Retention of Novice Science Teachers in U.S. School Districts: Findings from A Cross-Case Analysis

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For many years, the focus of research on teacher careers has been on identifying the reasons why teachers leave the profession, in order to provide interventions that mitigate the problems. Alternately referred to as *teacher attrition* or *teacher turnover*, these efforts have uncovered some of the systemic difficulties faced by teachers in their work lives and have provided important empirical support for improving not only the work lives of teachers, but the experiences of students as well. The problem of teacher attrition or teacher turnover is framed primarily by those who are charged with ensuring that there is a "good teacher in every classroom" (Darling-Hammond et al., 2005) because there are few problems more vexing to an administrator than staffing shortages. In the United States, this is particularly true in areas of perennial teacher vacancies, such as in secondary science subjects like biology, chemistry, and physics, where there is no guarantee that an open position can be filled in a timely manner.

And yet, this construction of the problem of teacher attrition as motivated primarily by figuring out why teachers leave has foregrounded the act of leaving and normalized the act of staying. Perhaps this is because it is natural to conflate the fact of someone staying with the internal state of wanting to stay, that is, out of satisfaction. In other words, a common assumption in thinking about teachers who stay is that they are different from the teachers who leave, because whatever reasons there are for leaving do not necessarily impact them to the same extent. In the present study, we question this assumption right from the outset, and posit that the reasons people stay are not simply the inverse of the reasons people leave.

If job satisfaction is the explanatory framework for leaving or staying, then teachers who stay are satisfied and teachers who leave are not. In fact, it only takes the briefest of thought experiments to consider cases where someone who is very unsatisfied with their teaching job might stay (perhaps the job is a financial lifeline that cannot be risked in any way), and someone who is very satisfied might leave (perhaps if a partner is offered a dream job on the other side of the country and a move is necessary). In the larger human resource literature, it turns out that the construct of job satisfaction has very little predictive power in predicting attrition, even while ensuring employee satisfaction with their jobs remains a key aspect of creating a sustainable working environment.

The literature on has identified both personal and organizational factors related to teacher retention. Some personal factors such as age and sex seem to offer limited explanatory power with respect to retention, while others such as race/ethnicity, education level, and teacher preparation pathways and components do appear to have some predictive power. Certainly these factors interact with organizational and contextual

factors that appear related to retention, such as the adequacy of salary, teacher autonomy, respect in organizational culture, and professional opportunities for growth. We have argued elsewhere that teacher attrition and mobility are different concepts, and that care needs to be taken when defining teacher retention, especially when comparing across different contexts (Larkin, Patzelt, et al., 2022).

New teachers are of particular concern when considering issues of retention. There are a number of reasons why new teachers are more likely to leave the profession than experienced teachers. A new teacher may realize that teaching is not what they expected it to be, or find it personally challenging in unexpected ways. New teachers also tend to be young adults, when life circumstances tend to be less certain and new opportunities or personal circumstances may arise. A new teacher may simply not meet expectations with respect to the professional skills or attributes required of them, and fall short of teacher quality measures or opportunities to improve. Across nearly all organizational contexts and policy environments, it appears more likely that an 11^{th}-year teacher will return to be a 12^{th}-year teacher, than a first-year teacher will return for a second year. While this may not be unique to teaching as a profession, given the fact that in the United States educators form one of the largest groups of employees—over 3 million people, or 1% of the U.S. population work in education—as well as teachers' daily relevance to everyone who is a caregiver to a school-aged child, the retention of new teachers is an issue of high visibility to the general population in the United States. In some districts where the average experience of the teaching faculty is less, the effects of teacher attrition and mobility are for keenly felt for this reason.

One of the key strategies arising from the teacher professionalization policy changes of the 1980s has been the institutionalization of practices relating to supporting new teachers within the school districts and settings into which they are hired. Two important efforts—often conflated in practice—are mentoring and induction programs. We review these concepts further below, but broadly our definition of mentoring concerns efforts that connect newly-hired and experienced individual teachers, while induction programs are more systematic aimed at providing organizational resources to address the needs of new teachers. For decades, mentoring and induction programs have been considered key practices in state and district efforts to retain teachers, and have sometimes been justified by their subsequent impact on student learning, even if the evidence has been thin. In many ways, the commonsense notion that a new professional in any profession needs support appears to have been the buoyant force keeping such practices afloat for the past few decades.

In secondary science and mathematics subjects however, the persistent shortage of teachers has led to a reassessment of current efforts for teacher retention. Ingersoll has repeatedly noted that the supply of new science and mathematics teachers would likely be sufficient if the flow of such teachers out of the profession could be addressed.[1] Our research team's expertise and experience in secondary science teaching led us to focus solely on this population of teachers, and we sought to do so in districts that had demonstrated novice science teacher retention longitudinally over with multiple cohorts of

[1] The National Science Foundation took up this challenge by creating a funding source for researching STEM teacher recruitment, preparation, and retention through its Noyce Teacher Scholarship Program, which served as the funding source for the present study.

new teachers. We also sought to ensure that we had enough variation in state policy contexts to be able to properly attribute differences across schools within a state. As described below, we ultimately selected four states for the selection of high-retention districts: New Jersey, North Carolina, Pennsylvania, and Wisconsin. In this study we aimed to investigate a wide range of factors related to teacher retention.

The primary question we investigated in our research was, **"In districts that have demonstrated comparatively more successful novice science teacher retention, what are the factors that relate to such retention?"** We sought to understand what retention efforts were working to retain novice science teachers across the schools in each state, but given the priorities of the Noyce program, we also specifically looked for districts that were successfully retaining teachers of color, as well as high-need schools that were also successful in retaining teachers.[2]

As research team, we had a number of methodological and ethical commitments from the outset. First, was that a focus on why novice science teachers stayed, rather than why they leave was important because the pathological approaches taken in prior research on teacher attrition had borne limited fruit, and we felt that a "search for the good" in educational research was likely to produce new insights. In order to do this, we had to be rigorous in identifying places where novice science teachers were being retained, using trustworthy data on teacher staffing to identify retention. Yet we also recognized that quantitative or survey data could only tell us so much, and that we had to be open to

[2] Add high need definition here

collecting qualitative data—through case study methods— to capture the richness of the stories about teacher retention conveyed to us by our participants.

A related commitment of our project was respecting and valuing of the knowledge of educators. It was clear to us from our own experiences as classroom teachers that educators often have a wealth of knowledge and practical wisdom that often goes unrecognized outside of their own contexts. We took it as a given that administrators and teachers had developed practices that fostered teacher retention, and that part of our role as educational researchers was to bring their hard-won knowledge to a wider audience. It also meant that we shared our analyses and open ourselves to their feedback.

This study was conceived and designed prior to the start of the global COVID-19 pandemic, and the first site visits took place in early 2020 just before schools began going remote out of safety concerns. Though we initially planned for a larger sample, we also had to respect district administrators' choice not to participate in the project—and nearly all who declined participation did so out of concern for the ongoing stress on their teachers during this time. Ultimately, we conducted 13 case studies on high-retention districts, and the purpose of the present paper is to present the findings of the cross-case analysis to share our answer to the question of what is working in efforts to retain novice science teachers.

Review of the Literature

In this section, we review the literature for the factors that are currently considered important for teacher retention. The section ends with a brief overview of the ways in which school and district context factors are portrayed in this literature with respect to

teacher retention. The practice of mentoring and induction for novice teachers as a specific approach for supporting teachers will be treated separately and through the lens of teacher retention.

We begin this section with careful attention to the ways in which teacher retention and its associated terms have been characterized in the literature. One of the findings from our research team's prior analysis of teacher retention literature was the need to specify the duration of retention envisioned in research so that results could be compared across studies. For the purposes of this research, we considered the five-year point an adequate benchmark by which to ascertain whether a teacher was retained in their district of employment. Further, because the district (or Local Educational Authority, in the parlance of U.S. educational policy that is inclusive of charter, vocational, and special services schools) is our unit of analysis, we considered a teacher to be retained as long as they remained a teacher employed by the same employer. We recognize that to an administrator who has to hire a replacement for a teacher who has shifted to a school across town, it may not seem as if that teacher was retained, but our definition of retention is with respect to the employer, and by extension, the profession of teaching.

In our study, rather than defining retention as a first year teacher returning for a second year, we have chosen to view retention as finishing five years and starting a sixth for a few reasons. First, according to the U.S. Department of Labor, the median number of years that wage and salary workers have been with their current employer is a little over 4 years, though for education, training, and library occupations it is a little over 5 years. So by defining "retention" as completing a fifth year and starting a sixth, in our study we are really looking to see if a given teacher stays as long as the average employee. Also, in states

with tenure, this time marker also ensures that teachers have had the opportunity to earn the rights and job security of tenure—which is 3 or 4 years in most places—so in a way this reflects the field's view of when a teacher no longer is considered a "new" teacher. Finally, a six-year span seems a reasonable amount of time to allow for new teachers who take time off for family or medical purposes (about 13% of new teachers in our preliminary analysis) to return to the workforce, and not be counted as teachers who have left the profession. In our determinations of retention, we have found that sometimes employment is not counted in whole years, or that the line between long-term substitute teacher and full time teacher can be difficult to tease apart. Therefore, even though we mark five years as the retention point, we can only say with certainty that the individual teacher has taught at least four full years within that period of time. As noted in our previous scholarship on this topic (Larkin, Patzelt, et al., 2022), we intentionally avoid the use of the term "teacher turnover" because of its imprecision.

