A descriptive analysis comparison of retained vs. non-retained novice secondary science teachers in four U.S. states from 2007-2018.

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Over the past two decades, a great deal of research has examined the issue of science teacher retention, with specific emphasis on retaining novice teachers within a school, district, or even in the profession itself. This issue presents uniquely in the United States, where conditions of employment vary widely across over 18,000 local education agencies, and teachers enter the classroom through an array of pathways that may or may not include teacher preparation programs.

We define retention in this research as staying with the same employer for at least four of a teacher's first five years (Larkin, Patzelt, et al., 2022); a definition that allows for ambiguity in reported dates of hire present in the publicly available data sets used for this study. This definition is more robust than the commonly used one-year retention metric that is often required in state or federal reporting efforts (e.g. Ingersoll & Perda, 2010).

Admittedly, for some teachers, staying may not be a choice if their contract is not renewed by their employer. For others the question of whether to stay —either in a position or the profession — is a deeply personal one. Even so, there remains the possibility that certain characteristics of employers, schools, or the teachers themselves may be salient in influencing such decisions. We set aside the question for the moment of who *should* be retained, and instead focus this study on the question of who *is* being retained as a necessary precursor to understanding the issue of teacher retention in U.S. schools. Therefore, the question investigated in this study was: **Across different U.S. states, are there categorical differences between**

teachers who are identified as being retained (i.e. stayed with an employer at least 4 out of first 5 years) and those who were not?

We look at this question with the aid of state-level staffing data that provides us not only with demographic information (which includes teaching assignment and years of experience), but also indirectly provides us with the means to examine other factors, such as starting salary, the number of departmental colleagues, and the number of other certified science teachers in the school system. To be clear, this study did not aim to create a model or identify causal mechanisms for retention in the descriptive analysis provided here. Rather, our purpose was to compare the identifiable demographic characteristics and organizational factors between those science teachers who stayed and those who did not in the four states under consideration, to provide markers for potentially fruitful areas of research.

Background

The recruitment, preparation and retention of science teachers, embedded within the larger issue of teacher retention generally, has been a recurring topic of concern for the United States since the late 1950s, (Rudolph, 1999, 2019), with attention often driven by science teacher shortages (Aragon, 2016; Garcia & Weiss, 2019; Sutcher et al., 2019). Currently, a common understanding in the field is that addressing the science teacher shortage entails engaging with issues of teacher retention as much as attending to recruitment (American Association for the Advancement of Science, 2021; Ingersoll & Perda, 2010). While not every science teacher is likely to be retained in a teaching position or even in the profession, it is likely that many leave for one reason or another when perhaps, if things were different, they might have stayed. Our general orientation to the problem of teacher retention as a research team is that there are actions

stakeholders and policymakers might take in order to affect the retention of teachers (Rinke, 2014).

A common approach to researching teacher retention concerns investigating the correlations between specific factors and measures of teacher retention (Achinstein et al., 2010; Borman & Dowling, 2008; Carver-Thomas & Darling-Hammond, 2017). Research on teacher retention conducted over the past two decades has focused on both individual and organizational factors correlated with teacher retention. In the state-level staffing data analyzed in this study, *teacher background* and *school contexts* are two broad categories of factors that are readily apparent. Teacher background encompasses age, sex, race/ethnicity, preparation, and subject area certification. School contexts included salary and specific school characteristics such as school size, socioeconomic indicators, administrator characteristics, and as is salient here, the number of colleagues comprising an organizational unit (e.g. a science department).

In terms of teacher background, the literature shows that age is a strong predictor of teacher retention (Borman & Dowling, 2008; Ingersoll & Perda, 2010). Similarly, Tai et al. (2006) found that older science teachers had higher rates of retention. Detailed studies have also shown that the attrition rate for teachers of color surpassed that of White teachers in recent years (Achinstein et al., 2010; Ingersoll, 2015; Marvel et al., 2007). Teachers of color are more likely to work in settings with low teacher retention rates, and often face other unique challenges in teaching (Griffin et al., 2022; Kohli, 2018; Kokka, 2016), a finding echoed in a wide range of STEM fields (Mandel et al., 2018; McGee, 2021). Though not addressed in the present study, the relationship between preparation routes (i.e. traditional teacher preparation vs alternate pathways to certification) and retention has been mixed, and provides different results depending on the time frame examined for retention. (Grissom, 2008; Grossman & Loeb, 2010; Zhang & Zeller,

2016). Achinstein et al. (2010) found higher attrition rates for teachers of color in either pathway, and Borman & Dowling (2008) noted that attrition was twice as likely for teachers holding a math or science degree as compared with other disciplines and grade levels.

