080/02635143.2022.2070148>
- Vagi, R., Pivovarova, M., & Miedel Barnard, W. (2019). Keeping our best? A survival analysis examining a measure of preservice teacher quality and teacher attrition. *Journal of Teacher Education*, 70(2), 115–127. <https://doi.org/10.1177/0022487117725025>
- Watlington, E., Shockley, R., Guglielmino, P., & Felsher, R. (2010). The high cost of leaving: An analysis of the cost of teacher turnover. *Journal of Education Finance*, 36(1), 22–37. <http://doi.org/10.1353/jef.0.0028>
- Weinstein, M., Shiferaw, M., & O'Hagan, K. (2023). *The urban advantage: Comprehensive science professional development and student achievement*. SSRN Working Paper: 4542712. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4542712
- Weinstein, M., Whitesell, E. R., & Schwartz, A. E. (2014). Museums, zoos, and gardens: How formal-informal partnerships can impact urban students' performance in science. *Evaluation Review*, 38(6), 514–545. <https://doi.org/10.1177/0193841X14553299>
- Whitesell, E. R. (2016). A day at the museum: The impact of field trips on middle school science achievement. *Journal of Research in Science Teaching*, 53(7), 1036–1054. <https://doi.org/10.1002/tea.21322>

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