In this study, we draw from Ingersoll and Strong (2011) to define *induction* as a set of systemic programmatic efforts designed to support new teachers during their first five years of teaching. Dawson's (2014) typology of mentoring does include models that might be considered equivalent to induction, but in this study we define *mentoring* to be a one-to-one relationship between one less experienced teacher and one with more experience. Within this definition there are certainly a wide range of approaches and models for how, how often, and where mentoring takes place.

Teacher Retention Factors

Over the past two decades, there has been a fundamental reconceptualization about the shortage of science teachers in U.S. schools. For a long time, the problem was considered to be one of recruitment, but a sustained program of research led primarily by Ingersoll's detailed investigation of multiple decades of data from the School and Staffing Survey has led to the finding that the labor shortages in middle and high school science and mathematics teachers is driven primarily by teacher attrition and mobility (Ingersoll, 1997, 2007, 2011; Ingersoll & May, 2011, 2012; Ingersoll & Smith, 2003). Recruitment remains an important link in the process of addressing this shortage, particularly in chronically hard to staff areas of certification such as science, mathematics, special education, and bilingual education (Barth et al., 2016).

A great deal of prior work on teacher retention has focused on the labor pool for teachers, and specifically the question of whether teachers survive their first year and returns for a second. The methodology for this program of research required a national sample of teachers to make broader generalizations about the labor pool of teachers. This remains an important avenue of research, and a few key insights of this work serve as a starting point for our project, including:

- Math and science teachers leave the profession at about the same annual rate as teachers in other subject areas
- The new supply of qualified mathematics and science teachers has been more than sufficient to cover those retiring.
- The issue of teacher of teacher turnover seems more pressing in math and science because there are fewer un-hired teachers out in the labor pool in these areas.

- Few of the measured individual characteristics of first-year teachers were related to their likelihood of leaving.
- First-year teachers who took more courses in teaching methods and strategies were significantly less likely to depart.
- Greater teacher autonomy is connected to reduced turnover in low-performing schools.

Literature on the determinants of science and math teacher attrition has identified variables that contribute to teacher attrition such as discipline, classroom management, poor administrative support, contradictions between theory and practice, scheduling, and socialization (Saka et al., 2013). Qualitative and quantitative studies have examined the characteristics of teachers' context that influence intrinsic and extrinsic factors leading to attrition and migration from math and science (Borman & Dowling, 2008; Guarino et al., 2006; Ingersoll & May, 2012; Ingersoll & Perda, 2010; Ingersoll & Strong, 2011).

Research that draws upon organizational theory identifies major trends that impact both attrition and retention, which include: individual difference (e.g., personality, motivating forces), increased emphasis on contextual variables with an emphasis on interpersonal relationships (e.g., leader-member exchange, interpersonal citizenship behaviors), enhanced focus on factors looking specifically at staying; and dynamic modeling of processes with the consideration of time (e.g., changes in job satisfaction), and financial incentives (Fulbeck & Richards, 2015; Holtom et al., 2008; Ingersoll & May, 2012).

It has long been recognized that school and district contexts play a significant role in not only student experiences and outcomes, but in the teachers' work lives as well. Issues

as wide ranging as school funding, racial integration, school size, the physical conditions of buildings, school climate, the ages and grade-levels of students, degree of curricular and professional autonomy, administrative support, the local character of the community, and the relationship between the individual school and other organizational characteristics may all be considered part of this context. Throughout the teacher retention literature, these contextual factors appear to play a very important role in determinations to stay.

For example Nguyen (2021) notes a strong correlation between teacher retention and administrative support while a study in Sweden emphasized social support from colleagues as an important factor (Casely-Hayford et al., 2022).

Mentoring and induction

Understanding the role of induction and mentoring programs in retaining science teachers remains an important yet under-researched aspect of ensuring that well-prepared teachers stay in the profession. In recent years, greater attention has been drawn to the issue of supporting new teacher learning in their first years of teaching—a period commonly referred to as *induction* (Feiman-Nemser, 2001). The professional needs and challenges of science teachers specifically during these induction years are well documented in the literature (Bianchini & Brenner, 2010; Davis et al., 2006; Saka et al., 2009; Wood et al., 2012), and include improving subject matter knowledge (Abell, 2007), developing a professional identity (Kelly, 2006), learning about students, specific instructional practices, and professionalism. One core finding concerns the positive value of discipline-specific induction support for novice science teachers (Luft et al., 2003).

Yet, in a large randomized controlled trial of induction in a sample of large, urban, low-income schools that indicated significant positive effects on student achievement were correlated with teachers involved in induction programs, there were no effects on either teacher retention or teachers' classroom practices (Ingersoll & Strong, 2011), and a similar absence of effect of induction on retention was noted in another large-scale study as well (Isenberg et al., 2009). These findings are counterintuitive and point to a need to better understand the relationship between specific types of induction support during the first years of teaching and retention in the profession.

Despite a culture of training and mentorship that exists in other skilled professions, the absence of or limited induction is a reality for many new teachers. It is not uncommon for new teachers to work in isolation from colleagues and be left on their own to succeed or fail despite being placed in the most challenging and difficult classroom and schools (Ingersoll & Strong, 2011). This "sink-or-swim" theory of teacher learning runs counter to decades of research on teacher learning (Feiman-Nemser, 2001, 2012), particularly concerning the widely understood role of necessity of feedback for learning (Hattie & Timperley, 2007). Rather than leaving new teacher success to chance, the field of teacher preparation has recognized that the function and structure of induction are now critically important and areas of further research.

Currently, some states such as Massachusetts and California have coherent and robust programs of induction for new teachers, influenced by research-based models of induction, such as those published by The New Teacher Center. However, many nationally recognized programs of science teacher induction like the Knowles Science Teaching Foundation (Galosy & Gillespie, 2013; Trygstad & Banilower, 2015) and The Exploratorium

in San Francisco (Shore & Stokes, 2006) only reach a limited number of teachers, and have a specific focus on developing science teacher leadership. It is clear that even in states with existing requirements for mentoring during the first year, like New Jersey, there is little to no data on the effectiveness of various types of support during the first years of science teaching. The proposed study will address this gap by examining the induction and mentoring programs of a much wider sample of districts across multiple states, and in greater detail.

Aspects of induction that requires greater scrutiny are the mentor-mentee relationship and the process of becoming part of becoming a reflective teacher in a professional learning community, particularly as these relate to equity (Achinstein & Barrett, 2004; Zeichner & Liston, 1996). Individual schools' mentoring programs vary based on constraints such as the number of teachers they serve, release time to develop the mentor-mentee relationship, and the mentor's areas of expertise, among others—thus raising the question, in hard-to-staff schools and districts, of what types of mentoring programs exist, and what constitutes a "good" mentoring program to support teacher retention.

Currently, much of the literature around science teacher induction and mentoring has focused on describing or comparing different models of induction (Ceven McNally, 2016; Luft et al., 2011; Luft et al., 2003; Roehrig & Luft, 2006) or providing individual case studies of teacher learning during an induction program (Bang & Luft, 2014; Galosy & Gillespie, 2013; McGinnis et al., 2004; Ortega et al., 2013; Saka et al., 2013; Saka et al., 2009; Sickel & Friedrichsen, 2015; Soares et al., 2008). While these studies are quite valuable both in mapping out the developmental pathways and learning progressions for new

science teachers, they are also limited in being able to inform policy, and may overlook current locally developed efforts that have had positive results on either student learning or teacher retention.

One of the clearest visions of the theory of teacher induction was offered nearly 15 years ago by Feiman-Nemser (2001), who set out clear developmental and professional benchmarks for teacher learning during the first five years of employment. These included: gaining local knowledge of students, curriculum, and school context, designing responsive curriculum and instruction, enacting a beginning repertoire in purposeful ways, creating a classroom learning community, developing a professional identity, and learning in and from practice. However, the interactions between all of these components are still not well understood and have been difficult for researchers to characterize a more fine-grained developmental pathway or learning progression for teachers. Often, the available resources for mentoring are concentrated in the first year (as is the case in NJ), and this ambiguity over what sorts of issues ought to gain precedence in mentoring has left many induction programs operating without a clear curricular approach or even learning objectives.

Theoretical Framework

To make sense of our data, we have chosen to theorize teacher retention by using an adapted version of the framework of job embeddedness (Holtom et al., 2006; Kiazad et al., 2015; Mitchell et al., 2001), which we have borrowed from the field of applied psychology and economics. This adapted theory, which we have termed teacher embeddedness (Larkin, Carletta, et al., 2022), offers new insights on meaningful support for novice

teachers and is consistent with our aim to focus on why teachers stay, rather than why they leave (Lee et al., 2014).

As shown in Table 1, the main components of teacher embeddedness theory are fit, links, and assets, and are applied to two distinct domains: the organization and the community (Larkin, Carletta, et al., 2022). In our teacher embeddedness framework, the organization refers to the workplace of the school and district itself, and community refers to the local area surrounding the school. In our research, we seek evidence of fit, links, and assets in both these domains.

Fit refers to the comfort and compatibility of an individual to the organization and community, and includes the degree to which the goals, values, and worldviews of the employee are aligned with those in evidence in those domains (Holtom et al., 2006; Watson, 2018). It also includes the degree to which there are emotional attachments and aspirational commitments to these workplaces and settings. Simply put, new science teachers who may flourish in some environments might find it difficult to continue in others. In their study, Zumwalt et al (2017) note, "Finding the right match, regardless of the type of school, seems to be the critical factor for many of the teachers who chose to remain in classroom teaching," (p.18).