In terms of organizational factors, salary has been shown to be a significant predictor of retention, with the highest effect sizes among older teachers later in their careers (Borman & Dowling, 2008; Carver-Thomas & Darling-Hammond, 2017). Ingersoll and May (2012) noted that science teachers in particular were most likely to state that a retention decision was influenced by salary. Studies suggest that school characteristics such as setting, socioeconomic status, and student demographics are correlated with measures of teacher retention (Ingersoll & May, 2012; Nguyen, 2021), and a statistically significantly higher rate of teacher turnover in high-poverty schools (Ingersoll & May, 2012).

Findings from our broader study indicated the importance of departmental colleagues as an important factor in science teacher retention (Larkin et al., 2024), and the number and availability of science colleagues, either within the same school or across a wider local education agency (LEA) organization could certainly be a way to try to measure their possible influence. Yet, we were unable to locate any large-scale studies that examined the relationship between science department size and science teacher retention, a gap addressed by the present study.

Research design

This study is part of a larger 5-year research project on the retention of novice science teachers in four U.S. states: New Jersey, Pennsylvania, Wisconsin, and North Carolina. These states were selected for their differing teacher retention policy environments, the availability of staffing data for each of the focus years of interest (2007-2018), and other aspects of the project

discussed elsewhere (Larkin, Carletta, et al., 2022). The data in this study were obtained through publicly available data or records requests in each state, and each was supplied in the format designated by state regulations. One of our first tasks was to clean the data and align each state/year file in order for the formatting to be commensurable with one another.

While not all files were complete in every category for each year of interest, most contained a listing of individual personnel with the following information: name (or anonymized teacher ID), local educational agency, race/ethnicity, sex, year of birth, job code (proxy for certification area), highest degree, total years experience, and total years in the LEA. New Jersey, Pennsylvania, and Wisconsin provided the annual salary as a field, while North Carolina listed the "pay level" designation for the statewide salary schedule. For the purposes of this analysis, teachers with race/ethnicity reported were categorized as a teacher of color if their race was not White or their ethnicity was Hispanic, and though we recognize that such characterization can be problematic (Teranishi et al., 2020), we felt it was a reasonable first approximation for this analysis. All state data with the exception of North Carolina included birth year. There were a number of additional data fields, such as teacher preparation pathway, only present in some staffing files.

After the data was cleaned, we limited our inquiry to teachers who were first-year high school science teachers—as designated by their teaching assignment—between 2007-2012 in the four focus states. We then constructed a 5-year retention map for each of the six cohorts of novice science teachers in each of the four states. Any teacher meeting the criteria of teaching in the same LEA for 4 out their first 5 years was designated *retained*; those who did not were designated *not retained*. These two groups —for each cohort and each state— were compared in the following manner.

The majority of analyses were conducted using IBM SPSS 25 in conjunction with Microsoft Excel. Analyses were conducted on all six cohorts as a unit in each state. An additional analysis was conducted on each cohort for starting salary only, with the exception of North Carolina. Crosstabulations were conducted to compare retained teachers to not retained teachers with regards to degree, sex, and whether or not they were teachers of color. Mean, median, and mode were calculated for age and compared across groups for each state except North Carolina, for which this data was unavailable. LEA and School Department sizes were calculated as the number of other teachers with secondary science certifications in the LEA or school, and a similar comparison retained to non-retained teachers was conducted.

Starting salary in the New Jersey, Pennsylvania, and Wisconsin was listed as a field in the data, and as a matter of state policy was set by the individual district. A review of the data found a small number of outliers that could not be explained, and therefore salaries of two or more SD from the mean (likely from data entry errors from the LEA) were excluded from analysis. North Carolina has employed a state-level salary guide with local salary supplements for decades, but only salary levels based on highest degree attained were reported in the data. Therefore North Carolina was excluded from the salary analysis. Given that in all three of the remaining states, teachers with bachelor's degrees and master degrees appeared to be paid a different base rate, we disaggregated this analysis by degree listed, with bachelor's degrees in one category and master's degrees in the other. The number of doctoral degrees in each state data set was too small to include in this analysis. New Jersey did not report degrees for 2012-13 school year, so NJ data only shows five cohorts instead of six.

Findings

The full set of descriptive statistics for the data from all four states are shown in Table 1. Wisconsin had a much higher overall rate of retention than the other three states, and this finding is consistent across all six years of data. North Carolina and New Jersey hired many more teachers of color, but they were retained at a much lower rate than those in Wisconsin and Pennsylvania. In all four states, there was not a significant relationship between highest degree and retention.

Though the average starting salary was quite different across three states, with New Jersey the highest and Wisconsin the lowest (See Table 2), within each state there was no correlation between starting salary and retention for teachers, when the degree level was taken into consideration, as shown in Table 3. The average salary for both bachelor's and master's degrees within each state as shown in Figures 1, 2, and 3, and averages for all four states are shown in Figure 4.

There was no significant relationship between LEA department size and retention, though the larger LEAs with over 150 science teachers certainly demonstrated lower science teacher retention (Figure 5). Though there was a slightly lower rate of retention in schools with a science department size of between 5-17 people as compared with smaller or larger departments (Figure 6), a clear correlation between department size and retention could not be demonstrated from this data.

Discussion

In this analysis, we simply sought to seek out and describe any differences between populations of teachers in four states who were retained, and those that were not. Explanations of those differences—such as the startlingly low numbers of science teachers of color hired in

Wisconsin or the policy implications of the cost of living on starting teacher salaries—remain an area of future work.

It is worth recalling that the study of teacher retention is rooted in an effort to understand—and perhaps influence—the choices that individuals make about the provision of their labor, both in a specific setting and to a profession. In the early days of negotiating the parameters of this study with the funding agency, we received a clear message that there was great interest in an examination of the determinants of science teacher retention that included the possible impact of salary. This of course, made perfect sense to us, and we readily accepted, knowing that salary was one of the key pieces of data to which we had access.

In the United States, public school teachers are salaried employees, meaning that they are not paid an hourly wage for their primary job assignment, but instead provided with a contract that stipulates the terms and conditions of their work, as well as the amount to be paid over a set pay schedule by their LEA. Typically, in order to satisfactorily discharge the responsibilities of the job, teachers spend additional time outside of hours they are contracted to be present in order to work directly with students. This is why teachers often stay after the school day ends, take home student work to grade, and spend evenings and weekends planning lessons. By signing a contract, the teacher agrees to exchange labor for payment. As in common in many professions, achieving a sufficient level of quality in one's work and managing the multiple demands of the job can be a steeper challenge for novices. Over time, there is likely a built-in survival bias for experienced teachers, who have figured out how to do both.

Public school teacher salaries vary widely across the United States for a variety of reasons, and may differ not just in gross pay, but in how a starting salary is determined. Some

states, like North Carolina, have a statewide salary scale set by the legislature, with LEAs permitted to supplement pay through local taxation to make allowance for regional differences in the cost of living. Other school systems rely on the collective bargaining of contracts between school LEAs and teachers' associations. There has even been some experimentation in school reform efforts—such as in the case with charter schools—where schools directly negotiate salaries with individual teachers. Teachers' salary may also take into account experience level, education (in the form of graduate degrees or credits), or other benchmarks of teacher quality such as earning National Board Certification from the National Board of Professional Teaching Standards. Some LEAs may offer signing bonuses to new teachers in an effort to attract teachers in shortage area certifications or high-need schools, or offer performance bonuses or merit pay for meeting certain student achievement targets. From year-to-year, depending on where they work, teachers' base salaries may change in clearly defined increments over time, or remain static until changed by legislative action or a renegotiation of a contract. Further, teachers often take on additional work for their employer as coaches, curriculum writers, club advisors, summer tutors, teaching an extra class to cover for a teacher on leave, etc. Such work may be salaried, or paid at a negotiated hourly rate, and the opportunity to accept these additional jobs may vary greatly both across and within LEAs. Therefore, asking the question of how a teacher's pay correlates to their retention within an LEA (or retention in the profession) is linked to how that pay is determined and changes over time, and what opportunities there are to supplement base pay or advance on a salary guide.

Conclusion

Categorial differences between the retained and not-retained groups of novice science teachers offer the promise on informing future inquiries and interventions that support teacher

retention efforts as well as a move away from common practices currently used to increase retention. These differences are embedded in the state contexts of teacher policy in each of the focus states, and suggest that the demographic differences interact with the state and local contexts in meaningful ways. Wisconsin's significantly higher rates of retention across all demographic categories points to a further need to understand why such a differential retention rate exists. Additionally, this study highlights the possible need to move away from incentives to recruit teachers, such as degree attainment and initial salary hikes, to more sustaining efforts focused on both recruitment as well as retention. Along similar lines, this study also suggests that efforts to recruit should already be considering efforts of retention, rather than treating these two problems as distinct from one another.