Table 1. Teacher embeddedness theory from Larkin et al., (2022), adapted from Mitchell et al. (2001) and Holtom, et al. (2006)

Component	**Domain: Organization**	**Domain: Community**
Fit	The comfort and compatibility of an individual with respect to the local educational context. This includes the degree to which the aspirations, career goals, values, culture, and worldview of the teacher are aligned with the environment of the local educational context in which an individual works.	The comfort and compatibility of an individual with respect to the community. This includes the degree to which the aspirations, career goals, values, culture, and worldview of the teacher are aligned with the environment of the local community in which an individual works.
Links	Personal relationships and connections made with colleagues, students, and others within the local educational context.	Personal relationships and connections made with individuals and groups within the community, which may include family, consumer, religious, and other social affiliations.
Assets	The sum of the tangible and intangible benefits from a job to	The sum of the tangible and intangible benefits from a

Component	Domain: Organization	Domain: Community
	an individual in terms of perceived material and psychological value. Such assets may include salary, workplace space and materials, perquisites, established patterns of working, and support for professional growth.	community to an individual in terms of perceived material and psychological value. Such assets may include housing, sense of place, established patterns of living, personal safety, favorable commutes to work, and other aspects of one's quality of life influenced by the community.

Links are formal and informal social connections and relationships. Within the workplace these links may be to colleagues and associated professionals. Within the local area, these links may include family, religious, and other social affiliations. Links with students and their families are also important and may span the boundary between organization and community. Certainly, such links may also influence a person's decision not to leave their place of employment (Mitchell et al., 2001). Links are often stronger when the district is familiar to a teacher. Reininger (2012) found that most young teachers in the United States live in close proximity to their hometowns, and Redding (2022) found that homegrown teachers from urban districts do tend to remain longer.

The third component of the teacher embeddedness framework, *assets*, refers to the tangible and intangible benefits from a job to an individual in terms of perceived material

and psychological value. We describe as assets those things which would be sacrificed if an educator voluntarily left a position (Larkin, Carletta, et al., 2022).

Methodology

This study consisted of two distinct phases. In first phase, we used publicly available data to track the retention of individual secondary science teachers in four states over a ten year period. Using these data, we then identified candidate districts/LEAs for further case study based on their record of retention in the focus areas. In the second phase we identified and then recruited districts with a high rate of novice science teacher retention to participate in a site visit and qualitative data collection. The data from this visited was then analyzed to construct a written case study to describe the factors influencing teacher retention in each district. A multiple case analysis of the 13 complete district/LEA-level case studies was then conducted, with the goal of identifying common themes across the cases. The methodology and data sources for each phase are described in detail below.

Phase One: Analysis of State-Level District Staffing Data for all years 2007-2018

In this section we describe the data sources and methods used to identify novice science teachers who were retained for at least four out of their first five years of teaching in a single school LEA. We limit our discussion of methods to the identification and selection of focus districts, even though we conducted a broader analysis of each state's staffing data with respect to the differences between retained and non-retained novice science teachers. The results of that analysis will be reported in a future paper.

Data Sources

In the United States, much of the research on teacher retention has tended to draw upon two types of data sources. First are the large-scale surveys of teachers produced by the National Center for Education Statistics such as the Schools and Staffing Survey (SASS) and the Teacher Follow up Survey (TFS) used between 1987 and 2011. Data from the SASS have informed a great deal of foundational research in teacher retention research in the United States, particularly the work of Richard Ingersoll and colleagues (e.g. Ingersoll, 1997, 2007, 2011; Ingersoll & May, 2011, 2012; Ingersoll et al., 2016; Ingersoll & Smith, 2003). The successor to SASS, the National Teacher and Principal Survey (NTPS) is currently used to produce an annual report on the condition of education in the U.S. (McFarland, 2019), but as of this writing has not been used to report on teacher retention. There are also smaller and more focused studies that are also survey-based, such as the NJ Pathways study of a 1987 cohort over 11 years (Natriello & Zumwalt, 2017) and the later NYC Pathways study (Boyd et al., 2006).

The second type of data source informing teacher retention research comes from smaller-scale qualitative studies that track relatively small numbers of teachers longitudinally. For example, much of the literature around science teacher induction and mentoring has focused on tracking, describing or comparing different models of induction (Ceven McNally, 2016; Luft et al., 2011; Roehrig & Luft, 2006) or providing individual case studies of teacher learning during an induction program (Bang & Luft, 2014; McGinnis et al., 2004; Saka et al., 2013). While these studies are valuable in understanding the particular experiences of novice teachers, they are somewhat limited in being able to inform policy. Given the often wide range of teacher education program quality (Zeichner,

2006) and variation in district and state mentoring and induction supports (Dawson, 2014), the ability to generalize from such in-depth studies may also be limited. While such studies are crucial in grappling with equity and justice issues in education (e.g. Achinstein & Barrett, 2004; Bianchini & Brenner, 2010; Lee, 2006), they may not point to salient trends in the teacher labor force that could meaningfully influence policymakers.

In this paper we join a growing number of researchers to make use of a new kind of dataset: state-level school staffing reports. While in certain states these reports have been available for decades, the U.S. Department of Education's Race to the Top grant proposal process from 2009-2013 in the United States brought new attention to the pressing issue of the development of longitudinal data systems (Howell & Magazinnik, 2017). As a consequence, many state-level education data systems now have unique teacher identifiers that allow for education researchers to examine questions about teacher retention (which includes teacher mobility, persistence, and attrition) at a scope and level of detail that was previously available only to state departments of education. Ultimately, the development of these systems across states was uneven, and often focused more on student achievement outcome data (Boser, 2012; Flores et al., 2017). Yet, the existence and availability of these databases gave many U.S. states the capacity to look at old questions about teacher retention in new ways. Indeed, a growing number of researchers have gained access to these or similar state-level (or even large district-level) data to research teacher retention (e.g. Bastian & Marks, 2017; Mandel et al., 2018; Marinell & Coca, 2013; Simon & Johnson, 2015).

Data contained in the state staffing reports typically includes certain common fields, such as first, middle, and last name, salary, and year of birth. Reporting of race and

ethnicity have changed over the past decade, and given that states must report race and ethnicity data to the federal government, many state data systems appear to have adopted federal guidelines that allow for respondents to choose more than one race, and present ethnicity as a separate category (Spellings, 2007). Sex data is also included in this data set, and while some states have moved to include a non-binary response option for students, none of the teacher-level data examined for this study included this option. We note here that by the final data year of this project (2017-2018), the states in this study no longer published race/ethnicity or year of birth in their publicly available staffing data. Salary data may be reported differently depending on the state or year (e.g. monthly, annual, base rate, total with supplemental, etc.).

The professional data in these reports typically include educational attainment level, teaching assignments (used as a proxy for certification area), full/part time status, years of experience in the LEA, years of total teaching experience. The school and local education agency (LEA) assignment and location is also included, and may include the grade level or grand band (e.g. elementary, middle, high school) taught. Some states included a field for preparation pathway (e.g. New Jersey data provides the option for the selection of "traditional" or "alternate route").

Used in combination with other district and school data made publicly available by state departments of education, it was possible to link other contextual factors such as district size, school size, and student demographics to the data on individual teachers.

The four states in this study, as shown in Table 2—New Jersey, North Carolina, Pennsylvania, and Wisconsin—were chosen because they are high-population states with diverse populations, have a mix of rural, suburban, and urban school districts, and

represent a range of teacher preparation and retention policy contexts. Further, each of the four states had full and available annual data sets of teacher employment that included demographic and teaching assignment fields. Pennsylvania, and Wisconsin published their staffing lists as spreadsheets on state websites. New Jersey's data was not publicly available but was obtained through the state's Open Public Records Act process. The State of North Carolina stores all education data with the North Carolina Education Research Data Center (NCERDC), and was made available for a fee. Notably, data from North Carolina did not include teacher names, only unique numerical identifiers. Though a larger study with more states would likely have enriched our investigation, given the constraints of time, funding, and data availability we felt that the four states selected were likely to yield sufficient answers to the research questions.

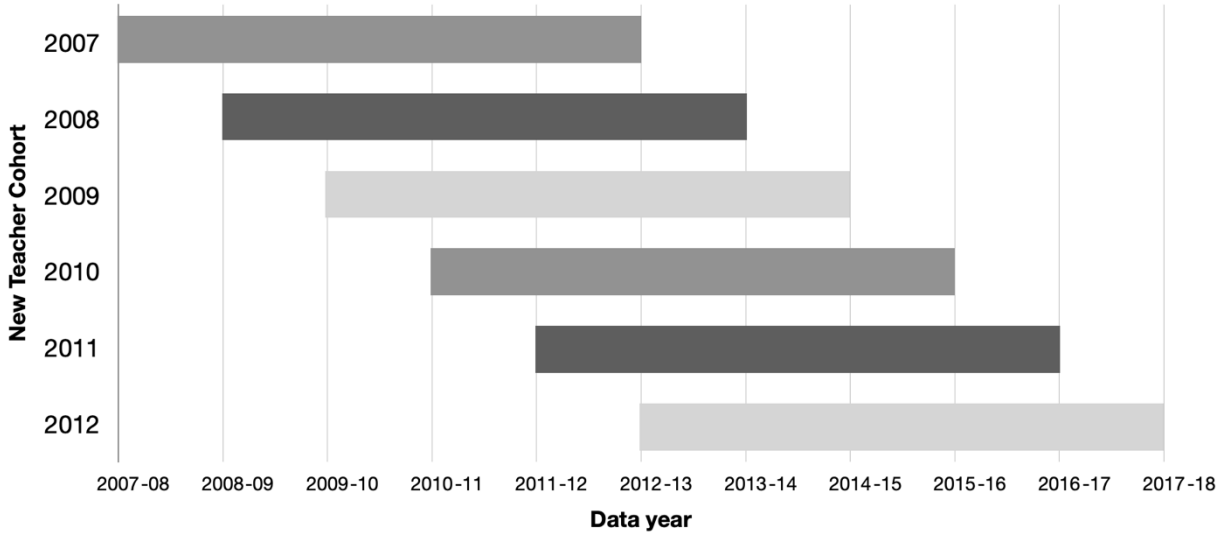
Table 2. Population data for selected states in 2017 (cite US Census, NCIS)

	NJ	**NC**	**PA**	**WI**
Total state population	8,900,000	10,400,000	12,800,000	5,800,000
Number of Teachers	116,351	98,590	120,681	60,649
Number of secondary science teachers	~7000	~8000	~9000	~5000
Total regular local public school districts[3]	562	121	500	420

[3] Our data included other public school LEAs, such as county-level vocational schools and charter schools. "Regular local public school district" is a data category used by the National Center of Educational Statistics.