Tables and Figures

		New Jersey		Pennsylvania		Wisconsin		North Carolina	
Number of New Science Teachers	**Total**	**1691 (100%)**		**1679 (100%)**		**845 (100%)**		**1645 (100%)**	
	Retained	728	43%	803	48%	573	68%	701	43%
	Not Retained	962	57%	875	52%	272	32%	944	57%
Teachers of Color (Hispanic or non-White)	**Total**	**282 (17%)**		**60 (4%)**		**24 (3%)**		**265 (16%)**	
	Retained	100	35%	34	57%	11	46%	112	42%
	Not Retained	182	65%	26	43%	13	54%	153	58%
non-Teachers of Color (White and non-Hispanic)	**Total**	**1408 (83%)**		**1618 (96%)**		**821 (97%)**		**1292 (79%)**	
	Retained	628	45%	769	48%	562	68%	542	42%
	Not Retained	780	55%	849	52%	259	32%	750	58%
Women	**Total**	**983 (58%)**		**945 (56%)**		**473 (56%)**		**1101 (67%)**	
	Retained	431	44%	441	47%	312	66%	477	43%
	Not Retained	552	56%	504	53%	161	34%	624	57%
Men	**Total**	**707 (42%)**		**733 (44%)**		**372 (44%)**		**544 (33%)**	
	Retained	297	42%	362	49%	261	70%	224	41%
	Not Retained	410	58%	371	51%	111	30%	320	59%
Bachelor's Degree	**Total**	**802 (61%)**		**1140 (71%)**		**718 (85%)**		**1294 (90%)**	
	Retained	348	43%	518	45%	495	69%	542	42%
	Not Retained	454	57%	622	55%	223	31%	752	58%
Masters' Degree	**Total**	**400 (31%)**		**453 (28%)**		**111 (13%)**		**148 (10%)**	
	Retained	168	42%	224	49%	69	62%	78	53%
	Not Retained	232	58%	229	51%	42	38%	70	47%
Ph.D or equivalent	**Total**	**106 (8%)**		**22 (1%)**		**16 (2%)**		**0 (0%)**	
	Retained	39	37%	15	68%	9	56%	-	-
	Not Retained	67	63%	7	32%	7	44%	-	-
Age Mean (SD)	**Total**	**46.57 (11.4)**		**43.19 (SD= 8.9)**		**43.66 (SD= 8.9)**		n/a	
	Retained	44.68 (10.1)		43.70 (SD= 9.1)		43.15 (SD= 7.9)		n/a	
	Not Retained	48.01 (12.1)		41.94 (SD= 8.3)		44.75(SD= 10.6)		n/a	

Table 1: Descriptive statistics of retained (5-year) and non-retained secondary science teachers in four U.S. states hired between 2007-2012.

		2007	2008	2009	2010	2011	2012
NJ	**BS Avg**	**$45,364**	**$46,427**	**$47,713**	**$48,432**	**$49,098**	-
	BS Retained	$44,923	$46,883	$48,017	$48,607	$49,078	-
	BS Not Retained	$45,812	$45,844	$47,334	$48,133	$49,126	-
	MS Avg	**$52,781**	**$53,273**	**$52,511**	**$53,464**	**$54,413**	-
	MS Retained	$52,925	$54,435	$52,538	$52,270	$53,400	-
	MS Not Retained	$52,565	$51,976	$52,475	$55,425	$55,851	-
PA	**BS Avg**	**$39,195**	**$41,147**	**$41,102**	**$42,749**	**$42,485**	**$43,931**
	BS Retained	$39,163	$40,331	$41,818	$42,072	$41,731	$44,195
	BS Not Retained	$39,219	$41,839	$40,594	$43,187	$42,948	$43,773
	MS Avg	**$45,029**	**$43,161**	**$44,782**	**$45,194**	**$45,062**	**$46,865**
	MS Retained	$43,358	$44,598	$44,406	$45,206	$44,091	$48,154
	MS Not Retained	$46,143	$41,260	$45,126	$45,183	$45,678	$45,115
WI	**BS Avg**	**$32,643**	**$32,589**	**$30,622**	**$31,615**	**$33,553**	**$33,632**
	BS Retained	$32,476	$33,259	$31,152	$31,002	$33,521	$34,081
	BS Not Retained	$33,167	$31,134	$29,365	$33,020	$33,602	$32,767
	MS Avg	**$34,725**	**$43,467**	**$34,645**	**$40,529**	**$34,736**	**$41,171**
	MS Retained	$37,504	$44,406	$38,196	$35,997	$38,058	$36,494
	MS Not Retained	$28,955	$40,415	$31,489	$54,122	$29,991	$45,848

Table 2. Starting salary NJ, PA, & WI retained vs not retained by degree (2007-2012)