Number of LEAs with at least one novice high school science teacher between 2007-2018	242 (43%)	85 (70%)	353 (70%)	182 (43%)

Figure 1. Annual staffing data required for each cohort of novice science teachers



For each of the four states, we sought to identify teachers who had been retained for four out of their first five years. Because staffing data was compiled at the beginning of each state's academic year, six years of data were required. Additionally, we aimed to examine teacher retention of multiple cohorts of novice science teachers who all began teaching in the same year. Given that complete data was available for each of the four states beginning in 2007, and this project began in 2018, we were able to analyze six full cohorts, as shown in Table 3.

Therefore we required 11 years of annual staffing data from each state, spanning from 2007 to 2018.

Creating a Master Table for Each State

The first step in this analysis was to construct a master list for each state that included the employment status of each novice science teacher who was a member of the 2007 through 2012 cohorts. Each data set was trimmed to include only teachers of secondary science who were in their first six years of teaching within this time frame, and each individual was assigned a unique project identifier that included their state and cohort year (e.g. NJ2007-001). All of the data sets for a given state were then merged and cleaned. This process entailed ensuring consistency in fields, imputing any missing data, and double checking to ensure that first-year teachers were properly identified as such. This process was painstaking and time-consuming, particularly in ensuring that each first-year science teacher was identified with a unique identifier. One final trim of the data excluded any teacher who was not a member of the 2007-2012 cohorts and in their first six years of teaching.

This process ultimately resulted in four master state data sets consisting of every teacher in the novice science teacher cohorts, along with their employment history. Additional data tags were assigned to each individual to characterize their "real" years of experience, and whether they were retained four of their first five years in the same LEA. Ultimately each teacher in the data set was designated with a binary indicator for their retention status. A visualization of the result of this analysis may be seen in Larkin, Patzelt, et al. (2022).

The race and ethnicity data within the original staffing reports was inconsistently reported across states and cohorts, therefore we elected to create a binary category in order to capture whether or not a given individual was from a minoritized demographic group. The overwhelming majority of teachers in the data set were characterized as White and non-Hispanic. Indeed over 80% of the teacher workforce in the United States identifies in this manner(McFarland et al., 2019). The second group included all individuals identified as either Hispanic or non-White or both. Though these categories are problematic in many ways (Nguyen & Teranishi, 2020), and imprecision of the phrase "teachers of color" threatened to introduce new errors, we did ultimately assign teachers to a binary category of whether they were White and non-Hispanic (0) or not (1). This approach seemed a reasonable choice given our purpose of analyzing the data through the lens of race and ethnicity to identify districts that were successfully retaining teachers who reflected the. However, there is no guarantee that individual teachers themselves were consulted for how they identified racially or ethnically.

Phase Two: District-level Investigation of Teacher Retention Factors

In the second phase, our district identified districts that we deemed to be successful in retaining novice science teachers and investigated the factors that appeared influence this outcome. In this section, we discuss the selection of focus districts and their subsequent recruitment into the study. We then detail our qualitative data sources and methods and construction of the individual cases. We conclude this section with a brief discussion of the cross-case analysis in our effort to identify generalizable and actionable findings.

Case study district selection

Our research team created a retention index measure as a first step in identifying potential districts of interests. Six factors were weighted equally in this index: top 10% in a rank of total number of novice science teachers retained, top 10% in a rank of the ration of novice science teachers retained to student population, retention of three or more novice science teachers in 11 years, retention of at least one novice science teacher of color, greater than 50% of students receiving free or reduced lunch, and top 10% in a ranking of districts by number of students identified as limited English proficient. Each of these factors was worth 1 point on the index. Districts that did not retain more than 50% of its novice teachers were excluded, as were districts that only retained one novice science teacher in 11 years.

From this initial index, we identified a subset of districts in each state that demonstrated high retention rates for novice science teachers for possible further qualitative study. In selecting this subset of districts, we sought to balance our opportunity to learn (Stake, 2005; Stake, 1995) by including a number of factors such as the district's geographic location in the state, districts that demonstrated success in retaining science teachers of color, and the demographic profile of the school, which included the percentage of students receiving free/reduced lunch or were designated limited English proficiency. This selection process involved the entire research team in deliberation, and was repeated for each state. For each state we selected five target districts for invitation, and another five districts as suitable backups in the case that an invited district declined our invitation to participate in the study.

After an initial email and/or phone call invitation to the study, the principal investigator and project manager typically met with district leadership to discuss the study, and begin the process of local project approval, typically through a director of research or review board prior to full school board approval. Though we had aimed for 20 cases total (5 for each state), even with inviting our backup districts, we were unable to obtain permission and conduct research in mdistricts focused on essential functions an key personnel fell ill or left their positions. as districts focused on essential functions and key personnel fell ill or left their positions. A total of 13 districts in all four states agreed to participate in the study.

Qualitative Data Collection

The research team scheduled a site visit and interviews with teachers, science area supervisors, administrators, and other district personnel involved in supporting novice science teachers. In each district, a liaison typically aided in arranging and scheduling the interviews. Site visits prior to March 2020 and after April 2022 were conducted in the district, while those during the intervening time were conducted virtually over the Zoom online video application. Interviews took place at the convenience of the interviewees, and the consent form promised both individual and institutional confidentiality. While the majority of the interviews were individual, a number of group interviews took place by necessity. These we grouped by experience level (e.g. novice teachers, experienced teachers) and did not mix teachers and administrators in order to permit them to speak freely.

Interviews typically lasted 30-45 minutes and were recorded, transcribed, and then analyzed using NVIVO12 software. All active members of the research team collaborated on the data collection and construction of the case narrative. Other data collected included publicly available district documents on district websites. We welcomed any other documentation related to the mentoring and induction efforts that districts wished to provide as well. This additional information was used primarily for corroboration, accuracy, and detail for the written case studies.

All interviews were recorded and transcribed, and each was imported into the NVIVO12 application for further analysis. At least three members of the research team independently coded data for each case prior to a meeting to identify emerging themes related to the salient factors influencing novice science teacher retention in the district. Additionally, the mentoring and induction efforts within the district were added as a focus for each case in order to characterize the relationship between these efforts and teacher retention in the district as portrayed in the data.

Case Study Construction and Cross-Case Analysis

Active members of the research team then collaborated on constructing the narrative of the case (Stake, 1995), with a single author taking the lead on the writing of each case. When a draft of the case was ready for member-checking, a copy was sent to each person in that district who had been interviewed along with a feedback form. Of all cases, four participants responded with feedback of correction, clarification, or affirmation, and final case study text was subsequently modified to address these comments. A total of

13 cases were completed over the course of the project, and final drafts of the case studies were published on the project website.

The case studies sought to identify the most salient factors related to novice science teacher retention in each district, and the cross-case aimed to synthesized the findings across the completed cases. Though case study researchers typically caution against using multiple-case study as a reliable method for producing generalizable findings, we feel that the focus of this investigation on practices that have been successful in one context for possible use in another make the effort at producing actionable suggestions from a broader analysis worth the risk of over-generalization.

Following the procedure suggested by Stake (2006) for multiple case study analysis, our research team has analyzed the findings of each particular district case in light of the themes of this research to develop *assertions* about the multi-case as a whole. Our multiple case study analysis was conducted by having three research team members first establish inter-rater relatability by independent coding and consultation, and then proceed to code the remaining cases individually using the *a priori* categories of the previously identified retention factors in order to identify commonalities and sub-themes across the cases that comprise the assertions. Stake emphasizes the need for the evidence behind these assertions to be presented in the final report, so as to make a persuasive case to the reader, and we do so in the subsequent section.

Findings

Our analysis yielded 11 distinct categories of factors that influenced teacher

retention across all of the case study districts. These themes are shown in Table 4, and though there was some elements of many of these factors in each case, our analysis focused on identifying the major factors in each district based upon the preponderance of evidence presented in the case data. We therefore present these factors in the order with which they appeared most frequently as major themes in the cases.

Table 4. Major teacher retention factors from the cross-case analysis

Table 3. Participant Districts

Teacher Retention Factor	Count of cases

Support from departmental colleagues	7
School/district-level systems and culture of support	7
Compensation	6
Teacher autonomy	6
Specialness of place	6
Resources for Teaching	6
Opportunity and Agency for Professional Growth	3
District and school-level race-consciousness	3
Affordances related to school size	3
Personal Satisfaction and Rewards	2

Support from Departmental Colleagues

Throughout our interviews with science teachers, both novice and retained, the word “collaborative" often came up. Teachers explained that one of the biggest reasons that they remained teaching in the same district, and often within the same school, was due to the collaborative nature of their science department. Along with the word collaborative, teachers we interviewed described their science departments as cohesive, close-knit, and cooperative, where they felt a strong sense of camaraderie. Teachers reported being welcomed by their colleagues in the department as novice teachers, and that welcoming turning into long-lasting friendships.

When we asked what it was about their departments that made them so

collaborative, an overwhelmingly frequent response was the willingness to share resources. New teachers in Aspen were immediately given access to a shared online drive full of unit plans, lessons, and slide presentations and activities. In Pompano, this support was evident to all, as one of the novice teachers explained:

> Whenever I needed help, I knew I could go to people who are either teaching the same curriculum as me, at the same time, or have taught it, and they would give me whatever they had and help me in any way I needed. It's a very nice feeling when you know you have your department people who do this, who have done this for years, to rely on for resources and material.

Similarly, in Granite County Technical School, one teacher shared that she felt that sharing resources should be a default stance for teachers:

> That whole Teachers Pay Teachers thing, I can't stand that. Somebody gave me something, now it's my turn to pay it forward to give it to you. So that's how we operate as a department. And that's I think why we've all stayed. It's a great place to be because you're not just stuck out there—people are excited to share their stuff! If I came up with something really awesome, and it worked great, let me share it with you so that you can have the same success I did.

Science teachers we spoke with told us that in addition to sharing resources and materials, they received informal mentorship from the individuals within their department.

Many explained that although they were assigned a school or district mentor, it was their department colleagues who provided the most meaningful support. In the case of Wallago, informal mentorship by the department was not just hoped for, but expected, so much so that formal mentors were specifically assigned from outside of the department.

This departmental support sometimes came in the form of mandatory professional learning communities (PLC's), which were described by one teacher in Wallago school district as "sacred time." However, it was more commonly cited that this support stemmed from the many daily interactions, like shared lunches, where teachers could discuss with one another their struggles and triumphs in the classroom, as well as what they did for fun over the weekend. From our interviews, we started to get a sense that perhaps, in districts with high levels of science teacher retention, it was the department as a collective who served as the mentor to novice science teachers, rather than a single individual. One teacher in Rivuline district described it in this way:

> I will just say one thing that's so impactful as far as like thinking back on me, is having other science teachers kind of mentor and collaborate. Because you can have that generic mentor be helpful in some part, but just having someone in the science department mentor and really kind of take you under their wing, it was so much more impactful for me and gave me more confidence in what I could do.

In some cases, the close ties teachers developed arose out of shared district challenges, as was the case in Granite County Technical School and Sandstone School District, or because their coworkers were their family members and neighbors for

generations, like in the Kingfisher School District. However, in many of the districts we visited, teachers cited their closeness derived from simply knowing they were not in it alone, saying:

> You know, for a few reasons, I would say, probably at the top it has been my colleagues. We have a set of colleagues here that is very supportive, very welcoming, very encouraging. It just really makes you feel right at home. But my colleagues would be my top reason. I mean I don't feel like I'm in my classroom alone, sometimes teaching can be an isolating kind of endeavor but right next door, I know I can always knock (Mulberry School District).

School/district-level systems and culture of support

A common feature of high-retention schools and districts in our study was the existence of a systemic culture of teacher support. This culture was evident in the ways that organizations made it possible for new teachers to receive support through the regular operation of the workplace. While other factors among the continuum of reasons for teachers' retention are connected to the school/district-level system and culture of support, we want to differentiate this factor by solely focusing on the culture of support teachers received from their school and district. Teachers stated that their supervisors and administrators were very supportive and valued the teaching profession. This support extended towards the district by nurturing novice and experienced teachers with individualized support. The district support system was reflected in the time, work, and monetary expenses invested in teachers to make them grow professionally, work in

adequate conditions, and meet their professional needs. The school support system came from the school leaders, administrators and supervisors. This was shown as value, care and appreciation for teachers, content and socioemotional support, and personalized assistance for teachers.

Teacher appreciation efforts at Aspen, Birch, and Chestnut school districts reflected the clear priority these districts made in order to make teachers feel valued and cared for. The Aspen district supported new teachers through the initiative of The Aspen Teacher Academy, which is an induction program that allows novice teachers to receive support in their pedagogical skills and connect with the community. Aspen district also supported their experienced teachers by offering reimbursement for graduate level coursework, in-house and external professional development, and encouraging them to participate in the new teachers' hiring process.

In the Birch district, teachers mentioned that their school district provided opportunities for their administrators to show and demonstrate their teacher appreciation through social events, where teachers were allowed to voice their concerns. In addition to that, interviewed teachers mention that their district developed a partnership with the town university so that teachers and students were allowed to use the university's facilities. This partnership demonstrated to Birch teachers that their district really valued them and supports them by going above and beyond for them. Birch teachers also mentioned that their supervisor was very supportive in building relationships with teachers. One experienced teacher noted, "Thankfully our supervisor is very supportive that way, and tells us, 'If you need something, please come to me.'"

Interviewed teachers at Chestnut mentioned how they felt valued, cared for, and

supported in their school district because the school put academics before sports. “Here, it’s academics before athletics,” one teacher noted, “which helps us as teachers.” This push for education is what made teachers feel stable in the profession.

> You have great kids. You have great families. You get tons of support from the families for education. There's a push for education. Having gone here and having friends through here and my family, it makes it easy to come to work and teach.

Teachers at Egret County Public Schools mentioned that their school provided social emotional support by showing that people “genuinely care” about their personal life and professional growth. Egret teachers also stated that the district provided content support by facilitating the tools they need to make every lesson successful:

> They provided content support, and then there's also social emotional support. And I want to say content support. I can look up a lesson, but you can't look up how to manage. Well, you can, right? But when you're a first-year teacher, you're not thinking about doing personal development. You're thinking about, "I'm trying to survive." I guess maybe it's a top-down thing where you feel supported, and so you're able to work with your colleagues and support them. Those things I think keep the science teachers here.

Interviewed educators at Pompano and Mulberry stated that their retention has been influenced by the district’s personalized assistance with science pedagogy and

consistent attention to their individualized needs. Mulberry school district focused on fostering close relationships between the schools and community by encouraging their teachers' participation in community events. The Mulberry district also worked hard in demonstrating their commitment to serving teachers by trusting them as professionals. Something that Mulberry school district did that broke the traditional hierarchy of authority in the school building was giving walkie talkies to the mentors and induction coaches rather than administrators. The walkie talkie system challenged traditional power dynamics within the school while prioritizing the teachers' needs.

Pompano has supported teacher retention by being attentive to the needs of its teachers. An example of this was when the district increased tremendously the drop in enrollment and the school district did not lay off their teachers, they rather restructured the school to maintain their teachers.

> We were able to keep folks that came on board, simply because you know, as the school shrunk and folks retired, we just didn't fill those positions. We were able to structure the schedule in a way that we kept people.

Compensation

In New Jersey, state-level policy decisions have impacted school districts and led to successful practices. For example, charter schools operate as autonomous school districts, allowing for more teacher autonomy. This is reflected in Birch, where a teacher shares, "I feel like I can be myself without someone controlling me, like, 'Hey, do this or that.' Yes, there's always feedback and keeping me on track, but at the same time, I have a lot of

freedom." Furthermore, nearly all public school districts in the state use negotiated salary tables between the school board and local teachers' union to determine teacher pay. The teachers' union provides support to teachers, including coaching and concrete suggestions for improvement. This system allows for competitive salaries, resulting in high retention rates in districts. Chestnut and Mulberry, for example, benefit from a competitive salary supported by contract negotiations between the teachers' union and the school board. Teachers also mentioned consistent salary increases, with one commenting that their "pay has gone up a tremendous amount" since starting at Mulberry. Similarly, other districts like Rivuline, Sandstone and Linnet are known for being high-paying districts, with starting salaries higher than those of surrounding districts.

Additionally, districts with favorable salaries also offer compensation for various roles. For instance, in Egret, Kingfisher, and Sandstone, mentors receive stipends, resulting in better-structured mentoring and induction programs that help retain teachers. In Linnet, teachers receive stipends for giving up planning periods to assist elsewhere in the school, while in Aspen, a teacher serving as an induction coordinator receives a stipend and support through a reduced course load.

Some cases mentioned compensation for professional development and continuing education as a benefit. In Rivuline, teachers receive financial assistance for college courses, which helps with retention and fosters connections among colleagues across the district. In Wallago, teachers are paid to attend professional development, and the district covers registration costs for each class, providing further support such as time off and substitute teachers.

On the other hand, in two instances, Birch and Granite, compensation was

mentioned as a tradeoff for meeting cultural needs or allocating funds to other resources. A Birch teacher expressed, "They don't pay much, but I love the small size schools. It's like a family school. You get to love others because you get to know them more." Similarly, a Granite teacher shared that a higher salary would not be worth losing access to material support and supplies from their department chair, noting that their requests are hardly ever rejected.

In Aspen, teachers considered the lower salary worth it because of the additional resources for students and teachers. One teacher stated, "When I first got hired here, the pay was terrible, but when I looked at it compared to the resources we had, it was immeasurable. That was very important to me. The fact that my pay wasn't that high, I could rationalize it. The draw for me here was because of all the opportunities for teachers and students, plus it's a beautiful school."

Teacher Autonomy and Agency

Teachers' autonomy influences aspects of the job itself such as professional status, job satisfaction, and work conditions (Vangrieken et al 2017). This factor has been reluctant when examining teacher retention across the case studies. Teacher autonomy has been shown in these cases as the freedom to teach, the voice given to teachers, and the decision-making in their school settings.

One of the first components of teacher autonomy was the freedom given to teachers to teach how they want. Within this freedom, there was an element of ownership, flexibility, and trust for teachers to make any changes in their lesson and create their own curriculum. Teachers at Granite spoke highly about their school's structure avoiding

classroom micromanagement. One teacher at granite pointed out that this structure was "the number one reason why I like working here and haven't looked anywhere else."