		New Jersey			Pennsylvania			Wisconsin		
		n	r_{pb}	p	n	r_{pb}	p	n	r_{pb}	p
2007	Bachelors	133	0.024	0.78	200	-0.005	0.94	158	0.031	0.70
	Masters	57	0.029	0.83	84	-0.104	0.35	31	-0.046	0.81
2008	Bachelors	201	-0.094	0.18	217	-0.104	0.13	115	0.061	0.52
	Masters	89	-0.096	0.37	78	0.210	0.06	15	*	-
2009	Bachelors	156	-0.089	0.27	182	0.105	0.16	69	0.141	0.25
	Masters	80	-0.081	0.48	66	-0.042	0.74	12	*	-
2010	Bachelors	140	-0.053	0.53	139	-0.088	0.30	65	-0.002	0.99
	Masters	72	0.203	0.09	51	0.002	0.99	3	*	-
2011	Bachelors	155	0.073	0.37	70	-0.107	0.38	101	-0.088	0.38
	Masters	89	0.071	0.51	48	-0.112	0.45	12	*	-
2012	Bachelors	-	-		98	0.033	0.75	101	0.015	0.88
	Masters	-	-		32	0.160	0.38	13	*	-

** Degree cohorts of n<20 were below the threshold for calculating reliable correlation coefficients.*

Table 3: Relationship between starting salary and retention for secondary science cohorts by degree type in NJ, PA, and WI (2007-2012)

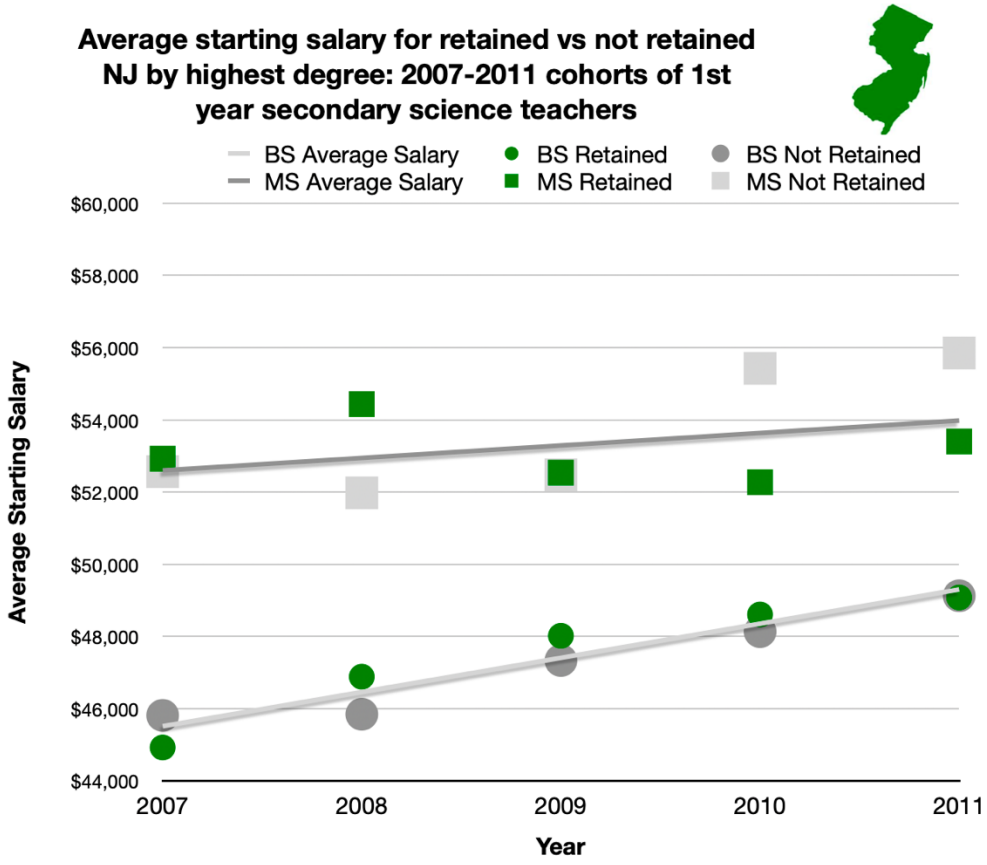

Figure 1. Average starting salary for retained vs not retained NJ by highest degree (2007-2011)

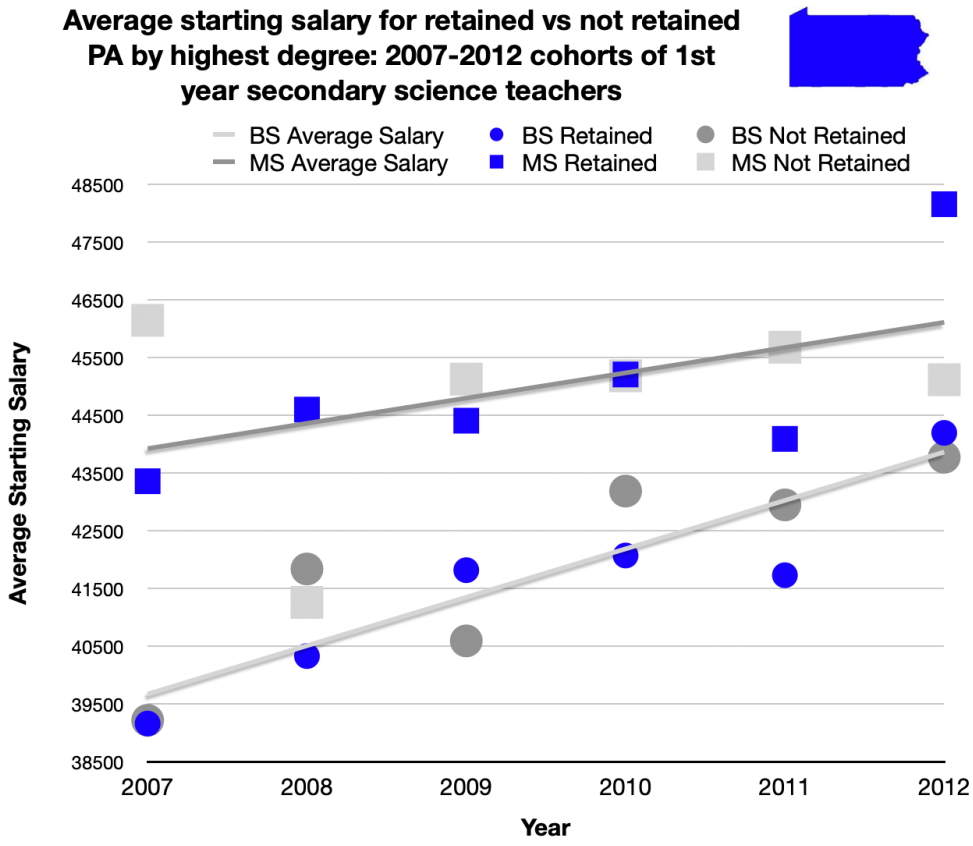

Figure 2. Average starting salary for retained vs not retained PA by highest degree (2007-2012)

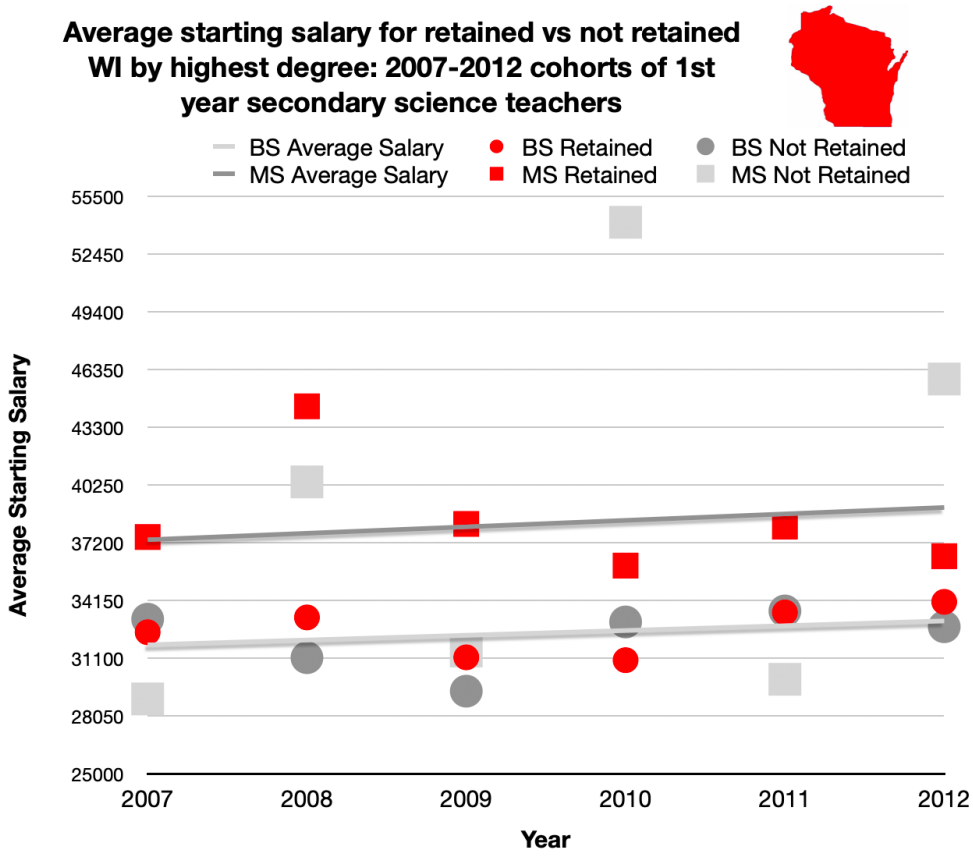

Figure 3. Average starting salary for retained vs not retained WI by highest degree (2007-2012)