> We obviously have to teach to the Pennsylvania state science standards, but we have a lot of freedom. Like, there's no micromanaging over what you want to teach as long as people know that you're teaching to the standards.

A Mulberry retained teacher mentioned how the freedom given to teachers is reflected in their flexibility to act as a professional.

> I'm allowed to teach what I teach in the manner that I feel that I need to teach my subjects. I don't really have people telling me, you need to teach this a certain way, you know I have flexibility. I feel like I know what I'm doing, and that flexibility is very important to me because you know there's a lot of other parts of the job. At least the flexibility to at the end teach the way that you want is worth quite a bit. I still have the freedom to act as a teaching professional.

Interview teachers at Birch, Egret, Pompano and Hickory stated how having "ownership in their curriculum" allows them to teach how they want and be creative in the classroom by adding their "own personal style" of teaching, which was echoed by the ability to "own the curriculum."

> So, I am teaching an ecology class. I love being outside, I'm a big outdoorsman. So,

> we have a pond by our school, so I asked one of our principals if we could get a bunch of fishing poles and stuff. We just went fishing for like a week and a half. We collected some data on the fish and put it all together to try to determine if the pond was healthy or not. But after I planned on being done, the kids were like 'Can we just keep going fishing?' and I was like 'Sure let's spend another day fishing.'

Teachers also reported that having a "voice" in their school was a very important element of teacher autonomy. This school "voice" was represented with the ability to communicate their concerns, ideas and share their knowledge without any repercussions towards their job. Teachers at Egret, Granite, and Aspen mentioned how giving teachers a voice made the difference in their teaching experience. However, it was not only having a "voice" that made the difference but being heard. One teacher at Egret commented that "having a voice" made teachers feel "valued and trusted".

> If I'm talking to you and you are the assistant principal, or you are the department head, and I feel like I just talked over your head because you just told me exactly what you want to do again. I'm like, "Okay, do that one more time and I'm walking out the door."

The last element found in teacher autonomy across the case studies was the ability to make decision making in the school settings. This included giving teachers the autonomy to be part of district-level interviews, participation in school executive decisions, and empowering decision-making in PLC topics and mentoring practices. The paradoxical

relationship between teacher autonomy and collaboration could individualize the practices of teacher autonomy (Vangrieken et al 2017). However, collaboration is highly needed when promoting teacher autonomy. One Egret administrator stated:

> [District STEM Director] has tapped, empowered, trained and grown, the capacity through us of teacher leadership. And so, she now has empowered teachers to take that role as leaders in professional development and curriculum development and curriculum writing. We still supervise the efforts with them, but they are the [right] people, because who better to know what the classroom should need them, those who are in the classroom.

Specialness of place

The concept of place-identity, drawn from environmental psychology, describes this factor. Teachers mentioned that the community and their connection to it were significant factors in their decision to stay in their current school district. The physical environment and unique geographical place of the area were important in creating a sense of belonging and contributing to teachers' reasons for staying. The presence of family members, church connections, and a sense of familial duty were mentioned as reasons for teachers to remain in their hometowns and contribute to their communities. Therefore some teachers have a strong sense of loyalty to the students and community, which influences their decision to stay in their current schools. In Hickory, the island's layout, housing locations, natural features, and human-made structures were all important aspects that contributed to teacher retention. The proximity of the school to the beach and the ability to take

advantage of the island's amenities were highly valued.

For some districts, the specialness of a place is tied to a location with a historical tie to cultural heritage. In the Kingfisher school district, the district's Native American culture was cited as a reason for the closeness experienced within the school community. Teachers and administrators emphasized the importance of culture and Native American identity in creating a supportive and comfortable environment for teachers of color. Additionally, administrators claim that teachers of color feel comfortable in Mulberry because of its distinctive culture and commitment to equitable and anti-racist education and uplifting of the Black community. The district of Egret County reflects and honors the legacy of the civil rights movement, and the commitment to students of color is tied to the district's history and initiatives. One teacher expressed, “I'd say for myself, the main reason I'm here is the community. That's what even kept me at the school that I was in my first year, was being loyal to those students [children of color] and making sure that I didn't leave them” (Egret).

Teachers also mentioned opportunities for professional growth as a factor in their decision to stay in their school district. The district's efforts to build connections with community partners, such as universities and businesses, provided opportunities for professional development and externships for both teachers and students in Pompano. Some districts’ proximity to universities provided financial resources, human resources, and opportunities for collaboration. This can be seen in a district like Linnet, where ample funding allows for well-equipped classrooms, support staff, and high salary supplements. The presence of parents working in universities or research institutions further contributed to the availability of additional resources for teachers, a theme continued in

the next section.

Resources for Teaching from the School and Community

Another theme we encountered in our conversations with science teachers around retention was the importance of having adequate resources for teaching. For most, this meant having the necessary supplies to teach your students without having to reach into their own pockets. Some teachers expressed, for them, having access to classroom resources was more important than having the highest possible salary.

Teachers often cited that access to adequate classroom supplies stemmed from having administration who understood the unique needs of a science classroom, and therefore budgeted accordingly. For example, teachers discussed having materials to conduct higher level laboratory experiments in their classrooms, rather than being limited to items, like vinegar or baking soda, they would need to purchase themselves at the local grocery store. For one teacher in particular, knowing she would have necessary supplies for her classroom was one of the reasons she referenced for accepting the position in her district in the first place, saying "it seemed like there was good funding, and that I would have support."

Sometimes resources came in the form of partnerships with the community, such as local universities, as in the cases of Birch, Linnet, Kingfisher, and Rivuline. By having relationships with universities, teachers had access to university laboratory spaces, materials, professional development opportunities, and in the case of Birch, a source of qualified student teachers and interns. In addition to having connections with the local universities, some of the districts we spoke with cited community members and parents as

a source of providing classroom supplies and other school related resources. In the case of Granite County Technical School, the community not only supplied the school with materials for teaching, but also served as physical places where students could intern using their technical skills. In the Linnet School District, parents who worked in the science industry or in university science labs often served as a source for providing laboratory materials that teachers may not have otherwise had access to. One of the science teachers at Linnet explained:

> We have a group of parents who, if we don't have equipment, I can always say — My first year there I said, "Oh I really wanted a skeleton but I forgot to order one." And I just sort of mentioned that to the kids like, "Oh, I would love to show this to you on a skeleton but I don't have one." And two days later a parent dropped off a skeleton like, "Oh I got it for you." "Cool, thank you." We've got parents that work in laboratories and we've had a lot of science equipment donated to us a bunch of years ago. We had about $200,000 worth of science equipment donated from a lab that shut down. So, we don't really want anything as a science department.

In addition to consumable classroom materials, teachers also cited ample opportunities for meaningful professional development and/or having their own classrooms as necessary resources for teaching that influenced their retention in their school or district. Specifically, in the case of Aspen, teachers cited having the necessary coverage so that they could actually attend professional development during the school day. As many of our research team worked previously in schools as science teachers, we

recognized how rare a resource like substitute coverage can be.

From our interviews, It became very clear that by working in a well-resourced district, teachers were not only provided perks that other teachers may not have, but it also reduced certain stressors that other teachers in other schools may face, leading to increased retention, such as having more positions for support staff, such as school counselors. An administrator in Linnet described it in this way:

> The counselor ratio has always been good. To have a social worker at all the schools to deal with other student issues —I think that plays a big part in the retention just to make sure the students are happy, and then all you have to do as a teacher is the content, knowing that the students are supported.

Some of the factors teachers cited in relation to their retention, were actually related to the community in which the school or district was located. Teachers often spoke with a sense of pride, not only for the school in which they worked, but also in the broader community outside of the school. For many, community factors included building relationships with organizations outside of the schools themselves, such as with local businesses. These relationships with community organizations led to career opportunities for both teachers and students, such as a site for externships/internships, as was the case in the Pompano school district and Granite County Technical School. In Wallago school district, in addition to providing internships, local businesses came into the school as guest speakers and provided the school with specialty manufacturing equipment that students could use.

Other community relationships included those with local universities. Similar to businesses, universities offered opportunities for internships as well as professional growth for teachers. Most notably was the unique role local universities played in the Linnet school district, a district described by many in the school as a university town. By having close affiliations with universities and being located in the same city as the university, the school was the recipient of many perks, including more than adequate funding. Although this factor was previously discussed in our section on resources, we felt it related to the factor of community as well. Additionally, many of the parents of the students in Linnet schools were employed as professors at the local universities. One teacher explained that because students had professors for parents, they tended to enter the classroom with more background knowledge in content, particularly in the sciences, and perhaps more than students in other schools and districts. The parents in Linnet also seemed to be heavily involved in the learning process of their students. A science teacher in Linnet described it like this:

> The history department, I don't know. Maybe. I mean they have a lot, every book that they could want, they get guest speakers to come in fairly frequently to talk about historical events, parents support. There's a teacher at our school that does a lecture series for the parents and that's well attended by the parents as well. He does it in his own time and evenings and he'll do it for a few weeks, a couple of nights a week. And those are well attended.

However, parental support was not unique to Linnet school district, and was suggested by

many science teachers we spoke with as a factor related to their retention, a factor we felt spoke to the community outside of the school. This was evident in the district of Wallago where one teacher expressed how supportive the parents were:

> Parents were very supportive of allowing the school to provide teachers with the Wednesday afternoon PLCs, even though that meant their children would be leaving school early one day each week. They also recently passed a multi-million dollar referendum to build a new elementary school.

Teachers also expressed an appreciation for the efforts of their schools, and the cities the schools were located, to foster community engagement. In the city of Mulberry, this was evidenced in the city's planned events, such as planting community gardens or community-wide reading events, where the school and city worked together to involve teachers, students, and student families. In Birch Charter school, this meant that teachers were obligated to participate in service-learning projects, aimed at fostering a deeper sense of community between the teachers and the city in which they worked.

Lastly, in relation to factors related to the community outside of the four walls of the school, teachers discussed the importance of living in the community in which they worked. For some this meant coming back to the town or city they grew up in and for others it meant moving to and becoming a part of the community in which they now worked. In the districts of Pompano, Sandstone, and Kingfisher, many of the science teachers we spoke with were currently teaching in the schools they attended as students. This finding is not unique, and can be found elsewhere in the teacher retention literature

(Reininger, 2012).

By working in the community they were already a part of, teachers came to their teaching practice with a greater understanding of how the school functioned and the ability to develop relationships with their students. One retained teacher in Pompano school district explained,"I suspect more of them [retained science teachers] are people from the area who have a more developed sense of what the areas are like, what the community is like, what the characteristics of the students are like, and are going back into education." For the teachers in Kingfisher county, it was not simply about returning to the school they went to, but more about giving back to the community in which they themselves were supported, a phenomenon we discuss in greater detail in the factor titled specialness of place.

For some teachers, although they may not have been raised in the district they were now teaching, they still felt connections to the community in which they now were a part of. In the districts of Wallago and Hickory Island, even when teachers came from outside the community, they felt welcomed into the small hometown feel the district had to offer. One of the retained teachers in Wallago told us, "I mean the community has been great. I've made a lot of connections, a lot of friends, and so that keeps me here as well." In Hickory Island, because it was so small, teachers regularly joined students on their walks onto the school campus. One administrator in Hickory Island emphasized how important it was for teachers to feel they were part of the larger community, whether they wanted to or not: "If you're going to be a part of this school, you're going to be a part of this community, there's no choice about that."

Opportunity and agency for professional growth

A teacher retention factor is the opportunities for professional growth. This includes access to graduate courses, financial support for professional development opportunities, and the opportunity to attain advanced degrees. This theme highlights the importance of ongoing education and the district's investment in teachers' professional growth. Multiple districts mention the support provided for teachers to pursue advanced degrees or graduate work, like in Birch's partnership with a university that offers teachers six graduate credits.

Additionally, some districts have opportunities for teachers to take on leadership roles and engage in professional development activities beyond their classrooms. In Kingfisher, teachers have professional development with a local university and local Native American tribe. This includes writing school curriculum, leading professional development sessions, mentoring novice teachers, applying for administrative or supervisory positions, and participating in the leadership of teachers' unions. These districts make efforts to encourage and empower teachers to expand their skills and expertise.

In two cases, the theme of equity support and retention of teachers of color highlights the significance of providing equitable support and opportunities for professional growth to ensure the retention of teachers from diverse backgrounds. In Mulberry specifically, the supportive and caring environment described ranges from person to pedagogical support, the personal and the professional well-being of the teachers is considered. This theme underscores the importance of fostering an inclusive and supportive environment for all educators.

District and school-level race-consciousness

One factor that emerged from our discussions with science teachers and administrators was one that we chose to label, "district and school-level race-consciousness." Here we define race-consciousness in education and by teachers as possessing an "awareness of race, of the possibility of their own racism and the racism of others, and the significance of these perceptions in the teaching and learning process" (Teel & Obidah, 2008, p. 4). as well as in district and school-level decision making.

Some of the schools in the case studies exhibited evidence of significant race-consciousness among educators, where teachers and school administrators not only acknowledged race, but intentionally implemented policies and practices to support both students and teachers of color. One intentional practice we observed was in the hiring decisions of certain districts. Examples included hiring graduates of the Noyce program (Birch charter school), hiring student teachers from the local community college (Hickory Island), and hiring both teachers and administrators of color (Egret and Mulberry).

In addition to hiring practices, some districts implemented strategic initiatives towards equity and social justice. In Egret, equity included practices such as allowing for curriculum flexibility in order to meet the needs of the community. One teacher at Egret related the district's commitment to students and teachers of color as a remnant of the district's deep ties to the civil rights movement. Most notable however was the way in which certain districts implemented race conscious practices in their mentoring and induction programs. In Egret, with a large number of teachers of color on staff, novice teachers of color were mentored and coached by experienced teachers of color. In contrast,

Hickory recognized the lack of diversity in their teaching staff as compared to their student population and therefore emphasized educating their teachers on race consciousness, such as helping teachers to understand the difference between equality and equity.

For other schools and districts we visited, some struggled to separate race from other socioeconomic categorical markers. Phrases such as, *high-needs*, *inner-city*, or *urban* served as proxies for race and culture, and were connected to the degree of personal satisfaction felt in supporting the students in classrooms. For example, one teacher in Rivuline expressed:

> I think I got good at teaching here. I think it's a high needs area and it needs good teachers. I have a sense of pride teaching here, knowing that I'm teaching in a high-needs school, an inner city school, something that a lot of people couldn't handle and couldn't do. So I am proud of that.

In some of the districts that had a high population of White students and teachers, we found that an absence of evidence pointing to race-consciousness also correlated with high teacher retention. Milner (2006) notes that in such settings, teachers may view students of color as "liabilities." One example of this was the way in which teachers in the districts of Aspen and Linnet spoke about teacher burnout, associating a lack of teacher burnout with increased levels of retention. However, for these teachers, they experienced less burnout in the classroom because they did not have to deal with the difficulties that came with teaching students of certain demographics.

Specifically, when talking about English language learners, students experiencing

homelessness, or students struggling with drug abuse, one teacher in Linnet expressed, “When you just have a couple of students who are dealing with those issues . . .you don't burn out.” Similarly, one teacher in Aspen explained:

> We don't have the same student population as perhaps an inner city school does, where perhaps the burnout rate is a bit higher. So in general... I don't feel tremendously threatened when I walk into one of our classrooms.

On the surface, the two examples provided may not appear to be related to a limited level of race consciousness, however, by using language such as “inner-city” and “student population,” that fail to explicitly acknowledge student race, teachers may be reproducing harmful color-blind ideologies in education. Similarly, by associating burnout with the number of students of color a teacher has in the classroom, White teachers in this district saw students of color as liabilities. We note here that there seems to be a possibility that some teachers may feel a better sense of fit with a district in which race is seldom discussed.

Affordances related to School Size

Despite having a small or large school size, districts like Birch, Chestnut, Hickory, and Rivuline transformed this characteristic into a significant attribute that influenced teacher retention. For smaller districts like Birch and Hickory, teachers felt they were a part of a “tight knit family,” which inherently made them “very close to a lot of coworkers.” Teachers we spoke with explained that a small size school resulted in smaller class sizes, as

well as receiving “personal support” from administration.. Administrators of small schools appeared to be attentive to teachers’ needs. A Hickory administrator noted:

> One of the consultants that we’ve been working with for years talks about being nimble and being able to react to what you need to react to and give people what they need, and we do. We pride ourselves on that. It’s a lot easier for us because we’re so small.

During our interviews with the teachers at Birch Charter School and Hickory school district, they expressed working in a small school size was one of the reasons they decided to remain in the district. They explained the small size of the school increased their ability to form closer relationships with colleagues and community. Teachers described that having a “family” in their workplace was a consequence of the “very small community” in their school district. One of the retained teachers said it like this:

> They don't pay much but I love the small size schools. Yes. It's like a family school. You get to love others because you get to know them more. Students, teachers, administration, and parents.”

Another affordance of working in a smaller school was the low student -to -teacher ratio. This was evidenced in our interviews with teachers in the Hickory Island school district, where the student-to-teacher ratio was below the state average. The student-to teacher ratio was even lower in the advanced science courses. One science teacher

mentioned:

> My biggest class has 15 kids, and that's probably an overload. In most cases, I get 6-9 kids per class. So, my ability to kind of focus, get to know where they're at and then kind of take them along as a herd and get to know them personally, get to know them as a student and kind of figure out what their aspirations are and build on those, is a lot easier here than it is [in other districts].

In contrast, districts like Chestnut and Rivuline benefitted from their large school district structure to retain their teachers due to their job mobility and having a large variety of colleagues In large districts, teachers' mobility enabled interviewed teachers to remain in the district with the option to move to another school that they preferred. One Rivuline administrator stated:

> I know pretty much every high school science teacher in the district. And over time… the best science teachers…. all have, like, shifted over to our magnet schools and I understand why.

Another affordance of a large school size was the variety and larger number of colleagues. A science teacher mentioned, "That was probably the biggest difference when I came here. All of a sudden, I'm not the only physics teacher, and there's people that I can work with and share ideas with."

Personal Satisfaction and Rewards

Across our case studies, the retention of teachers was connected to unique features of each individual district. However, when the district is not directly responsible for the retention of teachers, there is a sense of acknowledgement towards the teachers' own decision to remain in the district. The factor of teachers' personal satisfaction and reward from their job and profession played a big role for the retention of teachers at Kingfisher, Linnet, Sandstone, and Rivuline. This factor included the personal satisfaction to give back to the community and to teach students who were "interesting" and "invested". It also includes the rewards of the teaching job itself, such as impacting someone's life and having time to raise a family.

Interviewed teachers at Kingfisher stated that there was a satisfaction in giving back to their community because they were born and raised in the area. Having a personal drive to teach in the district they call "home" was the same reason why they decided to remain in their job positions. Teachers at Rivuline took pride in teaching in high needs schools because they need "good" teachers. One teacher connected the skills she possessed as a teacher and her ability to overcome challenges:

> I think I got good at teaching here. I think it's a high needs area and it needs good teachers. I have a sense of pride teaching here, knowing that I'm teaching in a high-needs school, an inner-city school, something that a lot of people couldn't handle and couldn't do. So, I am proud of that.