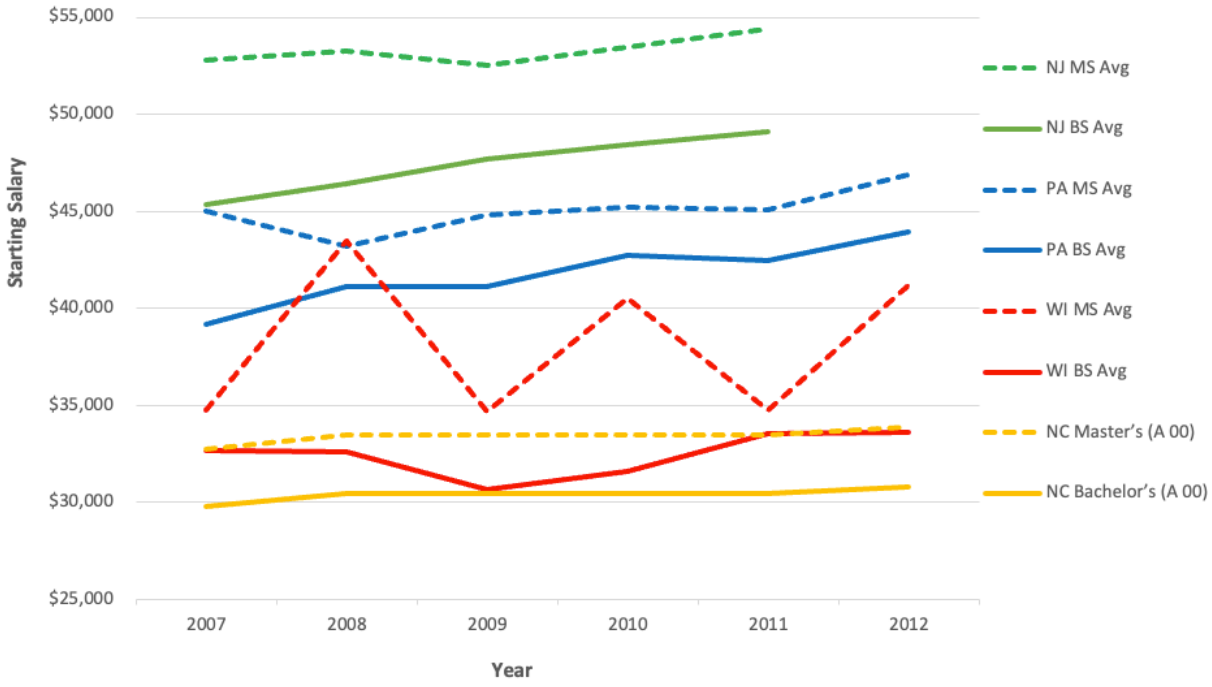

Figure 4. Average Starting Salary for First-year Secondary Science Teachers (2007-2012)