Besides the school area, another main element in teachers' personal satisfaction in districts

like Linnet and Rivuline was the students. Even though interviewed teachers at Linnet and Rivuline have very different students' bodies, they all shared the satisfaction of teaching their unique set of students. Teachers at Linnet state that they feel satisfaction in teaching students who were "interesting" and "invested". A Linnet teacher mentioned:

> I think that I've had over the years a number of students that just come to hang out during lunch chat about, "Hey, I read this article," or "I watched this movie and this thing happened, do you think something like that could really..." The kids think about stuff. They don't just allow things to wash over them. They bring a lot to the classroom. I get interesting questions every single day. I get questions where I go, "You know what? I don't know." And there's a little place I have carved out on my board where I write their questions. I'm like, "I don't know. I'm going to look that up, find that, let's learn something new." And there are things that I never even thought about. "Why is that? That I don't know. Let's find that out."

For teachers at Rivuline, this satisfaction came from teaching students in need. A teacher explained the connection between helping students in need and the personal satisfaction of working in a high needs area:

> I think, deep down its because I want to teach the kids that deserve it. I mean, I could do this anywhere, but I feel like these kids are the kids that are really getting what they should get. They know that they're getting top notch education and they end up going to college prepared, and I feel like they deserve that. They're not

> getting that in every classroom and every discipline area, but I feel like I send them off to college ready to go. I've got a ton of kids that end up being engineers and chemists and you know I feel good about that. I feel like I'm doing a better job here than most of the suburban students are getting.

In districts like Sandstone, teachers mentioned their passion for teaching, and they call it a fulfilling vocation where they have been able to personally grow from. They also mentioned that there was a rewarding feeling when they are impacting someone's life.

> I like a lot of things about it. I also enjoy teaching and meeting people and I like that it's different every day. You definitely do not get bored, its different every year. And you know, on those occasions where a kid will tell you that you've made a difference, or something like that, sometimes it's enough to get you through the hard days you know.

For interviewed Kingfisher teachers, there was a sense of reward for their career because the teachers' schedule provided them with time to raise a family and spend the holidays and weekends with their children.

Discussion

In this discussion of the factors, we highlight four specific aspects of the findings: socialization into a science department, the professionalization of teaching, factors related to the retention of teachers of color, and the role of mentoring and induction in teacher retention.

Specific Factors for Teachers of Color

Three districts stood out when we were looking for factors that retain non-white teachers. During this study, Egret retained the highest number of science teachers of color compared to the rest of North Carolina. Teachers of color in Egret highlighted the importance of equity support in their career for their retention. The commitment of the district to the education of children of color was cited by participants as a significant factor in retaining teachers of color.

For many teachers of color, supportive working conditions are the reason for their recruitment and retention. Mulberry district offered a degree of refuge and a supportive environment for teachers of color. Mulberry's schools operated with a well-defined purpose for African American uplift, shared by teachers, principals, and community members, reflective of Historically Black Colleges and Universities. Teachers in Mulberry felt comfortable and supported due to the distinctive culture of the school district and community.

"In districts where the students are predominantly African American, the top-level

> administration rarely reflects the population. In [Mulberry] it does, and I think that makes us unique….How did that happen? I'm not sure, it's just always been that way since I've been here. It's one of the reasons that drew me to the district in the first place" (Mulberry).

The commitment of teachers of color to an equitable education for children of color also overlapped with having a supportive professional environment, for example teachers in Egret emphasized that because they had professional input, and that they felt like they were making a difference in the classroom.

In the same line, the Native American culture in the district of Kingfisher influenced school dynamics and contributed to the close knit broader community. This district retained a larger average retention of novice teachers of color and also emphasizes the importance of loyalty to the community. One teacher answered, "Why did I become a teacher? I wanted to give back to my community. I work at the same place I was born and raised; I mean in the same area. I had some really awesome teachers during my school years who really encouraged me and pushed me. And I wanted to do the same for students here in Kingfisher County. It's home to me".

The Role of Mentoring and Induction in Teacher Retention

When looking across induction and mentoring programs, it was evident that some districts generally followed state guidelines, while others exceeded what was mandated, in terms of time expectations, monetary compensation, and other areas of support. For example, in Birch Charter Schools, rather than paying the minimum required stipend,

mentors at Birch received hourly payment for the work they did. Going above and beyond took other forms as well, such as mentoring more than teachers novice to the teaching profession but also those who had previously been teachers of record but who were new to the district, something we saw in three of the districts we visited.

In most cases, the mentor programs were run by the principal, an administrator, or the human resources department, but in certain districts, there was an individual assigned with a specific role related to mentoring and induction. In North Carolina, this individual was often given the title Beginning Teacher (BT) Coordinator, a reflection of the language used at the state level where new teachers are referred to as beginning teachers (BTs). In Granite County Technical School, we were informed that although the mentorship program was technically overseen by administrators, it was really run by the teachers in the department.

Depending on the state, mentors were required to support new teachers from one to three years as well as complete a certain amount of mentor specific training, either online or in person, ranging from 15 hours to two days. Additionally, many of the districts we spoke with required mentor teachers to complete a certain number of teaching years in order to become an official mentor. For example, In Egret County Public Schools, mentor teachers were required to have at least four years of teaching experience in order to be considered and 24 hours of mentor specific training.

In Sandstone and Wallago however, although mentor teachers did not receive specific training, the principals in each district took careful consideration to select mentors that they felt would be best suited for the position. The principal of Sandstone school district explained “we do pick our mentor teachers, you know we don't give it to

everybody. They are purposely chosen and matched up with people as best you can." In Wallago school district, the principal told us that when choosing a mentor, they look for someone who is collaborative, open-minded, willing to learn, good/constant communication with mentee, positive, and "understanding of the direction that we need to go to increase student achievement, based on our kids."

Often mentors were matched with a single new teacher, according to grade level as well as content area. In one of the Kingfisher schools we visited, individuals teaching the same discipline shared a common planning period, which made mentor/mentee meetings more feasible. In Wallago school district however, new teachers were intentionally paired with a mentor outside of their department, first because it was expected that science teachers would already support one another, and second because Wallago administration felt it was important to get a perspective from teachers outside of their department. Another unique example of mentoring was in the Egret school district, where new teachers of color were mentored by experienced teachers of color, something viable only due to the large number of teachers of color in the district.

In some districts, in addition to the formal mentor, additional positions were developed to support novice teachers. For many of the districts this meant putting in place an induction coach to provide additional support, however, in a few cases, we saw unique positions. For example, in Linnet Public Schools, on top of providing a mentor and an induction coach, the district provided teachers with "advocates." The CTE director that we spoke with explained the role of the advocate, a role she was assigned in the past, in this way:

> Once a month we are to give them ten dollars or something and touch base with them. So whether I bought them lottery tickets or breakfast, or whatever it was, to touch base. How are things going? Let me just give you a little something. 'I'm thinking about you' note or something.

Mulberry school district also provided additional support to their new and experienced teachers by assigning district-level trainers, who worked with teachers across grade levels and subject areas.

Alongside providing teachers support with specific personnel, districts also required/strongly encouraged new teachers to participate in induction programs. Often programs were simply referred to as induction, however, some districts gave their programs unique names, highlighting perhaps the intention behind them. For example, in the Aspen school district, new teacher induction was referred to as the Aspen teacher academy and in North Carolina, schools referred to their programs typically using statewide terminology, as the Beginning Teachers (BT) Program.

When speaking with teachers across the districts we visited about their induction programs, we realized there were mixed reviews. For some of the teachers we spoke with, they felt that these programs were not particularly helpful, and in some cases felt that what they learned in the meetings could be communicated via email. However, for others, induction programs offered valuable information and support for new teachers to the field as well as those entering the district for the first time. In Mulberry, one teacher spoke of the importance of the induction program in their early years as a new teacher and how it influenced they way they interact with the teachers who are currently new to the district:

I started out in the district as a new teacher. They had new teacher orientation for an entire week from 8 to 3 for like the last week of August. It was probably one of the most valuable times that I had, which is why I love working now with new teachers and doing orientation because I'm like, “I did the same thing you guys are doing right now years and years ago, and it was so valuable to me.”

Typically induction programs begin prior to the school year and in some of the cases, continue regularly, often once a month, throughout the school year. Meetings covered a variety of topics related to new teacher support, from traditional onboarding procedures you might see at almost any new job, to more focused attention the acclimation of new teachers to the culture and community of the school. In Kingfisher school district, the BT coordinator made an effort to tackle topics that teachers reported via survey they needed help with. In Hickory school district, due to the lack of diversity of the teaching staff in comparison to the student population, induction also included raising a certain level of race consciousness among their new staff. For example, explaining to teachers the difference between equity and equality.

However, although our study highlights ways in which induction and mentoring were used to support new teachers, we also heard from many teachers that it was the informal mentorship they received that influenced their decision to stay. Even more specifically, in five of the districts we visited, teachers reported that it was the science department as a whole that provided this informal mentorship. One of the retained teachers in Granite County Technical School expressed that although, “you can reach out to anybody within the department and there's going to be this sense of helping each other and community and whatnot”, she felt it was the “organic” informal mentorship that impacted

new teachers the most.

Conclusion

The findings of this study offer a reframing of current debates about teacher retention, many of which continue to be focused on factors related to individual teachers, such as pay incentives. Yet the evidence from this study points to the importance of colleagues, teacher autonomy, opportunities for professional growth, and assets arising from the school community itself as important factors in teacher retention.

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