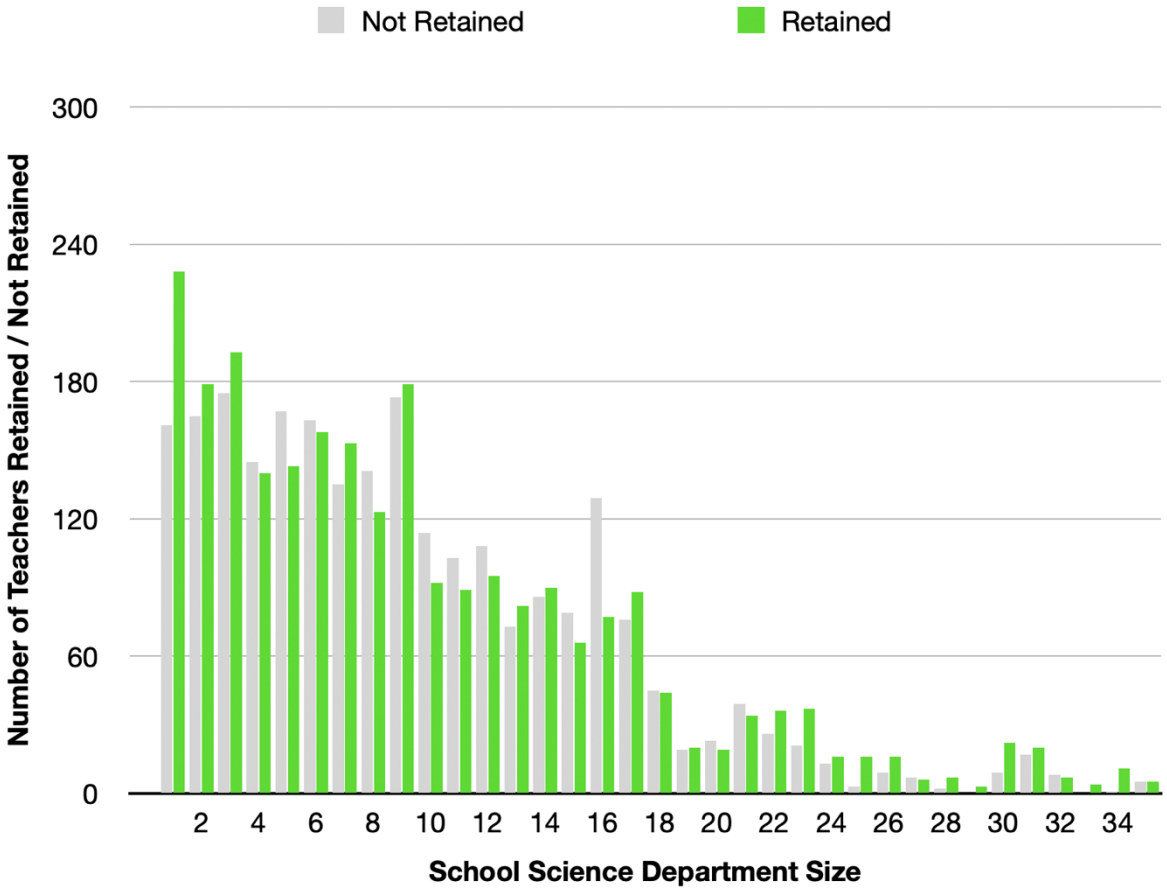

Figure 5. Retention 2007-2012 vs. School Science Department size (NJ, PA, WI, & NC)

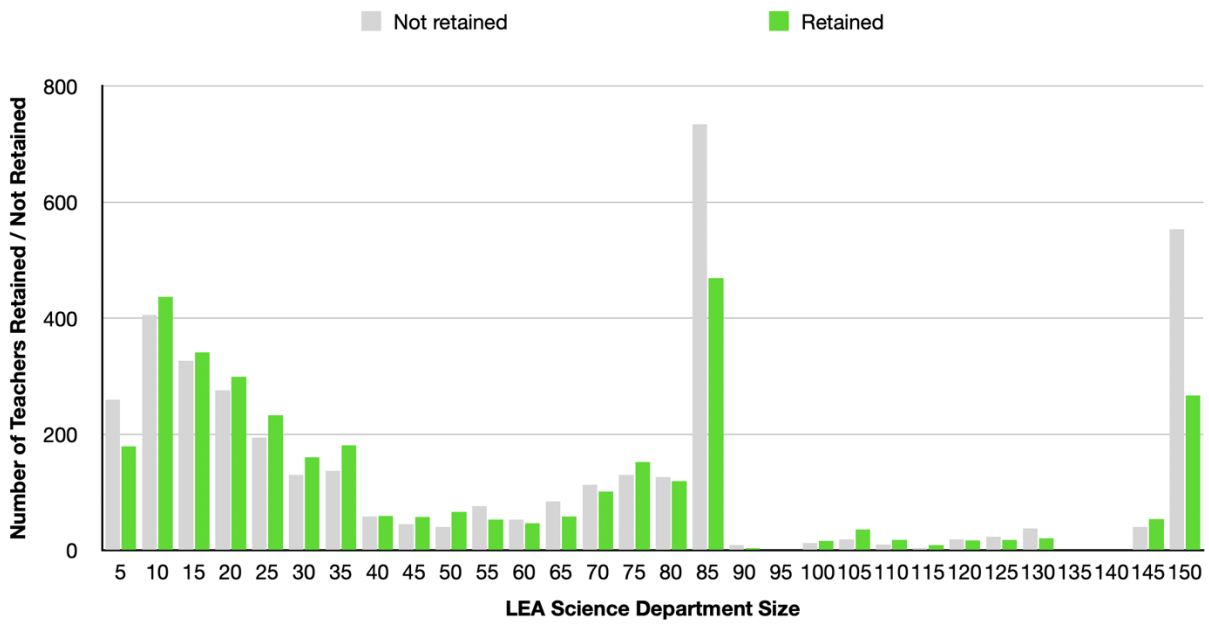

Figure 6. Retention 2007-2012 vs. LEA Science Department size (NJ, PA, WI, & NC)

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